**A Road Location Method Using Noise Contours for Land Use
Planning Around Airports**

by

**Allemander J. Pereira Filho
B.Eng. (Federal University of Rio de Janeiro)
M.Eng. (Carleton University)**

**A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfilment of
the requirement for the degree of
Doctor of Philosophy**

**Department of Civil and Environmental Engineering
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Allemander J. Pereira Filho, B.Eng, M.Eng.

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Chair, Department of Civil and Environmental Engineering

Thesis Supervisor

External Examiner

Carleton University

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Abstract

Airports are initially located in rural areas near to the urban fringes. All infrastructure related to roads, services and utilities required to support the growth of its activities foster other incompatible land development such as residential and housing projects. Over time, additional roads are built, extended, paved or enlarged - over adjacent vacant land - increasing access to the airport's surroundings. This brings a myriad of possible development schemes, and begins a process of land use guided by private interests and financial gains that sometimes slips through government controls and regulations.

Control-oriented measures applied in land use planning have not been enough to guarantee compatible airport and surrounding land development. Action-oriented measures, particularly road location, are a powerful tool to guide land development close to the urban edge. The existing government policies and guidelines do not specifically orient engineers and planners when dealing with new/extended road near airports, about the importance of its location to avoid incompatible development for areas affected by aircraft noise. Roads located near urban fringe airports can foster land development increasing population density, and consequently peoples' reactions and complaints toward aircraft noise.

A fragmentation of the planning activities near airports has also contributed to the difficulties in harmonizing aviation and urban\rural growth by not paying adequate attention to the interactions between road location and land development.

Traditional land use and transportation models are not location sensitive to the development effect over a new road corridor. This research developed a road location method

based on a Geographical Information System (GIS) to be applied in the implementation of land use planning around airports in medium-sized cities. Adopting this method, roadway location near airports becomes an action-oriented approach to guide land development away from noisy areas. Two functions explaining people's responses and road corridors for several land uses defined by population density under different noise exposure levels were derived to be used as an analytical tool in the GIS software. Then, analysis of alternative road locations can be performed through the proposed methodology. This method should be included in the government policies and planning guidelines to achieve a compatible airport and land development.

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Chapter 1

Introduction

1.1 Overview

Transportation performs an essential role in our society. The progress of cities is historically linked with the existence of a transportation infrastructure designed to enhance intracity mobility and accessibility (Muller, 1986).

The evolution of cities point out that urban settlements have usually followed waterways, railways and roads, and are supported by the location of marine, air or ground transportation terminals. There is no doubt that development of such transportation infrastructure can shape urban form, a fact recognized long ago. When referring to the accessibility provided by transportation infrastructure Wingo (1961) states that "... there are vast, if invisible, changes which new facilities have induced in the processes of urban organization - new prime land made accessible for development, the older areas more acutely disadvantaged, the competitive opportunities redistributed".

The roadway is the primary guidance to urban shape and expansion. However, transportation and land-use planning fields, responsible for the use of land surrounding airports, have not adequately addressed the changes to land-use that result from the road's increase in accessibility near airports. New or extended roads in areas surrounding airports make changes in land development, possibly bringing people into those areas affected by aircraft noise. Airport planning field has only paid attention to the access system required for air passengers and other users to move to/from major centres of demand without considering

the effects of the road system location on land development and use changes. Figure 1.1 shows a Venn Diagram identifying the three planning fields and the problem area to be covered by this thesis research.

Figure 1.1 - Venn Diagram - Problem Area Identification

The literature, regulations and technical standards from these three planning fields have not considered, in-depth, the importance of road location near airports in land development from rural/agricultural to urban residential. This lack of depth and little amount of co-ordination among airport, roadway, and land-use planning has become seriously apparent in medium-sized cities where the airport is located in rural areas close to the urban fringes.

1.2 Problem Identification

Noise emitted by aircraft taking off and landing at runways is a major problem of airport operation and usually reaches large areas beyond its property limits.

To deal with aircraft noise impacts on airports' surroundings, Bishop and Horonjeff (1967) developed procedures to forecast noise exposure (Noise Exposure Forecast - NEF Method) which enable lines, also known as noise contours, to be drawn, identifying those affected areas on regional maps. This NEF method has been adopted in Canada, the USA and other countries to plan land-use in the vicinity of airports.

Planners have only relied on these NEF noise contour lines to plan and control an airport's compatible land-use and development. As a result, the primary tool for land-use planning around airports is a broad correlation between levels of exposure to aircraft noise and complaints. Further, it happens that this approach may not be effective because even after more than twenty years of implementing this so-called "airport land-use compatibility planning" in neighboring communities, the number of peoples' complaints against aviation noise has increased over time while the levels of aircraft noise emissions have been reduced.

The federal government's control-oriented guidelines for land use in the vicinity of airports (Transport Canada - first edition 1973 and seventh edition 1989) simply address airport externalities, particularly aircraft noise, by trying to restrain incompatible land-use (residential developments and housing projects) through regulation such as zoning limits, subdivision permits and building codes. No direction is given to prevent, obstruct, deflect or avert basic roadway development which will ultimately encourage unsuitable land development near airport property limits. Therefore, road development near the airport,

when planned and designed, should be analyzed not only in terms of accessibility to new areas but, also in terms of the land-use changes that may occur on its adjacent land affected by aviation noise. *Pro-active or action-oriented measures* such as guiding road location away from noisier areas near airports are needed (Feitelson, 1989).

The existing transportation and urban planning policies have a gap by not specifically considering the importance of road location near urban fringe airports and its cyclical interaction with land use and development.

Action-oriented or pro-active measures, particularly referring to road location, that start and guide the land development process have not been included in the Canadian federal and provincial government documents (Transport Canada 1989 and Ontario Ministry of Housing 1978). These *action-oriented or pro-active* measures involve prime government decisions that determine where a road or utility infrastructure should be located. Such action-oriented measures are essential to a rational land development process because they trigger other public secondary decisions like school, park, and street siting, as well as private decisions about residential, commercial, industrial and other developments (Chapin 1979 and Leung 1989).

However, despite their significance, no methodology or guideline has been located that allows transportation engineers and city/urban planners to give full consideration to the implication of aircraft noise on land-use change near airports when planning and designing roads in surrounding undeveloped areas. The associated problem that arises, then, is that the increased accessibility to undeveloped land, and pressure from landowners, developers and speculators to change the use of land, results in more people being exposed to aircraft noise.

This interaction process between road and land development takes place (usually over a 10 to 20 years period), allowing people to move in noisy areas. As a result of this population growth, more people get annoyed by aircraft noise and make complaints to authorities.

1.3 The Approach

This research work expanded the NEF concept to deal with aircraft noise in the context of land-use planning near airports. It focused on the importance of roadway location near airports, which encourages land development, peoples' decision to move into noisy areas and, consequently, increasing population density and peoples' reactions (complaints). This influence has been included as a conscious decision factor towards an anticipatory (action-oriented) approach to the airport land-use compatibility planning process.

Roadway location near airports should be carefully analyzed when passing through areas under great impact of aircraft noise. Its location should be avoided or diverted if it supports further detrimental population growth in adjacent corridors compromising the future people's well-being in these areas affected by aircraft noise.

A historical perspective of land development about the positioning and evolution over time from the city core to its urban/rural boundaries and airport location can show the dynamic interaction between the road system around airports and changes in population and land-use, and demonstrate the importance of an anticipatory view of the future. This factual analysis, supported by aerial photos and old maps, helps to better understand the relationships between road and land development near airports.

The NEF method is instrumental in providing a consistent procedure to identify the

noisy areas in airport surroundings, and to quantify the levels of exposure to aircraft noise.

In order to fully understand the contemporary evolution in land-use (population growth and density), peoples' exposure to aircraft noise (NEF noise levels), transportation infrastructure (distance to the nearest road location) and peoples' response to aircraft noise (complaints), a spatial analysis was carried out using Geographical Information System (GIS) mapping techniques.

Then, based on the variables quantified in this spatial analysis, mathematical models were developed to ascertain variations on noise complaints, population density and distance to the nearest road resulting from the dynamic interaction between road and land development around the airports. These functions were used, as an analytical tool, in the GIS-based road location method for areas around airports allowing a strategic long-term planning for roadway, in particular concerning with location/alignment analysis. Such a location method may also be applied to support planning activities regarding additional ground access required for the airport development and operation. The results obtained by adopting this GIS-based road location method for areas near an airport was also used to examine the effects of further extension of nearby road system presented in the official city plan.

1.4 Purpose and Scope of Research

1.4.1 Purpose

The long term effects of road location/alignment near airports situated in the urban fringes of medium-sized cities have not been adequately considered in the planning process. The literature review did not yield reports on specific methodology to help transportation and

urban planners to conveniently locate roadway in the early stages of land development around airports. As a result, this research was aimed at proposing and testing a method to be applied when planning roads in the airport surrounding areas, particularly to guide land development and to shape urban form in a way to cope with aircraft noise.

Then, this road location method for areas near airport, that considers the undesirable impacts of aircraft noise on people, can provide a technical tool to assist engineers and planners to analyze roadway development schemes for areas near urban fringe airports and to support the introduction of action-oriented approach in the official government documents as a complementary concept to produce a compatible airport land-use planning.

An application of this method was carried out in this research with data from the Regional Municipality Ottawa-Carleton (RMOC). The RMOC Official Plans presented in Appendix A (RMOC 1992) and Appendix B (RMOC 1994) show a clear example of the trend to plan, build and design ground transportation facilities on agricultural/vacant areas near airports without careful consideration of its effects on land-use changes, population density, and noise complaints.

Therefore, the basic purpose of this research was to establish a road location method near airports which addresses not only people's responses in terms of complaints toward aircraft noise, but also includes specific roadway and land-use conditions. It is proposed that such a method can be used to identify potential for unwelcome urban growth that adversely affects the airport development and operation since people's reactions to aircraft noise can bring pressures to implement night curfews and even closing the airport in the long run.

1.4.2 Scope

The huge urban sprawl phenomenon observed during the last half-century has been mainly caused by land speculation pressures from developers and land owners who took advantage of high population growth and internal migration rates, and supported by transportation "improvements" (infrastructure accessibility and car mobility). As a result, ground transportation infrastructure networks in major cities become very dense and also expanded, so that some cities become grouped together in large metropolitan regions. For these cities, little can be done in terms of implementing land use planning based on transportation *pro-active/action-oriented* measures, particularly related to new or extended road location since there are not large vacant lands. However, it is in the medium-sized cities (from 100,000 to 1,000,000 inhabitants) that an *action-oriented* approach, particularly regarding roadway location, has potential to be considered. These cities are still experiencing rapid growth and urban sprawl. They are usually economic centres creating opportunities for people who cannot be accommodated in the major metropolitan regions, to move from rural areas (Gilbert and Gugler, 1992). Medium-sized cities perform essential functions as producers of goods and services for their regions, and for export to other regions and abroad. On today's dynamic financial and trade markets with satellite communication, and modern air and ground transportation systems, distance does not restrain competition. Those medium-sized cities with economic diversification and improved income distribution represent an urban attraction for rural migrants outside traditional main metropolitan centres. These cities generally have a small spatial structure and are not yet fully developed, but their rapid growth will call for expansion of transportation infrastructure and utility services. Moreover, cities

with less than one million people usually do not have enough population density to make light or commuter-rail transit systems feasible and, thus rely on roadway modes of transportation (Warren, 1993). Indeed, land-use planning based on *action-oriented* measures, principally those involving government primary decisions about road/highway location, is best suited for application in these intermediate-size cities both in developed and developing countries.

The land-use planning implementation that is based on control-oriented measures to deal with aircraft noise around medium-sized city airports has not fully addressed the first stage of surrounding land development. At this stage, when airports are still located in rural areas close to urban edges, and adjacent land is in a process of conversion from rural to urban use, the location of new or extended roads is the most important factor to determine land development and use change.

In addition, the relative location of airport facilities, areas influenced by aircraft noise, ground transportation facilities, and areas to be developed need to be primarily identified in the land-use planning process taking into consideration possible alternative locations for road, utility and service systems.

Anticipatory/action-oriented measures that effectively deal with noise caused by construction and operation of transportation facilities, require a comprehensive analysis of the development phase (over time) and location (over space) of both transportation facilities and land-uses.

Noise is a spatial externality that has adverse effects over a limited area. The approaches/measures to deal with noise environmental problems can be identified in the transportation/land-use development process shown in Figure 1.2. There are four basic

measures that may be needed to deal with environmental problems depend on the stage of the transportation facility and land-use development process.

Figure 1.2 - Approaches to Environmental Problems in the Transportation - Land-Use Development

Source: Adapted from Feitelson, 1989.

The first quadrant in Figure 1.2 (top right) represents a situation where both transportation and land have reached almost full development. Transportation facilities exist and urban areas are built up. Management measures such as limiting or restricting hours/speeds/sizes of vehicular traffic are usually adopted to minimize noise problems. In the

second quadrant (top left) land has not been developed yet and transportation facilities are already constructed there. Hence, control measures such as zoning and subdivision permits must be placed to prevent noise-sensitive land-uses from being located too close to the transportation facility. This is what usually happens when airports already have a mature road network and an access system available for land development. Thus, zoning and subdivision permits, as a control-oriented measures, become a major land-use planning implementation approach to be used.

Quadrant four (bottom right), indicates that a basic nucleus of land development has started and more transportation facilities will be required in the near future to support new development. In this case, when a new road will extend into these already developed areas (sometimes close to the airport) design measures such as noise barriers, tunnels, and so on will be most appropriate to mitigate the effects of road traffic noise. In the case of undeveloped areas close to the airport that are affected by aircraft noise, no roads should be planned, designed or built to restrain any further development nearby.

It is in the third quadrant (bottom left) that the airport is at its initial development phase, since large pieces of undeveloped land in rural settings are not far from the demand generating centres, usually between 10 km and 30 km distance from the city core (see Table 1.1) and usually connected by a single road. With this scenario, a careful analysis needs to be carried out taking into consideration the airport development master plan, the identification of surrounding areas affected by aircraft noise, and the diversion of road (infrastructure) systems from noisy areas to avoid incompatible land development.

Table 1.1 - Time and Distance from City Core to Major Canadian Airports

City	Toronto	Vancouver	Dorval	Calgary	Ottawa	Winnipeg	Mirabel	Halifax
Distance	29 km	18 km	23 km	15 km	18 km	7 km	55 km	42 km
Time	30 min	40 min	25 min	45 min	30 min	20 min	60 min	30 min

Source: OAG Desktop Flight Guide - North American Edition - October 1991

The literature still needs to address the influence of the cyclical interaction of the transportation/land-use development process, in the context of areas surrounding airports, since airports are initially planned, designed and built in vacant areas under rural/farm use with no noise impact on people. Yet, as urban areas grow toward airport property limits, accessibility to nearby areas becomes essential, creating major arterial links. While the basic goal of these initial links is to provide air passengers with ground transportation corridors for easy access to/from city core and major demand centres, residential development starts taking advantage of cheap empty spaces with minimum additional transportation costs. Then, comes the pressure from land consumers, individuals and developers on local government to extend urban areas. At this point, residential development proposals are presented delineating minor arterial links and possible areas or block subdivisions. Once this cyclical interaction between transportation/land-use begins, preventive or *anticipatory/action-oriented* measures are no longer enough. After road access is provided to the land in the vicinity of airports, only *control-oriented measures* can deal with externalities such as aircraft noise.

This research focuses on the roadway location process in medium-sized cities around airports. The applicability of the action-oriented approach for land-use planning by means of the road location method was carried out for areas around Ottawa Macdonald-Cartier International Airport (OMCIA), in Ontario.

1.5 Research Goal and Objectives

1.5.1 Major Goal

Existing technical guidelines that support control-oriented measures (zoning by-laws, subdivision permits and building codes) for land-use in the vicinity of airports was assessed to identify its weaknesses and speculate on the implementation of a complementary strategy based on an action-oriented approach.

In order to implement this action-oriented approach and to achieve a broader strategic planning framework for areas near airports located in the urban fringes of medium-sized cities a road location method, that considers aircraft noise impacts in its surrounding, is required at the early stage of road-land development process. This method integrates the dynamic and cyclical interaction between road system, population density and airport operation.

Therefore, the major research goal is to develop a method which will provide decision makers with better information to analyze road location effects around airports. This method can be instrumental to include the complementary action-oriented approach in the existing guidelines for land-use in the vicinity of airports.

1.5.2 Research Objectives

In general, transportation and land-use researchers have addressed the demand and congestion aspects resulting from development and operation of specific transportation facilities due to land-use change effects. However, it appears that these researchers have not looked at further effects of new roads or extension of existing ones in areas already affected by other major facilities, such as an airport. This happens, in particular, when the airport site

is located in rural areas close to the urban fringes, when roadway influences land development, which increases accessibility, and which further encourages land-use change and higher population density, has not been placed into dynamic (spatial/temporal) perspective as a means of predicting, preventing and diverting incompatible kinds and levels of development.

The major research objectives are:

- a) to evaluate the relationship of ground transportation (road system) location to population density and land development around airports;
- b) to analyze the effects of aircraft noise levels and variation in population density (in areas near airports) on the levels of peoples' reactions in terms of complaints;
- c) to assess alternative locations for roads near airports based on aircraft noise contours; and
- d) to include action-oriented measures concerning road location the existing guidelines for land-use in the vicinity of airports in order to achieve a compatible airport land development.

This research has also proposed a planning framework that allows much more co-ordination and anticipatory strategic measures to be adopted in airport, road and land-use planning activities.

Major tasks carried out in this research work included:

- a) analyzing historical data of complaint activities around OMCLIA and linking these data with the evolution of population density and transportation infrastructure;
- b) evaluating constraints to airport expansion/enlargement and aircraft noise negative effects particularly associated with land development and urban/residential encroachment;
- c) identifying legislation and technical documents that need to be analyzed and addressing

specific concerns of the road-land development process in airport environs; and

d) demonstrating the opportunities to adopt action-oriented measures for land use planning implementation near airports in medium-size cities by means of the road location method.

1.6 Thesis Organization

This thesis is divided into seven chapters and several appendices. Chapter 1, a general introduction identifies the problem at the intersection of three planning fields - airport, road, and land-use. In Chapter 2, the planning background for these three fields and current approach deficiencies are discussed. A review of existing transportation and land-use models are included in Chapter 3, focusing on how they are not sensitive to the roadway location effects on land development along its corridor. Chapter 4 presents a formulation of the research problem including the action-oriented approach and the identification of variables taken into consideration by the proposed road location method near airports. The Noise Exposure Forecast (NEF) method, the proposed methodology, theory and mathematical modelling is presented and the work flow for development of the GIS-based road location method is also included. Chapter 5 describes the case study for the Regional Municipality Ottawa-Carleton, where empirical data were gathered and mathematical modelling work done, and the functional relationships among studied variables are defined. In Chapter 6, the method application is carried out using a GIS software package and forecasting data for year 2021 available from the RMOC official planning documents on access to roadway, population density and land use, and aircraft noise contours. This method application allowed an analysis of the proposed road developments in terms of location and effect on population density

increases and potential complaints. Chapter 7 presents a summary, conclusions and recommendations.

Chapter 2

The Planning Process

2.1 Introduction

The problem area in this research has been identified at the intersection of three planning fields - land-use, road and airport planning (shown in the Venn Diagram, Figure 1.1), which are involved in the planning process for areas near airports. This chapter introduces basic planning concepts and activities in these three fields focusing on the interactions observed among them in the airport surrounding settings.

The interaction of these three planning fields in the context of road and land development plays an essential role in the overall outcome of the planning process. This interaction will reflect upon many decisions that are taken over a long time-frame of the airport and road, which affect land development and use change in its surroundings.

However, in areas around airports, the boundaries for these three planning fields can not be clearly defined. They are intrinsically related and decisions taken in one field may irremediably affect the harmonic growth of the other. Thus, early planning coordination, long-term directions and trends should be considered by keeping an eye on the future so that further options are not foreclosed by current actions. This is a main deficiency in the areas around airports since there is no methodology that allow full integration of planning activities at the early stages of land development.

2.2 Land-Use Planning

Land-use planning is a mandate to local authorities to ensure harmonic growth and a high quality of life for the residents within city or county limits. In fact, land-use planning enlarges its scope as time goes on. It addresses health, safety, and environmental concerns as well as convenience related to time and distance between home, work, school, shopping, and other points of human activities.

In order to be effective, land-use planning, as indicated by Chapin and Kaiser (1979), should consider the three basic systems that influence urban spatial structure: human activity, land development, and environmental concerns.

The human activity systems involve all the interactions among people, firms and institutions in a day-to-day life. Its main agents are individuals carrying out household, firm, goods-producing and servicing activities as well as institutional activities such as education, health, recreational, public services (police, water, electricity, etc.), and other organizational groups (political, labour, social, etc.) .

Land development is the basic agent of converting or reconverting space to adapt it to the human activities identified above. It includes pre-development landowners (keeping the present state vs. selling or leasing) , developers (searching for land and opportunity for conversion), consumers (searching for space to attend activity needs), financial intermediaries (assessing risks/returns from land investments), and public agencies (reviewing and approving land-use and development proposals from public interest point of view).

The environmental systems refer to both biotic (plant and animal life) and abiotic (water, air, and matter) agents that support life on Earth. They include natural processes and

environmental effects that are fundamental to resource conservation and habitat preservation, as well as sustenance of human health and well-being.

The interactions among these three key systems is as relevant to land-use planning study as the order and relationship among physical elements and land uses.

The spatial arrangement of land-use planning's primary emphasis depends on physical conditions such as size, structure and specific features required by the activity to be performed, the land's surface and its subsurface natural characteristics (soils, geology, topography, vegetation, wildlife, hydrology and flood potential aspects).

Although there are many theoretical concepts for land-use planning, there are two types of decisions, as indicated by Chapin (1979), that "affect how space is adapted and put to use and how movement systems are established". Chapin points out that public-decision makers can influence land development by the selective priming decisions resulting "in patterns closer to desired forms than otherwise would be the case". But accuracy problems have arisen when land-use planning implementation is based solely on land-use control, a complex task which has its pitfalls. A population study carried out in 1920 by the Regional Planning Association of New York using data from the first two decades of this century reveal a high accuracy rate for the 1960 population projection to the total metropolitan area. However, it forecasted four to five million people in Brooklyn and 50,000 living in Long Island. These results underestimated the dispersion and spread of population that occurred in that period. There were two million people on Long Island, while the Brooklyn population declined (Dimitriou 1992). This is one indicator that the land-use control approach has not worked. It also suggests that there were not enough instruments to enforce land-use control.

Such disparity may have occurred in many other cities since interests behind the land-use and transportation planning process usually lie with private sector and politicians.

In general, pressure towards change in the land-use, from rural/agricultural to urban/residential, is directed at local governments, which then, may bring continuous urban growth toward airport property limits. This is seen more often in developing countries which experience high levels of population growth and migration flows from rural to urban areas, and less technical capability and political strength to counteract such a trend (Gilbert and Gugler 1992). As indicated by Van Kooten (1993), pressure to change the use of land stems from the profit of cheap prime land, which has become more accessible because of the construction or extension of roads. Such a scenario is often seen around airports, where the access "improvement" to previous vacant adjacent areas may become prejudicial by allowing further pressure for residential development towards noisier areas. As a result, the number of noise complaints increases.

A new approach to land-use implementation based on *anticipatory/action-oriented* measures is suggested by Leung (1989) and derived from Chapin and Kaiser's (1979) "priming decisions" strategy to influence land development. This research work aims to introduce such action-oriented approach in the land-use planning near airports which are more practical and feasible to be adopted in medium-sized cities.

2.3 Transportation Planning Process

The transportation planning process provides a rational framework adopted by governments around the world that brings together information required to address

transportation problems or issues. It starts with the problem/issue identification followed by formulation of goals and objectives. Next, alternative solutions are proposed and discussed, and then evaluated according to the benefits and costs of each one. Finally, the best solution based on the goals and objectives previously defined is recommended. The transportation planning process, therefore, provides information and analysis necessary for the decision-makers. Figure 2.1 shows this basic "rational framework" for transportation planning process.

Despite its simplicity, this framework has major flaws. As indicated by Altshuler (1979:13): "In general, it is highly misleading to think of societies and governments as having goals. ... It is far more useful to think of them as having an enormous number of values and a constantly shifting set of priorities among them. Public policies emerge from the interplay of objective conditions (reality), perceptions about the feasibility of altering some of these conditions (opportunity), and values for appraising the desirability of change (decision criteria)". He also later added that: "Viewed collectively, the objectives of public policy (in all their varying precision) are incredibly diverse and so weakly related as in some circumstances to seem directly at odds with one another. They are weighted in the context of actual budget and administrative practice but not in the framework of any comprehensive policy plan".

Figure 2.1 The basic "rational framework" for transportation planning process
Source: Meyer & Miller, 1984

The evolution of transportation systems results from many decisions based on different components over its life span. Major factors taken into account to enlarge or extend existing facilities, or to build new ones, are: increasing traffic capacity (flow) and safety standards, savings in energy consumption and travel time, socio-economic growth, and accessibility.

That basic "rational framework" has evolved to accommodate a growing number of data and analysis required for transportation planning. Figure 2.2 presents a more general framework for the urban transportation planning process based on major transportation studies carried out in Detroit (1953-55) and Chicago (1955-1961).

Figure 2.2 - General Framework for the Urban Transportation Planning Process
 Source: Adapted from Hutchinson (1974), Principles of Urban Transport System Planning

This broader framework has been adopted in other transportation studies world-wide with some modifications. Before going into the main four stages of this general framework, inventories of existing conditions providing information for the base year scenario must be prepared. These inventories covered data related to transportation facilities, land-uses and

travel patterns. The first stage analyzes the present conditions, then develops forecasts to visualize new scenario(s) with characteristics that take into account future changes of population, economic activity, and land-use. The next stage encompasses travel analysis and forecasts of trip characteristics and travel demand. Then, in the plan preparation (third) phase, the transportation system and land-use models are developed. The fourth stage tests trip characteristic models. An evaluation of the transportation system and verification of objectives and standards is done checked for consistency with the proposed solution.

Since an effective transportation planning process relies on existing and planned land-use patterns, the land-use forecast is an important piece of the transportation planning model puzzle. In fact, according to Dimitriou (1992) "sub-models of urban development analysis and forecasting associated with the urban transportation planning process are much less clearly defined". Much of the criticism about transportation planning has focused on increasing uncertainties of long-range forecasting, changes in community goals and values (particularly related to environment and natural resource use), and multiplying effects of multi-layer assumptions adopted in the planning process as well as change in human behaviour.

By reviewing the literature, as pointed out by Southworth and Owens (1993), it became clear that the form and evolution at the urban edge has not been discussed very often. They indicated that "driven by increasing mobility, steady economic expansion, an ample supply of relatively inexpensive land, and strong antiurban policies and ideology, suburban communities have grown from a few pockets of homes for wealthy aristocrats to the dominant form of American urbanism in less than one hundred years. By 1990, suburbs had

a clear majority of both population and jobs over core cities and rural areas combined". They also argued that the growth of the urban fringes have been guided by large real estate interests together with the fast emerging fields of city and transportation planning. Their criticism is toward blueprint development for the urban fringe, which are largely based on "the abstractions of magic marker" having often ignored "the overall experiential quality of the communities and neighborhoods it dictates". Because the urban fringes is being constantly created and developed, this ever-expanding area offers an unique opportunity to test and adopt innovative solutions which represent meaningful ways to achieve its sustainable development.

On the other hand, criticisms of the urban transportation planning process have lately arisen from changes in the transportation supply-demand equilibrium. By using transportation demand management (TDM) measures, the planning process has effectively reduced facility demand, facility supply or both. While these TDM measures may reflect on the needs for construction of new facility or postpone enlargement/extension of existing ones, their effectiveness is often limited to specific work trips and road segments, and they account for only one-fourth of all trips (Richard and Gordon 1989). The potential of TDM measures to reduce traffic congestion is uncertain at times, and future TDM policies should proceed with caution only after both the benefits and costs have been fully considered (Giuliano, 1992).

Still, the transportation planning process is quite popular, particularly highway planning, because road construction means a great number of job opportunities and investments. In fact, the new highways in major North American cities made it easier to commute in and out of the city core and support peoples' decisions to live in the surrounding

areas. However, route location was not taken into consideration except to serve some land developments, since the basic assumption was that local planning through official plans and regulations could control urbanization, even though this has not happened. But despite the planning process, highways pushed unintended and undesirable effects on to land-use, and social and environmental concerns were raised. As a result, great resistance against road extension and construction occurred in local communities. In addition, the economic recession in the 1980's, brought a booster for "no-build" options to alternative studies in transportation planning. Consequently planners shifted their emphasis to traffic/demand management and alleviation/mitigation of development impacts on road congestion.

However, after almost fifteen years with road infrastructure investment restrictions, urban growth, pushed by high internal migration rates, as well as increasing travel patterns supported by declining gasoline prices (50% from 1980 to 1992) have brought back congestion, especially in suburban areas, and have enhanced land development based on the roadway-centred model (Warren, 1993).

As indicated by Gakenheimer (1993), starting in the late 1980s transportation and urban planners realized that gentler actions have not succeeded, and therefore they returned "in desperation to land-use and transportation planning, but this time without generous expectations about the predicability of the land market and about the strength of local development control". He also mentioned that "this time even the states, despairing of keeping up with travel demand by building highways and of losing local popularity by trying, are stepping into land development and control, formerly the most exclusive prerogative of local government".

2.4 Interaction of Transportation/Land-Use

The complexity of transportation/land-use links is a consequence of the cyclical effects (Figure 2.3) that transportation has on land-use which generate opportunities for changes in human activities and perceptions, bringing impacts back on the transportation facilities.

Provision and location of transportation infrastructure, particularly roads, has been seen as an independent or isolated system identified by people's movement patterns according to demand studies. Its physical location concerning specific ground paths are usually defined by design techniques, terrain characteristics and intermediate socio-economical activity centres as well as environmental considerations. As pointed out by Leung (1989, 111): "Transportation planning has traditionally focused on highway systems without much coordination with planning of other modes of transportation, and still much less with the planning of land-use".

In particular, this lack of planning coordination has become serious in areas close to the urban fringes. Near urban boundaries road construction, enlargement and expansion has happened apparently without deep analysis of its future impacts. Even rural road improvements, particularly pavement, need to be very carefully analyzed when it is situated close to the urban edge. The effects of transportation infrastructure on urban fringes are greater in the long-range perspective, since those areas are usually the next available spaces for development purposes.

Figure 2.3 - The Land-Use Transportation Cycle
Source: Ashford 1989

However, when the transportation network system reaches maturity, its effects on surrounding area development are lessened and adjacent real estate, particularly residential, has had its value decline (Lenberger 1990). In addition, according to Lenberger (1990), with a mature transportation system in place, land-use planning and market processes become greater influences on urban form than transportation infrastructure investments. Finally Lenberger (1990) also mentioned that developers have been able to take economic advantage of public investment in recent years because the basic price of land on the urban fringe has been sufficiently low and the cost of transportation improvements still modestly priced.

Preserving farm or agricultural land-use in the face of urbanization requires a broader planning strategy. While the primary motivation behind farmland preservation is open-space preservation, Nelson (1992) indicates three other reasons. First, farmland near urban areas is needed for the production of specialty crops. Secondly, farmland provides certain public goods, such as flood absorption, air cleansing, and water filtration, and thirdly, farmland is open space protection and spatial definition to urban areas. However, Nelson does point out the economic effects of urbanization on farmland value. For example, government intervention, in the form of economic incentives and disincentives, can sometimes (unwittingly) cause greater inefficiencies such as underpriced urban facilities, highways, and tax incentives that attract people to larger homes on more land than they would have bought without the inducements. Farmland near urban areas, therefore, is likely to be overvalued for urban uses (residential and commercial developments) and undervalued for agricultural uses (farm business). As also mentioned by Nelson (1992), undervaluation of farmland is also caused when urban development imposes spillovers on less valuable for farming and more attractive for nearby farmland which reduce the productivity of farmland, thereby making it speculation.

The result of speculation encouraged by some public policies (roads and services) and by spillovers is that the productive use value of farm land declines, the closer it is to the urban development and the better it is the ground access system. In addition, Keene et al. (1975) and Currier (1978) describe an important aspect that takes place when farmland is facing, or in the proximity of urbanization. They call this an "impermanence syndrome" which is the belief among farmers that agriculture in their area has limited or no future because

urbanization will absorb the farm in the not-too-distant future. As a consequence, vast areas near urban fringes become underutilized and idle land just waiting for the increase in the raw land value which has been pushed up by speculation because of its conversion from rural/agricultural to urban/residential.

The rural/urban differential land values around urban fringe airports may also affect the implementation of compatible land-use planning based on control-oriented measures (zoning by-laws). As indicated by Van Kooten (1993:254), after a zoning ordinance or by-law has been passed, areas zoned as non-developmental, agricultural or rural will keep their market value or will lose some of it. On the other hand, land zoned as commercial, industrial or residential will be worth ten to twenty times more than its original value. Therefore, any land-use zoning limit changes would be an explicit opportunity for large financial profits. Van Kooten also suggested that costs involved with lawyer's fees, bribes and so on are generally much lower than the amount which can be gained through zoning limit changes.

Hanson (1992) suggests that public policies which brought in long-term subsidies for the automobile use directly through the funding of transportation infrastructure by taxpayer's money and indirectly through externalities and petroleum subsidies, have encouraged a sprawling pattern of urban and regional land-use. In fact, the construction of new roads or enlargement or extension of existing ones have focused on travel time, collision reductions, and construction cost analysis and ignored the consequences of the urban, suburban and rural reorganization. Therefore, public investments in transportation facilities may have potentially supported population density and land-use changes, bringing adverse effects to particular types of development.

2.5 Airport Planning

The Airport Master Plan, a component of urban/land-use/transport planning (see Figure 1.2) is prepared to guide an harmonic growth through balancing supply and demand between aviation activities and airport facilities. Its guidelines, set forth by federal agencies such as Transport Canada and the Federal Aviation Administration - FAA (1985), includes detailed studies of long-range development plans for a specific airport to prepare an airport master plan. The International Civil Aviation Organization (ICAO) has also published a manual called Annex 14 (1987), in which Part A refers to the Master Planning and Part B refers to Land-Use and Environmental Control. The airport master plan, then, comprises of the following basic elements which are briefly described:

- a) Inventory of existing conditions and issues;
- b) Aviation demand forecast;
- c) Requirements analysis and concepts development;
- d) Airport site selection;
- e) Environmental procedures and analysis;
- f) Simulation;
- g) Airport plans; and
- h) Plan implementation.

The inventory phase requires that all data needed to fully understand the conditions of existing facilities be collected including information on existing and projected land-uses as well as relevant legislative constraints related to bylaws, zoning, and building codes. Other essential data required deal with ground access, circulation, and parking.

Aviation demand forecasts are needed not only to develop growth scenarios over short-, medium- and long-range, but also to allow an analysis of the airport site's ultimate development. Another variable is the variation over time of aircraft fleet mixture, particularly in this coming decade when most of old noisier aircraft will be phased out by age and international regulation.

Requirement analysis and concept development is necessary to identify possible constraints relating to several of the airport development's components. A capacity analysis of existing runway configuration, the airport's primary component, and proposed expansions becomes essential to determine time frame accuracy for growth and major investments. The capacity analysis for a specific runway configuration determines practical capacity, for different periods of time - year, day and hour.

Airport ground access capacity analysis is also necessary to evaluate traffic demand and surface route capacity. However, since no analysis is required of existing or future locations of ground access in terms of possible effects on adjacent land-use changes, it should be considered in the master plan.

The airport site selection deals with the analysis in terms of distance from major demand centres for air transportation and aviation services, ground access to regional highway network, public transportation modes, and vacant land availability. The master plan needs to be consistent with area-wide planning on the airport's impact on land-use and its effects on transportation plans at local and regional levels. However, the master plan is not designed to consider compound effects on land-use changes caused by airport development and nearby ground transportation infrastructure, rather to deal with it in a compatible manner,

with minimum disturbance to the adjacent communities, assuring that enough land is assembled to the access system to meet future demand growth.

Aircraft noise impact is one of the most important environmental aspects involved in the airport master plan reaching areas far beyond airport boundaries. The Noise Exposure Forecast (NEF) method, developed by Bishop and Horonjeff (1967) is the main planning tool to deal with aircraft noise in areas around airports.

The NEF method takes into account cumulative aviation noise events based on factors such as duration of aircraft flyovers and discrete pure tones of various engines. This method produces an estimate of the total noise exposure from aircraft operations as a basic function of various types of aircraft, flight paths, and number of aircraft movements for different time periods. The NEF method can also compensate for the increased sensitivity of people to aircraft noise during the daytime (from 07:00 hr to 21:59 hr) and nighttime (from 22:00 hr to 06:59 hr) weighting the number of aircraft movements for each time period. Using the NEF method, a computer software called Integrated Noise Model (INM) developed by the FAA (1978) calculates aircraft noise levels expressing them in printout with noise contours to be applied to the land-use planning in the vicinity of airports. It is now in version 4.11 (1993), and has also been adopted by Transport Canada (1990).

2.6 Government Planning Guidelines and Policies

Aircraft noise problems have been so serious in the vicinity of world's airports that the International Civil Aviation Organization (ICAO) developed a manual Standards and Recommended Practices to deal with the control of aircraft engine emissions in December

1969. ICAO, in 1981, adopted a document called "Environmental Protection", as Annex 16 to the Convention on International Civil Aviation (Chicago, 1944), containing guidance material for use by States for "promoting uniformity in measurement of noise for monitoring purposes, use of an international noise exposure reference unit for land-use planning, and establishing of noise abatement procedures". Later, ICAO Resolution 28/3, adopted at the 28th Session of the ICAO Assembly (1990) included a paragraph that: "Urges the Council to promote and States to develop an integrated approach to the problem of aircraft noise, including land-use planning procedures around international airports, so that any residential, industrial or other land-use that might be adversely affected by aircraft noise is minimal".

2.6.1 Canadian Federal Policies

In Canada, local planners who are responsible for directing the nature of development of lands adjacent to airports are required comply with the Guidelines for Land-Use in the Vicinity of Airports (Transport Canada, 1989). This Guidelines cover a range of policies involved in the land development, use and control process around airports as follows: obstacle limitation surface; protection of telecommunication and electronic systems; bird hazards; aircraft noise; and restrictions to visibility. Appendix C presents Part IV (referring to aircraft noise) of the Guidelines which is discussed in this research.

Transport Canada (TC) functions in an advisory capacity related to land-use planning near airports. The exception to this is specific zoning regulations related to airport operations, mandated by law under the Aeronautics Act. TC is a circulated agency for land development applications under consideration by the local or regional municipalities, that is applications

for Official Plan Amendments, Rezoning, and Plans of Subdivisions or Condominiums. TC staff respond to these circulations by communicating concerns, if applicable, and recommended mitigative measures should the development application proceed to construction. Within the context of the municipal land-use planning approvals process, TC has positioned itself as a technical advisory body providing to the land-use decision makers preferred recommendations as opposed to firm requirements or appeals.

It is the position of Transport Canada that, subject to certain criteria, residential development may occur within the 30-35 NEF zone. However, as a result of high complaint activity, some municipal governments have instituted a "site specific" policy. This policy recommends against residential development within 30-35 NEF contour. This has been the case of the City of Brampton, Ontario which is located near to the Toronto Lester B. Pearson International Airport (LBPA).

Attention to aircraft noise, at the local government level, is generally paid when planning agencies are preparing or reviewing official plans in order to determine that planned, proposed or modified land-use zones around airports conform with federal guidelines. From an urban and transportation policy viewpoint, the aircraft noise problem around airports is a simple evaluation of the types of developments that meet specific set of land-uses according to the noise exposure forecasts (see Appendix C).

A review of transportation and land-use planning process in Ontario may be instructive in clarify the interplay among provincial, regional and municipal governments involved in the planning process.

2.6.2 Provincial and Municipal Participation

Various organizations regulate, administer and implement policies related to the land-use and transportation planning process. This section delineates a procedure to analyze the participation and influence of several key ministries and agencies involved in the planning and development process of lands adjacent to the airport. The area of focus is Ontario and Ottawa-Carleton in particular.

Provincial governments within Canada have been given the right to enact land-use planning legislation and regulations to conduct the orderly development of land with the exception of lands owned by the Federal Government.

In the Province of Ontario, several of its ministries regulate, administer and advise on land-use planning matters. Provincial policy on planning is expressed through statutes, the parent legislation being *The Planning Act 1983* as amended. Its purpose is to regulate and control development of land in a manner consistent with good planning principles.

Municipalities express their land-use planning and development intentions through official plans which provide guidance for the physical development of a municipality while conscious of relevant social, environmental and economic matters.

An Official Plan and its amendments must be approved by the Minister of Municipal Affairs or designated regional governments, although its implementation and daily administration is carried out by the municipality. Implementation is executed by municipal zoning bylaws, which prescribe specific land-uses and development standards. A proposal to develop or re-develop land must be consistent with the intent of the Official Plan and zoning bylaw, otherwise, an amendment is necessary.

Other planning controls exist so that development proceeds in an orderly fashion. Subdivision control, minor variances, site plan control and building permits are all mechanisms whereby municipalities can regulate development so that it is consistent with both provincial and municipal objectives.

2.6.3 Major Agencies Involved

Ontario Ministry of Municipal Affairs

The ministry charged with the administration of the planning process in Ontario is the Ministry of Municipal Affairs, which is responsible for carrying out The Planning Act 1983, as amended, specifically the protection of the Provincial interest as defined in Section 2. The ministry is also responsible for the circulation and final approval of all municipal land-use planning documents such as Official Plans, plans of subdivision/condominium, and consents.

To ensure the compatibility of airport operations and land-use, the Ministry of Housing (now the Ministry of Municipal Affairs) published in March 1978 a document entitled "Land-Use Policy Near Airports". Still in force, it directs which land-use will be permitted under what conditions. This document contains a land-use compatibility table relating land-use to noise exposure forecast levels to be included in the municipal official plans. Table 2.2 presents NEF levels and compatible land-uses recommended in the Ministry of Municipal Affairs (1978) document.

In general, this Ministry is in charge of co-ordinating the planning process in the province. According to the government structures, particularly in North America, similar government branches dealing with land development and planning under different departments

such as Ministry of Housing or Ministry of Provincial Development should be identified and their activities and attributions defined before preceding with the proposed planning methodology.

Table 2.1 NEF Land-Use Compatibility Table

Land-Uses ¹	Noise Exposure Forecast Value (NEF)			
	0	28 30	35	40
Group I residential, passive use park, school, library, church, theatre, auditorium, hospital, nursing home, camping or picnic area.	In this range noise is not usually a problem	Discretionary Range All buildings must conform with Acoustic Design Some annoyance will occur in this range but residential development will be acceptable if approved by the municipality ²		No new Group I uses may be established in this range, except those for which the outdoor environment is irrelevant and which meet the Acoustic Design Criteria ³
Group II hotel, motel, retail or service commercial, office, athletic field, playground, stadium, outdoor, swimming pool.	In this range noise is not usually a problem	Discretionary Range The characteristics of each proposed use must be studied and appropriate noise insulation must be incorporated into building design ³		
Group III industrial, warehouse, arena, general agriculture, animal breeding ⁴	In this range is not usually a serious problem		Discretionary Range Most Group III uses are permissible in this range, provided ancillary uses are adequated ³	

Source: Ministry of Housing, "Land-Use Policy Near Airports", March 1978.

¹ Uses not specifically mentioned should be compared to the uses listed, classified in the most appropriate Group and regulated accordingly.

² For residential uses, refer to "New Housing and Airport Noise", N.H.A. 5185-1:78 and any amendments thereto. The developer of a residential project must undertake to inform prospective tenants or purchasers of the possible noise problems.

³ For non-residential uses, refer to the Acoustic Design Criteria.

⁴ Research has shown that animals become conditioned to high noise levels. However, fur farms, and any use likely to create a bird hazard, such as feed lot or stockyard should not be located closer than recommended by Transport Canada in "Land-Use in the Vicinity of Airports".

Ontario Ministry of the Environment

The Ontario Ministry of the Environment (MOE) is charged under several statutes to achieve and maintain quality of the environment, including air, water, and land that will protect human health and the ecosystem, and which will contribute to the well being of the province's population.

Since noise is considered a form of environmental pollution, the MOE monitors and comments on any development application that may be adversely affected from a generator of noise. The Ministry's role in mitigating noise from airport operations is a circulating agency where it comments on development applications it receives, deferring to the policies contained in the Ministry of Housing (now the Ministry of Municipal Affairs) document 'Land-use Policy Near Airports'.

Although the Ministry of Housing's documents provide for residential development within the 30-35 NEF zone, the official position of the MOE is to allow residential development only up to the 30 NEF contour. In conducting the assessment of development applications, the Ministry refers to a set of draft "implementation guidelines" which acts as a detailed reference manual for staff when considering development applications. According to MOE officials, these guidelines have not been officially recognized in legislation and/or regulation.

The MOE has indicated that these implementation guidelines have had success before appellant boards such as the Ontario Municipal Board and the courts. Although MOE staff advocate and recommend no residential development beyond the 30 NEF contour zone, exceptions are made subject to the following qualifications:

- future owners and/or tenants must be made aware through the Agreement of Purchase and Sale of potential noise problems from airport operations;
- an acoustical study must be carried out by a qualified engineer to determine whether the proposed development (and future residents) would be adversely impacted from airport operations. In some circumstances, the actual noise impact on the ground may not be the same as that which is delineated on the Transport Canada NEF maps because geographical characteristics of the land may provide attenuation of sound to a greater or lesser extent than recognized by the NEF method and expressed in the noise contours; and
- building design and construction conform to the Canada Mortgage and Housing Corporation (CMHC) design standards for residential housing.

Regional Municipality Ottawa-Carleton

The Regional Municipality of Ottawa-Carleton (RMOC) is a regional level government responsible for co-ordinating policies, programs and projects designed to ensure that the RMOC remains environmentally sound and economically attractive as it grows. The RMOC consists of eleven municipalities: Ottawa, Vanier, Rockcliffe, Cumberland, Kanata, Gloucester, Nepean, West Carleton, Goulbourn, Rideau and Osgoode. The RMOC activities concentrate on:

- population and urban growth;
- population intensification;
- garbage;

- environment; and
- infrastructure servicing (transportation, water, and sewer).

The regional government has already initiated several studies to provide strategic information regarding planning and development issues to the year 2021. Among the most recent planning documents presenting information and related comparisons of development trends and focus concepts for future growth available are: Demographic-Economic Facts (1993), Ottawa-Carleton's Community Vision (1995), Transportation Vision - Principles and Issues (1995), and How Should We Grow ? (1995). These documents intend to be a basis for informed debate regarding the most appropriate future distributions and densities of urban development in the RMOC, and subsequent planning and development policies.

The regional and local municipal levels of government are the decision-making tiers where land-use plans, plans of subdivisions and zoning by-laws are approved. While the province plays a crucial role with some approvals, the RMOC government provides many of the approvals which determine the direction, form, scale and type of land-use using the Official Plan. It is a general policy instrument that a council passes in order to guide, among other things, the timing, form and conditions of land development within the boundaries of the Plan. Beyond the Official Plan, municipalities have mechanisms for implementing the policies of the Regional Official Plan such as subdivision approval process and building permit process.

Canada Mortgage and Housing Corporation

The Canada Mortgage and Housing Corporation (CMHC) is a Federal Crown Corporation without a mandate to regulate or control land-use decisions, although it has produced advisory documents which provide technical and policy advice to provincial and municipal levels of government, as well as to the private home building industry. One such document relating to land use near airports is "New Housing and Airport Noise". First published in 1976, this building advisory document provides detailed criteria and standards relating to the construction of new homes affected by varying levels of noise. In particular, for the NEF value affecting a site, the document provides precise standards relating to:

- overall acoustical insulation factors;
- window types;
- exterior wall construction;
- ceiling and roof combinations;
- exterior door types; and
- related floor area to building component area.

This document is commonly used by local planning and development approval authorities in conjunction with the Ontario Ministry of Housing document "Land-Use Policy Near Airports".

The CMHC also provides financing for social housing (such as public, non-profit and co-operative housing projects). Accordingly, the CMHC has employed the following standards relating to the projects it funds:

- where NEF values are greater than 35, social housing projects shall be

denied financing under the National Housing Act;

- where NEF values are between 30 and 35 inclusive, social housing projects should be denied financing under the National Housing Act unless adequate insulation is provided;

- where NEF values are 28 and 30, social housing projects shall be denied under the National Housing Act where the proposed sound insulation is substantively below that considered to be adequate; and

- where NEF values are between 25 and 27, the provision of adequate sound insulation is recommended.

2.6.4 Interpretation of Land-Use Policies Near Airports

The interpretation of the land-use policies applied to airport surroundings in Ontario make it clear that sound insulation is recommended to deal with aircraft noise starting at the 25 NEF value. In addition, it is expected that noise exposure levels up to 30 NEF value can be reduced to allow indoor activities by installing more strict sound insulation specifications.

However, the sound insulation specification and recommendation from the 25 NEF value and higher does not guarantee that:

- 1) The insulation required for houses to be built under these levels of noise exposure will be done according to its specification or done at all, after the site development have been approved and owner has accepted to bargain price by reducing such insulation specification;

- 2) The people moving in these houses will keep windows closed, particularly in the

summer months without getting fresh air or enjoying outdoors activities; and

3) The levels of noise exposure for certain peak periods of airport operation which usually occur in the morning and late afternoon hours during the spring and summer time will not be greater than the NEF forecasted values.

Therefore, even with all existing recommendations from land-use policies for areas in the vicinity of airports, feelings of annoyance and disturbance of activities could result in complaints from people living in these areas.

Finally, a combination of important factors that serves to facilitate land development regarding infrastructure (road and utility services) has not received specific consideration. At the forefront of any residential development efforts has to be the availability of roadway capable of accommodating and supporting these projects. Moreover, in-ground services such municipal water and sewer trunks usually follow road corridors allowing higher population densities

2.7 Deficiencies in the Current Planning Process

The adoption of compatible land-use planning for airport surroundings evolved under close government direction. The primary responsibility for integrating noise aspects into the planning process, then, rests with local governments which also have exclusive control over actual land-use and future land development. Airport land-use compatible planning implemented by local government authorities, based on zoning limits, subdivision permits and building codes, known as *control-oriented* approach, has followed the recommendations

included in the Transport Canada (1989) guidelines for land-use planning around airports.

From a theoretical stand point, these guidelines should work well if land-use planning was set up by the municipal councils based on noise contour forecasts, and implemented by its agencies and officials adopting control techniques such as: zoning by-laws, subdivision permits, etc. However, interviews with senior officials at Transport Canada - Airports, in March 1995, revealed local agencies have had problems enforcing such guidelines, resulting in incompatible development of areas affected by aircraft noise. Nation-wide adoption of such guidelines has been blamed for flaws, observed in its pragmatical application and results, since it disregards a variety of factors (land ownership, development pattern, housing demand, etc.). Implementing compatible land-use planning based on *control-oriented* approach may become even more difficult because of political pressure to permit land development and urban expansion towards the airport when these areas have already had a new or extended road added to the existing access system, or will have it soon.

In addition, existing planning activities in the vicinity of airports, shown in Figure 2.4 identified in documents such as the Airport Master Plan, City/Regional Official Plan, and Transportation Infrastructure Plan have overlooked important interrelated links represented by dashed arrows. These documents have, as a basic objective, the responsibility to guide a harmonic growth of human socio-economic activities minimizing conflicts and complaints for the sake of people's well being.

Figure 2.4 Existing Planning Activities in the Vicinity of Airports

The airport planning activities do not consider the land-use influence of the access system required for its operation. These roads, by improving site accessibility, will encourage land-use change, bringing further pressure for development and increase population density in areas affected by aircraft noise. Conversely, land-use planning activities near airports have not considered how improving specific site accessibility (through road construction) will affect land development in areas delineated by the noise contour lines. As well, transportation planners have not considered all the consequences of land-use changes when locating roads near airports. The high rates of population growth in these noisy areas have contributed to an increase in the number of complaints, which works against the basic objective of the Airport Master Plan and the Land-Use Planning Near Airports to minimize complaints.

In addition, Figure 2.5 presents the essential missing factors in the two documents that foster land development and use change. The airport planning activities do not consider the influence of the facility's size and location on the future access system required for its operation. These roads, by improving accessibility, will encourage land-use change, bringing further pressure for development and increase population density in noise sensitive areas.

Figure 2.5 Missing Factors and Links in the Planning Activities.

Conclusion

Criticism of land-use planning implemented based on control-oriented approach using NEF noise contour lines to define land-use boundaries and zoning control regulations has arisen because of conflicts among various interest groups involving: (a) developers, speculators, builders, and lenders who wish to keep control over land-use and to make as much profit as possible; (b) green movement groups fighting for environmental protection, ecosystem preservation and endangered species habitat; and (c) community and other association groups concerned with local and regional quality of life, and the health and well-being of individuals.

The use of land near airports is a fundamental factor in the way people perceive the overall impact of airports. An efficient location for road network in airport surroundings can ease development pressures from interested groups. This research examined the land-use planning guidelines and their results until now to bring up a complementary approach to the land-use policy near airports. An action-oriented approach to guide road location and land-use at the early development stages, should be included into the existing planning and policy documents. This research is timely because policies/guidelines have already been implemented for more than twenty years on the national level and regulations/techniques established by provincial and municipal governments.

Chapter 3

Review of Land-Use and Transportation Models

3.1 Introduction

The review of land-use and transportation models explores existing models in search of previous research that may have already addressed the interactions between land-use and transportation near airports. This chapter presents state - of - the - art land-use and transportation models with a brief review of some of the well-known models. It identifies the way the models were developed as well as their weaknesses and major contributions to the urban planning process. Particular attention is paid to ascertaining if existing models are able to take into consideration roadway location effects over adjacent areas when analyzing development in specific site conditions. Finally, GIS modelling techniques that could be applied in this research are discussed.

Land-use and transportation models have been developed since the 1960s as major tools for urban planning based on a rational paradigm. These models have become more sophisticated, with the ambitious desire to understand and express the complex mechanisms of urban development and, consequently to forecast and control the future of cities.

In recent years, the land-use/transportation models have taken a more humble posture towards planning, turning into an incremental view. This recent trend occurred because of criticism that these models have failed to reproduce major changes in urban and transportation developments (Lee, 1973 and 1994).

Land-use and transportation can be modelled at both aggregated or disaggregated levels. There are several urban models with different degrees of comprehensiveness and sophistication that have been used in cities around the world for various purposes. This chapter reviews specific models which integrate at least two basic processes of spatial urban development - urban land-use (residential, commercial and industrial), and transportation.

3.2 Lowry Model Overview

Most of the urban transportation models are based on the traditional Lowry Model (Lowry, 1964). The Lowry model for the residence-location component assumed that the greater the trip length (distance, time or cost) the smaller the propensity for trip making. Thus, to express such behavior Lowry adopted a negative power function:

$$p_{ij} = d_{ij}^{-1.330} \quad (d_{ij} \geq 1.0) \quad \dots(3.1)$$

where: p_{ij} is the probability of a trip being taken between zones i and j ; and

d_{ij} is the distance between zones i and j .

The residence-location model used by Lowry had a simple formulation:

$$N_i = g \sum_j E_j p_{ij} \quad \dots(3.2)$$

where: N_i is the number of persons living in zone i ;

p_{ij} is the probability of a trip being taken between zones i and j ;

E_j is the number of employees working in zone j ; and

g is a scaling factor.

By substituting the probability of a trip being taken for distance between zones a Lowry model general formulation can be expressed as:

$$N_i = g \sum_j E_j d_{ij}^{-1.330} \quad \dots(3.3)$$

The Lowry model showed that there is an impedance associated with trip length (distance, time, or costs) which determines a person's willingness to make a trip, and consequently defines the residence location choice. However, the Lowry model does not distinguish between activities (population and employment) and availability of physical elements (housing and workplaces). Therefore, it lacks in terms of modelling land use.

3.3 Description of the Integrated Land-Use and Transportation Models

Existing urban transportation models are considered to be more comprehensive since they address at least the two basic subsystems - land-use and transportation infrastructure network. Wegener (1994) has reviewed the current state-of-the-art of "integrated" urban models which helps to understand its actual development stage.

3.3.1 Urban Subsystems

The two basic subsystems of the urban models are the network and the land-use. These subsystems constitute a permanent physical structure of cities. Large infrastructure projects require a decade to be put in place and are continually extended, and expanded, while the arrangement of land-use is steady and is incrementally modified and expanded over time.

Another essential urban subsystem, related to the workplace, is comprised of building elements that house factories, commercial stores, shopping centres, warehouses, and schools,

and have a much longer lifetime span than the firms and institutions that occupy them. These important elements of the urban fabric may be changed by planning and policy instruments to redirect urban and transportation growth.

Employment and population subsystems can be located or relocated responding to the available markets and technologies. Housing consumption and location depends on people's need (employment, shopping and leisure) and land-space opportunities. Goods transport and travel demand are adjusted according of fluctuating population and market conditions.

Yet a more complex and important subsystem outlying all the others concerns the urban environment which is composed of direct and immediate impacts of human activities such as transportation noise and air pollution coming from goods transport, people travel, workplaces and housing subsystems. There are other negative environmental effects on the water, soils and climate that occur on a prolonged basis. Figure 3.1 shows linkages among subsystem in the urban models.

3.3.2 Comprehensiveness and Structure of Urban Transportation Models

When examining urban models, it becomes clear that almost all of them do not fully cover the entire set of urban subsystems. They also vary in terms of structure, theoretical background, modelling, time-space components, data requirements, calibration and validation. The structure can be classified in two groups: unified and composite. The first can be identified by a search for a unifying principle that models and connects all subsystems. The second type looks at the urban system as an hierarchical structure composed of independent subsystems. As a result, model structures can be very integrated or comprised of different

submodels, each with different internal structure.

Figure 3.1 Urban Subsystems of Land-Use - Transportation Models
Source: Wegener, Michael. "Operational Urban Models - State-of-the-Art". Journal of the American Planning Association, 1994.

The Projective Optimization Land-Use Information System (POLIS) is a model developed by Prastacos for the Association for the Bay Area Governments in San Francisco, California, USA (Prastacos 1986). It is a programming formulation in the Lowry Model

(Lowry 1964) which incorporated random utility and location of basic employment.

The California Urban Futures Model (CUFM) developed in California by Landis (1992 and 1993) at the University of California, Berkeley is a disaggregate model of housing development based on the rule-basis activity location, and one of the first urban models to use geographical information system (GIS).

Kim (1989) developed a model that took his name, at the University of Illinois, which combines in equilibrium, models of transportation and location for the Chicago region and incorporates goods movements.

The Integrated Transportation and Land-Use Package (ITLUP) developed at the University of Pennsylvania by Putman (1983 and 1991) was also derived from an adaptation of the Lowry modelling framework. This model has been improved, calibrated and used in urban planning across the United States over the years.

HUDS - Harvard Urban Development Simulation Model (Kain and Agpar, 1985) was the first large scale urban simulation model to utilize micro simulation techniques.

Leeds Integrated Land-Use/Transport (LILT) model is a Lowry-type model originally developed for the Leeds Region (Mackett 1983) and later updated by incorporating urban micro simulation techniques (Mackett 1990).

Marcial Echenique & Planners (1990), developed the MEPLAN model to integrate urban-regional modelling in a package with models built on a generalization of multi-regional input-output techniques. This model and some of its derivatives have been applied in Greater London, and regions in Italy, Spain and South America.

IRPUD, an hierarchical model of urban housing and land markets, transportation and

land-use was developed by Wegener (1985 and 1986) at the Institute of Spatial Planning of the University of Dortmund, in German.

Table 3.1 summarizes existing urban models with their particular characteristics according to the subsystems, structure, theory, policy/planning modelled.

Table 3.1 Summary of Transportation/Land-Use Models

Model	Subsystem	Structure	Theory	Planning/Policy Modelled
POLIS	Employment, Population, Housing Land-Use, and Travel	Composite	Random Utility Locational Surplus	Land-Use Regulations Transportation Improvements
CUFM	Population Land-Use	Composite	Location Rule	Land-Use Regulations, Environmental Policies, Public Facilities, and Transportation Improvements
KIM	Employment, Population, Networks, Goods Transport, and Travel	Unified	Random Utility, Bid-Rent, General Equilibrium, and Input-Output	Transportation Improvements
ITLUP	Employment, Population, Land-Use, Networks, and Travel	Composite	Random Utility and Network Equilibrium	Land-Use Regulations and Transportation Improvements
HUDS	Employment, Population, and Housing	Composite	Bid-Rent	Housing Programs
LILT	All subsystems except Goods Transport	Composite	Random Utility, Network and Land-Use Equilibrium	Land-Use Regulations, Transportation Improvements, and Transportation-Cost Changes
MEPLAN	All subsystems	Composite	Random Utility, Network and Land-Use Equilibrium	Land-Use Regulations, Transportation Improvements, and Transportation-Cost Changes
IRPUD	All subsystem except Goods Transport	Composite	Random Utility, Network and Land-Use Equilibrium	Land-Use Regulations, Housing Programs, Transportation Improvements, and Transportation-Cost Changes

Source: Adapted from Wegener, Michael. "Operational Urban Models - State of the Art". Journal of the American Planning Association, page 23, 1994.

Only MEPLAN encompasses all urban subsystems, while LILT and IRPUD address all subsystem except goods transport. KIM has a housing supply submodel but does not consider non-residential buildings, and only HUDS, LILT and IRPUD models include specific

submodels for demographic change and household formation.

The theoretical basis for almost all of these models counts on the random utility theory to rationalize and predict the behavior of urban actors such as investors, households, firms and travellers. It supports definition of choices between alternatives under uncertainty or lack of information. The multinomial logit model, based on the random utility maximization (Anas, 1983) and the entropy-maximizing model (Wilson, 1967), are equivalent at the same levels of aggregation. However, there are profound differences between the theory applied to the urban models. In general, models with transportation submodels use random utility or entropy theory for modelling destination and mode choice.

3.3.3 Critical Analysis and Prospects of the Urban Models

The review of urban models indicates that they have major problems related to data collection since they are “data-hungry”, and lack reliable and efficient techniques for calibrating their parameters, particularly when looking into the far future. As pointed out by Lee (1994) very few validation reports on these models exist.

Two of the most successful models, MEPLAN and IRPUD, are not statistically calibrated. They only use a fine manual tuning in a long interactive process. Another aspect of concern noted by Putman (1991), is that urban land-use and transportation models require informed users from the beginning of its development to the end, since any input change in one zone may need adjustments of several variables as well as consideration of the region-wide impacts which affect the residence-location decision.

In this research, the CUFM model deserves special attention because it is one of the

first urban models to use geographical information system (GIS) technology without relying on the random utility theory. This is a disaggregate activity location model that uses detailed land information in map form generated by GIS without considering the transportation networks. It also does not apply an equilibrium stage and deals only with two subsystems - population and land-use.

As noted by Wegener (1994) potential benefits to urban models are related to GIS developments. He realized that "GIS have so far contributed surprisingly little to the methodological innovation in urban analysis". He brings a conjecture that micro simulation may have a certain affinity to the way spatially disaggregate microdata are stored as point coverages in GIS. He concludes by stating that "in the past urban models have been mainly applied to a very narrow set of planning problems, and have failed to adapt to changing perceptions of problems. In particular, models should be made more sensitive to issues of equity and of environmental sustainability".

3.4 Other Models

3.4.1 Disaggregate Residential Allocation Model (DRAM)

The residence-location models like DRAM and ITLUP (Integrated Transportation Land-Use Package) are centred on the work-trip (home-to-work or work-to-home) or a combination of the work-trip with measures of attractiveness of potential residence locations. There is an implicit set of work-trip estimates in any estimate of residence locations made by these models, but those work-trips were made explicit by extracting them from the model directly, and were later used to load the transportation network. That perspective of the

residence-location process considered the entropy-maximizing approach to analysis of these models. Based on this approach the Lowry model may be written as:

$$T_{ij} = E_j f(c_{ij}) \quad \dots(3.4)$$

where: T_{ij} is the number of persons (tripmakers) working in zone j and residing in zone i;

E_j is the number of persons working in zone j; and

c_{ij} is the impedance usually distance, time or cost between centroids of zone i and j.

In the original Lowry formulation there was a problem because there was no existence of constraints on the sums of trips. Therefore, without such constraints one could not expect that

$$\sum_i T_{ij} = E_j \quad \dots(3.5)$$

This expression considers that the total number of employees in zone j would be equal to the sum of employees who live in zone i and work in zone j.

By following entropy-maximizing principles, a residence-location can now be derived:

$$T_{ij} = A_i B_j O_i E_j f(c_{ij}) \quad \dots(3.6)$$

where: T_{ij} is the number of trips between zones i and j (or the number of persons living in zone i and working in zone j);

O_i is the number of trip origins (or employed persons resident) in zone i;

E_j is the number of trip destinations (or employees working) in zone j;

A_i is a balancing factor for trip origins;

B_j is a balance factor for trip destinations; and

$f(c_{ij})$ is a trip (impedance) function.

The DRAM formulation makes its generation of trips more explicit, although it still requires the conversion of trip probabilities to vehicle trips. An infrastructure network is assigned to verify the effectiveness of its operation, and an algorithm for multipath assignment is also developed, along with a modal split procedure, used to allow a preliminary calibration.

Despite recognizing the noticeable gap between transportation and location theory, and the empirical evidence necessary to support, Putman (1991) performed some sensitivity tests of the response of the model to variations in input data for 108 zone system of Minneapolis-St. Paul, Minnesota. One of the interesting results was a change in accessibility to an urban fringe zone because of improved access which, consequently, decreased its overall impedance to the rest of the region by 20%. The model results showed a 68% increase in the total number of households and an 8% increase in total employment. By this example, it is possible to ascertain the importance of access improvement to the zones located close to the urban edge. However, DRAM can not physically distinguish among different alternatives for road location or alignment when connecting two zones' centroids.

3.4.2 EMME2 Model

The EMME2 model, first released in 1984, was developed in Montreal by INRO Consultants Inc. and its latest version, number 6, was released in 1992. This is a multi-mode transportation planning system designed for interactive-graphic use.

Its general framework is designed for implementing a wide variety of travel demand, forecasting model ranging from simple road or transit assignments or the classical four step models (trip generation, trip distribution, modal choice, and traffic assignment) to the

implementation of multimodal equilibration procedures that integrate demand functions directly into the assignment procedures.

The EMME2 model provides tools for comparison of future scenarios which may reflect changes in the road and transit network or changes in the socio-economic characteristics of the urban area. The three main data categories in the EMME2 include: Networks, Matrices and Functions. Auxiliary categories of data can be also entered as Demarcation Lines - to identify geographical references, and Log Book - to keep track of the EMME2 modules.

The transportation infrastructure that spans the region studied is represented by a multimodal network, depicted by nodes, base network, transit vehicles, transit lines and turn penalties. The base network is defined by the list of all nodes and all links between those nodes, used by any of the modes.

The user may specify up to three additional data elements for each node, link, turn penalty, transit line and segment, and also has the possibility to define the four types of extra optional attributes available: node, link, transit line and transit segment.

The results, then, are a special type of data that become available only after an assignment related to the network has been done. These results are the link between auto volumes and travel times (after an auto assignment) and the transit volumes, travel times, boardings and alightings (after a transit assignment). Each complete network data set (modes, base network, transit vehicles, turn penalties, transit lines and assignment results when available) makes up a scenario where a base year is one of these scenarios (EMME2 User's Manual).

The matrices that are handled in EMME2 may be full matrices, origin destination vectors or scalars. These matrices may contain various socio-economic data related to the zone subdivision of the urban area studied, such as origin-destination demand matrices, origin-destination travel times by mode. A matrix may be both an input or an output in the computational procedure.

All the functions that are used in EMME2 such as volume-delay functions, transit/auto travel-time relationships, turn penalties and demand functions are specified by the user as algebraic expressions.

The traffic assignment procedure provided by EMME2 is a vine-building assignment method with fixed or variable demand. Many application specific path and link attributes or link to link subarea matrices may be computed in addition to the usual assignment results.

In terms of results, EMME2 main feature is an interactive comparison of scenarios with accompanying graphical display. This comparison of scenarios is mainly related to link flows, origin-destination demand and service levels.

The EMME2 model has been used in the Regional Municipality Ottawa-Carleton as a basic software for transportation planning. As it has already been the case with previous models, EMME2 also does not produce road (link) location as an output (see Appendix D). The network (transportation infrastructure) is considered an input to the EMME2 model.

Conclusion

In general, the EMME2, DRAM and other integrated models were designed to analyze and forecast urban system, and to be implemented based on a computer modelling.

They integrated in a comprehensive manner at least two (land use and transportation) basic essential processes of spatial urban development. However, they have not addressed the location effects of a specific link (roadway infrastructure), particularly in a microregion scenario under conditions associated with undeveloped land of rural areas near urban fringe airports.

3.5 Unsuitability of Land-Use and Transportation Models

The land-use and transportation models were developed to deal with trips and land use in terms of balancing and analyzing the effects of differential growth in land-use and transportation over existing links. Of course, links can be added to the network, and that is particularly what happens at the urban/rural fringes. However, these models are not location-sensitive to forecast their effects along a pathway. On the other hand, the links contained in these models as input and output are usually straight lines that have time/ distance, capacity and demand values associated with them, but proposed links sometimes do not follow any strict path because of particular terrain physical and environmental characteristics. Thus, despite being useful to ascertain levels of traffic, and transportation demand and supply generated/needed by levels of population and employment in a particular zone, they are unable to determine the dispersion effects within that zone. Therefore, the existing land-use and transportation models are not suitable for the planning and design of roads, particularly their location, in vacant land near urban fringe airports.

Chapter 4

Formulation of the Research Problem

4.1 Introduction

The approach for dealing with aircraft noise has generally been followed in two ways: firstly mitigating or reducing noise emissions at the source (aircraft), and secondly driving noise-sensitive land-uses away from the airport by means of zoning nearby areas and controlling its development. This latter method relies on control-oriented measures for land-use planning and development in its surrounding areas.

According to the Guidelines for Land-Use in the Vicinity of Airports (Transport Canada 1989 and Ontario Ministry of Housing 1978), putting zoning considerations into the land-use planning process has been to encourage development that is compatible with various airport and aircraft operational requirements and impacts. In practice, this has often not been the case in areas around airports since pressure has come from land development agents - landowners, developers, consumers, and financial institutions to allow incompatible development, particularly residential. That occurs because of airport's locations, usually on the fringe of urban areas. Moreover, airports sit on almost perfect natural terrain conditions (soil, geology, topography, hydrology and low flood potential), and also boast good ground transportation facilities.

Aircraft noise impacts on surrounding areas are a spatial externality problem to which the most common solution is the definition of a spatial separation for human activities and

their corresponding land-use. The spatial factor between the airport facilities (runways, taxiway, and aprons) and sensitive land-uses, therefore, become the most important relationship to be considered. As the relative location of these facilities and land-uses are determined by official plans, the range of opportunities to influence this relationship needs to be identified and updated during the planning process.

The flexibility of locations for land-use planning around airports obviously decreases over time as the availability of vacant/undeveloped land shrinks and urban built-up areas grow towards the airport. This availability is directly related to the existence of ground access facilities such as highways and roads, and as the transportation corridors expand over time and the accessibility to further undeveloped land increases, it becomes feasible to develop more land.

4.2 Transportation and Land Development

Modern transportation facilities require large pieces of land. They have also recently been recognized as an important factor affecting the quality of the environment; many consequences of environmental degradation have been associated with transportation infrastructure development and operation. The infrastructure and its correspondent expansion towards vacant/rural areas encourages land-use changes to residential use, which are responsible for generating transportation demand bringing compounding degradation effects to the environment in these newly developed areas.

The concept of land, as suggested by Richardson (1989), "involves the entire ecosystem, the natural order which embraces water, air and living things". To incorporate

this land concept in the development planning requires the adoption of explicit spatial dimension within an integrative planning framework. Such spatial organization is represented by land-use which encompasses varying degrees of human activities interacting with biotic and abiotic systems on Earth. Development planning at local or municipal levels has been specifically addressed in rural development and urban planning, and in both cases transportation infrastructure is a key tool for planning. Therefore, transportation infrastructure, particularly roadways, plays an important role to achieve a compatible airport and land-use development, and consequently depends on the existence of a "*proactive or action-oriented approach*" that, in a timely, orderly and organized manner, is able to foster and support a spatial structure fully integrating environmental concerns, socio-economic growth and human activities.

The formulation and implementation of an integrative framework geared towards this compatibility between the airport and land development may be either *proactive* (anticipatory), which addresses, in advance, both socio-economic and human activity sources of environmental impacts, or *reactive*, which deals with environmental effects after their occurrence (Feitelson, 1989). The latter usually applies to existing or past cases of environmental degradation which may involve corrective (clean-up rivers/lakes), adaptive (noise barriers protecting communities) or control (restraint and/or place limits to levels of industrial air pollution) measures.

So far the guidelines, planning and policies have emphasized reactive strategies, but a shifting focus to the sources of environmental impacts is required, in order to produce an anticipatory planning framework that recognizes the fundamental role of governments - both

in causing environmental problems and solving them. This strategy must be adjusted to instruments generally adopted towards development such as government policy, budget proposal, political strategy or technical guidelines that drive the public decision-making process.

In reference to the airport and its surrounding areas, concerns have arisen about high population growth that has expanded urban areas toward its property limits, reflecting upon communities lifestyle and people's well being. This urbanization trend has been supported by new or extended roadway which brought environmental degradation, ecological decay, and community disturbance.

The dynamic and cyclical feedback process between the roadway system and land development in the context of airport region is quite complex involving many activities and people's location behavior. Figure 4.1 presents a view of the dynamic interactions in the land-use/transportation cycle near airports which co-evolve and interact, pushed by strong market forces under strict government regulations. Additional inputs to these regulations include land market regulation, capital taxes and subsidization, distributive adjustment effects, health impacts and environmental controls.

The dynamics of the transportation and land development system evolving over time - space in reaction to human activities has not been fully understood in the first phase of the land-use/transportation cycle when increased accessibility to an area (a primary decision made by government officials) triggers that development process and opens up the way for further human activities. This is especially true for land-use and development near airports, but negative aspects of airport operations on adjacent land are only noticed when neighbouring

areas have reached an already stage of community complaints and disturbance situation. The aviation sector pays the price, via restrictions on the number of aircraft movements, and reduction in operation hours, principally night time periods.

Night curfew restrictions have been implemented at Sao Paulo City Airport (Appendix E), and at several airports in Zurich, Sydney, Amsterdam, Hong Kong, London, Tokyo and Paris. Different temporary results have been achieved, but other problems have occurred because of these curfew restrictions such as shifting peaking periods, and airline operational and financial constraints that reflect on the level and cost of service to air passengers (Ashford 1984).

This research work follows three distinct parts, the first being a conceptual exploration of basic ideas to develop a strategic and integrative planning framework for road and land development near airports. The second part consists of gathering empirical data to validate those ideas and concepts and, finally, the development of a road location method near airports to broaden existing techniques and guidelines for land use in the vicinity of airports.

To improve upon the past experience, there is a need to better understand the roadway and land development process' effects on people over time and space. These dynamic interactions occurring in the land-use/road development near airports are expressed by the solid oval-shaped hair-line presented in Figure 4.1 connecting the airport (Centred Solid-line Circle) with the land-use transportation cycle suggested by Ashford (1989).

There are many factors affecting the dynamic interactions between land-use and transportation in areas surrounding airports. This research is focused in the effects of route (road) location/alignment which results from adding/extending transportation facilities. In the

case of airports located in rural/urban fringe areas, adding transportation facilities mean more land available for development, less green and open spaces, and consequently environmental degradation. It is emphasizing the land development aspect which support use change from rural/agricultural to urban/residential with people moving in areas affected by aircraft noise.

Some techniques, such as aerial photos and Geographical Information System (GIS) mapping tools, have been used to identify these dynamic interactions. The techniques were instrumental in detecting the effects of road development on land-use over long period of time.

4.3 An Action-Oriented Planning Approach

4.3.1 The Noise Problem

In the last two decades, the construction and expansion of transportation facilities has faced problems because of heightened environmental concerns. Questions have arisen about airport development's adverse impact on surrounding areas. These negative aspects have mostly been attributed to an increasing movement in air and ground traffic, thus disturbing nearby communities, and bringing or adding air, water and earth pollution. But, the major environmental problem associated with airport development and operation is not a physical matter. It is aircraft noise. This environmental problem became a critical issue in the early 1960's with the introduction of noisy, commercial jet aircraft. Complaints started coming in from neighbouring communities.

Figure 4.1 - Dynamic Interactions of the Land-Use/Transportation Cycle Near Airports
Source: After Ashford, 1989

Despite the great socio-economic benefits to its area of influence, airports are difficult to build or to expand because of the negative public perceptions toward aircraft noise (Chalabi, 1993). People living in nearby communities who experience disturbance of daily activities, or perceive a loss in quality of the environment, have felt the most adverse effects of airports. Researchers have shown peoples' perceptions to aircraft noise by determining a Noise Depreciation Sensitivity Index (NDSI) which indicates that an average of 0.6 % decrease on residential property values located in areas surrounding airports for one unit increase in noise level measured in decibels according to the Noise Exposure Forecasting method (Nelson, 1980 and Uyeno, 1993).

Moreover, existing airports have often suffered from the scarcity of vacant land for expansion because they have gradually been surrounded by residential communities, the most undesirable kind of airport neighbourhood.

During the site selection phase, as a part of airport master planning, an intense search and analysis of available areas that could meet the airport's operational requirements is carried out (Ashford, 1992). In general, this site selection locates the airport on a large piece of vacant rural or agricultural land. Therefore, airports are initially situated close to the fringes of urban areas on uplands and flat terrain. The airport operational activities are supported by physical infrastructure constituted of water, sewer, electricity, telephone, highway and road systems. Thus, airports are always served by all basic utilities. They are also accessible by road corridors which then attract residential development towards its property limits. This characteristic of airport location, observable in most middle-sized cities across North America, demonstrates the need for roadway planning to encourage land development

compatible with aviation noise. Practically speaking, the physical location of the arterial roads, will guide land development.

As a result, aircraft noise problems in medium-sized cities can be dealt with by adopting an action-oriented approach to implement a compatible airport land-use planning which guides roads away from noise-sensitive areas at the early stages of land development.

This action-oriented approach has been missing from previous studies. As it can be seen in Official Plans, particularly in the urban fringes around the airport (see Appendix A and Appendix B), not enough attention has been paid to the cyclical evolution of roadway expansion and land development. Such road-land interaction and the profits resulting from it, which causes skyrocketing in land prices and supports land speculation. Of course, depending on specific local economic and social conditions as well as population growth, this cyclical and dynamic process may be more or less accelerated.

4.3.2 Identification of Variables

To include an action-oriented approach in the land-use planning process in the vicinity of airports, it is necessary to identify basic variables involved in each planning field - airport, road, and land-use.

Variables related to the airport activities include the historic and forecast annual/peak day aircraft movements, fleet mix, and runway use and operation which are required to generate the levels of noise exposure indicated in the NEF contour maps. Data on aircraft noise annoyance and complaints also needed to be gathered from attitude surveys or airport records. These airport data allow a visualization of the noisy areas in the airport surroundings

as well as people's reactions to specific levels of noise.

The existing land-use and the foreseeable future land development should also be identified on city maps and official plans, but essential data is required on population density levels which can be obtained from statistic census tracts . This population density data should be examined to define specific density ranges which correspond to particular land-uses.

Finally, according to local development characteristics, zoning bylaws and building codes, road location should be analyzed in terms of average distance from dweller to the nearest road for each specific range of population density.

Figure 4.2 shows the basic variables adopted in this research toward an action-oriented approach for land-use planning near airports in medium-sized cities based on the road location method.

Figure 4.2 Empirical Work Phase.

4.3.3 Thesis Work Plan

In order to expand the land-use transportation cycle into a dynamic interaction concept for areas surrounding airports, this research work reviewed existing literature on related fields (Airport, Road, and Land-Use Planning), which identified relevant aspects that could benefit from more co-ordination. As well, an in-depth analysis and critical discussion of existing policies and guidelines from major government agencies involved in this matter have been conducted. This critical thinking is the basis to introduce specific considerations and measures based on an anticipatory/action-oriented approach into the road and land development near airports

As a result, a strategic planning framework for roadway and land-use in the vicinity of airports was developed by bringing together existing missing factors and links in the interrelated planning fields. Figure 4.3 presents a conceptual view of this research.

Empirical research was then conducted to support and validate conceptual observations concerning the significance of variables such as population density and accessibility, as well as those already taken into consideration such as aircraft noise levels and complaints. This empirical phase, using data available in the Ottawa-Carleton region, established a functional relationship among these variables to support a new action-oriented approach for land-use near airports based on a road location method.

Figure 4.3 Thesis Work Plan - Conceptual View

4.4 Mathematical Modelling

To formulate a mathematical model for making a real world representation of the transportation and land development process near airports, all basic variables involved must be identified along with a functional relationship to explain how they are linked. Then, this functional relationship becomes an analytical tool to be used in the GIS-based road location method. Many GIS and CAD software packages have been developed in recent years opening a new urban planning universe to transportation engineers and city planners (Barlett, 1996). As pointed out by Barlett, GIS has become a powerful tool by incorporating a mathematical engine that "allows it to carry out virtually any engineering analysis". Thus, the GIS-based road location method developed in this research can overcome the weakness of existing land-use and transportation models presented in Chapter 3, particularly regarding road location and alignment.

The functional relationship among variables involved in the planning process for areas near airports was based on curve estimation with specific mathematical models as explained later in this chapter. These mathematical models are based on independent variables, observed patterns according to sets of variables (x_i), that can be measured or accounted for, and controlled by decision maker. Such models involve other set of variables (Y), dependent variables, which represent conditions, factors or characteristics that need to be estimated or predicted. The mathematical models have been proven effective in predicting those variables which the decision maker cannot control and providing useful information to better understand the phenomena they represent.

$$y = f(x_1, x_2, x_3, x_i, \dots, x_n) \quad \dots (4.1)$$

Transportation engineers and urban planners have relied upon statistical analysis when dealing with interrelated systems. Therefore, functional relationships derived from this analysis become important tools applied to transportation and urban planning research (Chapin 1979).

4.5 Modelling Noise Impacts

4.5.1 NEF Method Background

The aircraft noise effects, expressed by people's annoyance and complaints, are related to the level of noise exposure, measured by the noise exposure forecast (NEF) method, developed by Bishop and Horonjeff (1967) for the Federal Aviation Administration (FAA). It takes into account cumulative aviation events based on the summation of the energy of noise and associated exposure factors such as duration of aircraft flyovers and distinct pure tones of different engines. This method can produce an estimation of the total noise exposure resulting from aircraft operations that include various types of aircraft, flight paths, number of aircraft movements and runway utilization. It can compensate for the increased sensitivity of people to aircraft noise during the day- and night-time periods by applying weighting factors for the number of aircraft movements.

The mathematical model developed by the FAA (1973) to generate NEF values, called Integrated Noise Model (INM), has also been adopted by Transport Canada. Actually, in its Version 4.11(1993), INM has evolved over the years to expand the database of aircraft noise and performance, and additional user selection for input data such as noise curves, take-off profiles, approach parameters, and propagation distance based on terrain topography. The

INM primary objective is to develop a map with specific noise lines connecting all points with the same noise exposure level. This set of noise contours estimates the noise exposure levels applied in the Transport Canada (1989) guidelines for "Land-Use in the Vicinity of Airports".

Bishop and Horonjeff (1967) recognized the complexity of predicting community reactions to aircraft noise, therefore, identified numerical values to define zoning boundaries around airports. These NEF values applied as zoning boundaries according to contours lines and respective response predictions are presented in Table 4.1.

Table 4.1 NEF Method - Community Response Prediction

NEF Area	NEF Value	Response Prediction
1	over 40 NEF	Repeated and vigorous individual complaints are likely. Concerned group and legal action might be expected.
2	35 to 40 NEF	Individual complaints may be vigorous. Possible group action and appeals to authorities.
3	30 to 35 NEF	Sporadic to repeated individual complaints. Group action is possible.
4	below 30 NEF	Sporadic complaints may occur. Noise may interfere occasionally within certain activities of the resident.

Source Bishop and Horonjeff 1967

In particular, this research attempted to ascertain the levels of complaints from areas where aircraft noise exposure varies from 20 NEF to 40 NEF and land development has occurred with different population densities. In these areas aircraft overflights can be distinguished from other noise sources, sometimes interfering with human activities such as sleeping, conversation, and watching TV, and thus generating complaints.

4.5.2 People's Perceptions and Reactions to Aircraft Noise

Many studies have been carried out on people's perceptions and reactions towards aircraft noise. Discussion has been voluminous on the nature of the functions that transform quantitative stimulus into quantitative continuum perception scale. The oldest function to represent the transformation of stimulus to a continuum scale of perception, was derived from Fechner's law which constitutes the basic element of a long line of thinking on psychophysical experiments. The main question in his experiment (Fechner, 1860) was about the relationship between the intensity of a continuously varying stimulus and the subjective sensation of the stimulus in the consciousness of the subject. On the basis of psychophysical experiments, Fechner came to the conclusion that the sensation was a logarithmic function of the stimulus intensity. Although the validity of such assumption is not clear, the logarithmic function has long been used for transformation regarding the sound pressure level that represents stimulus intensity in dBs (decibels), as shown below:

$$\text{SPL} = 20 \log (P / P_0) \quad \dots(4.2)$$

where: SPL = sound pressure level in decibels (dB);

P = sound pressure of a particular sound; and

P_0 = standard reference pressure (20 N/m²).

However, an alternative transformation of stimulus intensity into subject sensation has been suggested by Marks (1974). This transformation uses the observed stimulus raised to a certain power (power transformation) to quantify the subject perception.

In recent years, several studies have focused on levels of annoyance and complaints caused by transportation sources, particularly road traffic and aircraft noise (Schultz 1978,

Kryter 1982 and Hall 1981). These studies relied on polynomial functions to represent people's perception and attitude in terms of annoyance, disturbance of activities and complaints. Thus, quadratic and cubic functions could also be considered to express people's perceptions and reactions towards aircraft noise.

Schultz's work reviewed data from eighteen social surveys from various countries. The noise was generated by aircraft, street traffic, and railroads. The results of these surveys have shown a good correlation between the noise descriptors and the percentage of people surveyed, who indicated that they were "highly annoyed". The polynomial cubic function derived by Schultz to represent the average annoyance response adopted the Day-Night Average Sound Level (Ldn or DNL), one of the most used noise descriptors in the United States. The Ldn correlates well with NEF ($NEF \approx Ldn - 35$) and can also be defined by the Integrated Noise Model (INM). The Schultz function to express average annoyance response to noise generated by transportation is:

$$\% HA = 0.8553 Ldn - 0.0401 Ldn^2 + 0.00047 Ldn^3 \quad \dots(4.3)$$

where: % HA is the percentage of people highly annoyed; and

Ldn is the Day-Night Average Sound Level in decibels.

Kryter (1982) also conducted an analysis of those aircraft noise surveys and found a specific equation to explain people's annoyance to aircraft noise:

$$\% \text{ Highly Annoyed} = -40.2 + 0.0003129 Ldn^3 \quad \dots(4.4)$$

Therefore, during the statistical analysis, empirical data collected in the OMCLA region should be statistically tested for the goodness of fit with these functions - logarithmic, power and polynomial (quadratic and cubic) of decisions concerning the most appropriate

functional relationship to be applied into the GIS-based road location method.

4.5.3 NEF Calculation

The NEF method (Bishop and Horonjeff, 1967) establishes that the level of exposure to aircraft noise, at a specified point on the ground, depends on the following factors:

- effective perceived noise level (EPNL) at a specific point during every aircraft movement;
- characteristics of the aircraft fleet using the airport;
- aircraft landing and take-off flight paths; and
- number of aircraft movements during the forecasted planning peak day.

This functional relationship between noise exposure levels and airport activities can generally be expressed by:

$$\text{Noise} = f(\text{aircraft movements, noise emissions, fleet mix, in/out flight paths}) \dots(4.5)$$

Individual aircraft noise levels are expressed in terms of effective perceived noise level (EPNL) which takes into account sound duration and the presence of pure tones:

$$\text{EPNL} = \text{PNL} + \text{D} + \text{F} \dots(4.6)$$

where: EPNL is the effective perceived noise level and it is measured in decibels or EPNdB;

PNL is the maximum perceived noise level at any instant of time during the fly-over, weighted for each third-octave band levels of the noise and is measured in decibels or PndB.

$$D = 10 \log t / 15 \quad \dots(4.7)$$

where: D is the duration of the sound;

t is the time interval in seconds during which the noise level is within 10 dB of maximum PNL; and

F is the correction factor for the presence of discrete frequency components.

The NEF algorithm used to calculate NEF values can be expressed in mathematical terms as follow:

$$NEF_{(ij)} = EPNL_{(ij)} + 10 \log_{10} [(N_{ijk} / Q_k) + (N_{jka} / Q_k)] + C \quad \dots(4.8)$$

where:

$NEF_{(ij)}$ is noise exposure forecast value at the point of interest on the ground because of aircraft type i flying along flight path j.

$EPNL_{(ij)}$ is the effective perceived noise level at the point of interest on the ground because of aircraft type i flying along flight path j.

N_{ijk} is the number of aircraft type i flying along flight path j during a period k (k=1=day and k=2=night).

Q_k is the time of aircraft movement weighting factor. For k=1, daytime operation (from 07:00 to 21:59 Hrs), Q is equal 20, and for k=2, night-time operation (from 22:00 to 06:59 Hrs), Q is equal 1.2.

C is a constant C = - 75.

The total NEF at a given ground position is determined by summation of all individual NEF_{ij} values on an energy basis:

$$NEF = 10 \log \sum_i \sum_j \text{Antilog } NEF_{(ij)} / 10 \quad \dots (4.9)$$

where:

NEF is the total noise exposure forecasted at the point of interest on the ground because of the cumulative contribution from all types of aircraft using different flight paths.

Figure 4.4 presents calculation procedures to determine level of noise exposure for a particular point on the ground based on the NEF method.

The computer processes all the calculations of basic NEF values and produces the printout at any scale, with NEF contours using the Integrated Noise Model (INM). This research has generated two noise contour maps which were prepared at 1:25,000 or 1:50,000 scale to provide information required by the mathematical model. The map at 1:25,000 scale allowed the plotting of every noise level expressed in NEF(s) from 20 NEF to 40 NEF necessary to further evaluate noise climate for each complaint site. On the 1:50,000 scale map the 20 NEF, 25 NEF, 28 NEF, 30 NEF, 35 NEF and 40 NEF were plotted to allow a broader view of different areas affected by aircraft noise as used in the guidelines for land-use in the vicinity of airports in Canada.

Figure 4.4 NEF Method Calculation Procedures

4.6 The Road Location Method

4.6.1 Complaints

The NEF method has supported airport land-use compatibility that establishes zoning limits for development according to the noise contours lines. As presented earlier, the NEF method is based on a broad relationship between peoples' complaints and levels of noise exposure that can be expressed:

$$\text{Complaints} = f(\text{Aircraft Noise}) \quad \dots (4.9)$$

However, aircraft noise is a result of many movements (landings and take-offs) from various types of aircraft over different flight paths and with several profiles during day and night-time. Thus, complaints according to the NEF method can be redefined as:

$$\text{Complaints} = f(\text{Aircraft Number, Type, Take-off and Landing Path/Profile, Time, others...}) \quad \dots (4.10)$$

This kind of relationship is of the $Y = f(x)$ form, where x is expressed by variations in the type and position and other attributes regarding only the aircraft noise which is the source of emissions. Therefore, it deals only with the emission sources. But, noise is like a coin with two faces, where the emission source is one side and the listener is the other.

The number of complaints will be used in this research to explain people's reactions to aircraft noise, but attention is given to other factors that guide people to move into noisy areas around airports such as roadway location which influence population density increases. There are other indicators of people's response to aircraft noise, including the percentage of people who are highly annoyed, as determined by attitude surveys. Because complaint data was available from OMCIA, it was adopted as noise response indicator.

However, there are studies relating percentage of people who complain and the percentage of people highly annoyed by aircraft noise. The Tracor study of community reaction to aircraft noise around smaller city airports (Connor and Patterson, 1972) led to a formulation expressing this relationship:

$$\% \text{ Highly Annoyed} = 20 + 2 (\% \text{ Complaining}) \quad \dots(4.11)$$

Later in a broader study, Patterson and Connor (1973) derived another equation to explain the community responses to aircraft noise in large and small cities in the USA. This equation is:

$$\% \text{ Highly Annoyed} = 14.3 (\% \text{ Complaining})^{1/2} \quad \dots(4.12)$$

$$0 < \% \text{ Complaining} < 49$$

It is important to point out that in a research carried out around London's Heathrow Airport, in England, McKennel (1963) found that when 1% of the people had complained about noise, 10% felt like complaining, and when the noise was such that 10% had complained, 40% felt like complaining.

Kryter (1994) suggested that normal, sensitive people start complaining at noise exposure level equal to 20 NEF (55 Ldn), and group and legal actions should be expected about 30 NEF (65 Ldn).

Noise surveys in the United Kingdom (McKennel 1963 and 1973) noted that there are two parts of the population deserving special attention. Firstly, the supersensitive people (about 20% of the population) who are always annoyed and who may complaint at almost any level of noise. And secondly, the "imperturbables" portion of the population (about 25%) who do not get disturbed or annoyed no matter the noise levels to which they are exposed.

This research has been set up to evaluate noise complaints from 20 NEF and up to the 40 NEF. Noise contour lines were drawn on the regional maps for every NEF value allowing full consideration of complaints in that noise interval.

4.6.2 Population Density

To enlarge the analysis of the aircraft noise effects on airport surroundings, this research considered the influence of other variables that are under government decision maker's control such as population density and road location.

The population density as a variable can identify land use settings where people live, and it can also express specific people's characteristic and perception towards noise. As a matter of fact, people's reaction to aircraft noise involves socio-economic and behavioral factors. This research assumed that these factors can be explained by the individual's way of life - appreciating the quiet and secluded rural environment, or the privacy of a large suburban lot (reflected in low population density areas) or choosing a busy and crowd suburban/urban setting which has detached/semi-detached houses, townhouses and apartment buildings (higher populational density).

Therefore, it is assumed that a direct positive relationship exists between complaint activities, aircraft noise exposure level and population density, which ultimately can define individual characteristics:

$$\text{COMPLAINT} = f(\text{NOISE, DENSITY}) \quad \dots(4.13)$$

Using the NEF method and taking the noise exposure level as previous forecasted for a particular location, the number of complaints (COMPLAINT) should increase as population

density (DENSITY) increases assuming that on average people would react in the same way related to aircraft noise.

In addition, people living closer together in high population density area means smaller lots or vertical development (apartment buildings). Individuals are then able to communicate with each other much easier and can make their collective voice heard by airport and local government authorities.

Thus a basic assumption is that population density is inversely proportional to the lot size:

$$\text{DENSITY} = 1 / \text{LOT SIZE} \quad \dots(4.14)$$

In order to understand the relationship between people's complaints and aircraft noise level, population density was analyzed in intervals to ascertain the effects of such factors for different population segments. Table 4.2 presents a classification for land development stages used in this research, according to the population density segments.

Table 4.2 Classification of Land Development According to Population Density

Type of Setting	Population Density	Lower Limit (people/km ²)	Upper Limit (people/km ²)
Rural Areas and Large Suburban Lots	Very Low	0	999
Suburban Areas (horizontal developments)	Low	1,000	1,999
Suburban Areas (horizontal & vertical dev.)	Medium	2,000	2,999
Urban Areas (mix development-most horiz.)	High	3,000	3,999
Urban Areas (mix developments)	Very High	4,000	4,999
Urban Areas (mix developments-most vert.)	Extremely	5,000	∞

The proposed classification for population density fits well with the observed suburban development pattern of medium-sized cities in North America, where the average density is approximately between 2,000 and 3,000 people per square kilometre (ITE, 1992).

4.6.3 Accessibility (Distance to the Nearest Road)

Based on the assumption that people moving into low population density areas would settle near existing roads, as density increases they would move to inner vacant areas linked to these roads by streets. Thus, at early stages of land development, location of new roads can support population growth over its adjacent areas. People moving into these new corridors will still describe the setting as a rural and quiet one. Therefore, they will probably feel more disturbed by aircraft noise than people living in higher density areas who are used to a noisy and crowded urban environment.

Keeping in mind that airports in medium-sized cities are usually located in rural/suburban areas with low population density, an analysis of peoples' complaints against aircraft noise taking into consideration population density and location of nearest roads, can support implementation of land-use and transportation planning activities around airports based on action-oriented measures. This becomes essential when peoples' way of life is associated with population density and in turn with the land development pattern. To date no research has been located which investigates complaints about aircraft noise in areas around airports by addressing the population density effect on peoples' perception and reactions.

There is, then, a clear relationship between density and accessibility. Population

density increases as the access system is extended to inner areas. Medium to low levels of population density are most likely to occur in areas served by roadway and transportation needs attended by private cars and bus service. On the other hand, high population densities can support other forms of mass transportation.

In addition, zoning by-laws usually establish building density by defining the floor area ratio (FAR). These zoning by-laws vary from one municipality to another, but they clearly define a building density pattern that reflect on population density.

In theory, the spacing between major and minor roads should serve the kind of development proposed for a particular area or region. However, as pointed out by Leung (1989), land use and development has not been the main focus of roadway planning in the rural/urban edges. Thus, roadway location has just followed basic spacing principles, according to the type of transportation network adopted (grid, radial, circumferential, etc.). Most urban/suburban areas have applied general guidelines for grid networks which indicate that major/minor roads should be located between 800 metres and 1,000 metres apart in order to provide a better distribution of traffic flow.

This research assumes that as population density increases the adjacent development corridor will also be wider since people will be moving into areas farther from the main road access. At the same time, a long access to the main road usually provided by the developer will increase the project total costs and will require a higher population to make it feasible. Figure 4.5 illustrates the relationship between population density and accessibility measure as a distance from the nearest road.

Figure 4.5 Relationship between Density and Accessibility

Curves t_1 (time 1) and t_2 (time 2) represent distance as a function of population density at two points in time. Of course, time is a continuum but a two-period example illustrates the relationships. In this case, time is measured in years, and t_1 and t_2 are several years apart. Consider four locations: A, B, C and D . Location A and B are zoned and subdivided at time t_1 . Location C and D are zoned and subdivided at a later time t_2 . A and C are close to one another and have comparable accessibility. Similarly, B and D are situated near to one another at a greater distance from O , the point of maximum accessibility to that road. Assume that land has quite homogeneous physical natural characteristics (soils, geology, topography, vegetation, wildlife, hydrology and flood aspects).

As soon as areas further from airport property limits are developed and occupied, other adjacent areas closer to its boundary will be under pressure to follow the same development pattern (*A* and *B*). As time goes on, even adjacent vacant areas under higher aircraft noise impact will suffer the same kind of pressure towards development, and land-use control measures may not help (*C* and *D*). Because undeveloped lands, zoned as non-residential according to the Noise Exposure Forecasting (NEF) system, have similar accessibility to those previous and adjacent development, they generally become the next available area to be developed.

This hypothetical situation suggests that: (1) in terms of location, *C* will have higher density than *A*, and *D* will have higher density than *B* because *C* and *D* are zoned and subdivided at later time; and (2) in terms of time, *A* will have lower density than *B*, and *C* will have lower density than *D*, because *A* and *C* have superior accessibility locations being closer to the road.

Road development therefore, directly affects the availability of land, especially when close to urban fringes. Extending road infrastructure more than one kilometre from the end of existing roads and highways is not economically feasible except for very large developments. In areas surrounding airports, near urban fringes, land development are highly affected by the location of new or extended road because it can create profit opportunities for landowners, developers and speculators whose property or financial interest is conveniently next in line for development. Furthermore, when road access is available to these urban fringe areas around airports, development controls are restrictive, and land supply decreases, then prices for those marginal pieces of land rise. Thus, land development becomes feasible

with high population density to overcome higher prices of these marginal lands (Peiser, 1983). Unfortunately, the land is usually under higher aircraft noise levels, but this is not easily recognized by home buyers until after they move in. This is when aircraft noise complaints start coming from the airport neighbourhood. Some mitigative measures to deal with aircraft noise in areas near airports such as home insulation and forewarning of potential home buyers have not been successful since people moving in may have misjudged the aircraft noise level specified by NEF, or may have initially accepted that situation and then made up their minds. Therefore, it is quite difficult to deal with noise simply by mitigating its effects.

4.6.4 Other Variables

Other important variables that may influence the road and land development near airports are land-use characteristics and natural physical conditions. In this research, these variables will not be directly considered, but they can be included as different layers in the GIS software package for deeper road location analysis in future studies.

In that case, land-use characteristics can be classified as urban or rural, as well as others subsequent subdivisions and assign values according to the desirability of some particular use in terms of its compatibility with overall surrounding conditions regarding the possibility of further development. These characteristics will have different values according to their environmental sensitivity defined in the official planning document or established by legal mandate or regulatory environmental agency.

The natural physical conditions such as topography and soil characteristics can also be evaluated and receive a value probably related to the construction cost associated with

each particular terrain conditions. For instance, major topographic variations - depressions or elevations that may need major construction work - would be assigned a very high value.

4.6.5 The GIS-Based Road Location Method

As reviewed in Chapter 3, existing land-use transportation models have not addressed the location effects of a new road on land development particularly the population density increase over adjacent areas (corridors). On the other hand, models based on statistical regression analysis can support empirical study to the population growth and land development effects of road alignment in the vicinity of airports.

The proposed method considers that people's complaints against aircraft noise represent a unique combination of characteristics. Aircraft noise levels resulting from landings and take-offs can be expressed by airport noise contours which delineate those areas under heavier impact on footprint maps of the region. However, human environment degradation may appear if land-use planning and its implementation does not conform with these aircraft noise contours. Thus, land development and use change from rural to suburban and urban can be represented by different levels of population density. Other characteristic that may also influence people to move in these noisy areas is a good access system that can result in higher population exposed to aircraft noise.

This kind of statistical regression analysis for the number of noise complaints can be expressed by the following function:

$$C = f(E, D, T) \quad \dots(4.15)$$

where:

C is a vector of observations of people's complaints;

E is a vector of environmental (aircraft noise) conditions; and

D is a vector of land-use (population density) characteristics; and

T is a vector of observations of road system - distance to nearest road.

In practice, these characteristics are important and can be measured, but they depend on peoples' overall perceptions. Of course, assumptions have to be made in terms of their perceptions toward aircraft noise, living location choice, and house/land market conditions.

The basic assumptions of this research therefore, are:

- a) On average, people perceive and react to specific levels of exposure to aircraft noise in the same way with equivalent levels of annoyance and complaints;
- b) On average, people have a choice to live in a more quiet rural kind of environment or busy suburban areas or more crowded urban settings according to their own perceptions and life styles;
- c) On average, areas closer to the roads will be developed before areas further away from the road; and
- d) On average, people perceive that house and land markets are transparent and have a price equilibrium.

Thus, the GIS-based road location method near the airport will represent the best pathway for a new or extended road alignment which will minimize complaints by considering

land development opportunities and, consequently population growth in areas affected by high levels of aircraft noise. This method, developed using a GIS software, allowed an efficient location to reach a locus of equilibrium which minimized “associated costs” related to the people’s reaction (complaints) towards aircraft noise. This road location method considers specific conditions observed in the airport region regarding roadway system (distance to the nearest road) and land-use (population density) that are dynamic in space and time. These conditions may be prevented or stimulated to deal with aircraft noise problems in airport surroundings. An application of this GIS-based method using empirical data available in the Ottawa-Carleton Region was carried out to help understand the input and output required and the level of analysis produced.

Figure 4.6 presents work flow and variables to be analyzed for the development of the road location method near airports.

Variables to be studied: GIS-Based Road Location Method

Figure 4.6 GIS-Based Road Location Method Near Airports - Work Flow

Chapter 5

Data Collection and Analysis

5.1 Introduction

The area around Ottawa Macdonald Cartier International Airport (OMCIA) in the Ottawa-Carleton Region was selected to demonstrate how the method for road location around airports can be applied by urban planners and transportation engineers. As mentioned in Chapter 4, one of the objectives of this research work was to develop a planning tool that can help the decision making process concerned with roadway provision and land development in areas near airports under the impact of aircraft noise.

In this chapter the data collection and analysis processes are described. Detailed information is provided on the sources of raw data, the technical procedures to data handling, aggregation format, and statistical analysis used to find the functional relationships among the variables to be later implemented as an analytical tool in the GIS-based road location method near airports.

5.2 Aircraft Noise Levels

An extensive input data file related to the aircraft movements at OMCIA is required to generate noise contours lines according to the Noise Exposure Forecast (NEF) method. Such NEF input data included airport operation, runway configuration, and aircraft and fleet mix data. In this research work, the NEF Micro Computer System Users Manual from

Transport Canada - Aviation (June, 1990), derived from the Integrated Noise Model developed by the FAA, to generate and draw historical and forecast noise contours was adopted.

Historical Noise Contours

To obtain historical aircraft noise exposure in the vicinity of airports, the NEF method algorithm was used with data corresponding to observed past conditions in terms of runway configuration, airport operation and aircraft data.

Runway configuration involved information on the position, length, and geographical coordinates of each runway used. This configuration allowed the noise contours to be plotted using the airport runways as a reference. By reviewing the publication called Airport Facility Directory, which includes all information concerning Canadian airports, it was possible to observe that OMCIA runway configuration has not experienced any major change over the last 45 years. Thus, OMCIA is comprised of two primary runways 07-25 (2,438 metre long) and 14-32 (2,957 metres long) which serve air carriers and Instrument Flight Rules (IFR) commercial aviation traffic. Two secondary runways 04-22 (933 metres long) and 17-35 that serve local and non-scheduled commercial operators as well as private light planes. Only one minor change occurred in 1994 when the smallest runway 17-35 was closed. Therefore, this runway 17-35 is not included in the OMCIA case study (tables and maps). Table 5.1 shows OMCIA runway configuration data used in this research.

Table 5.1 OMCIA Runway Configuration

Runway	Length	Width	Approach	Elevation	Latitude *	Longitude *
14	2957 m	61 m	142°	112 m	50° 19' 23.2"	44° 63' 23.8"
32	2957 m	61 m	322°	113 m	50° 17' 40.2"	44° 86' 73.6"
07	2438 m	61 m	071°	114 m	50° 17' 66.3"	44° 74' 20.4"
25	2438 m	61 m	251°	114 m	50° 19' 02.3"	44° 94' 56.9"
04	1006 m	23 m	040°	114 m	50° 19' 18.0"	44° 58' 53.8"
22	1006 m	23 m	220°	114 m	50° 20' 12.1"	44° 63' 23.8"

Source: Airport Facility Directory and (*)Transport Canada - Aviation Group

The airport operation records consist of data on aircraft movements in terms of daily traffic by total movements, arrivals and departures aggregated during the daytime and night-time for each specific runway. These data presented in Appendix G were retrieved from OMCIA database files at Transport Canada using a software called AMSAP that was developed in its Aviation Branch by the ANS Long Range Planning Group (AANDFA Ottawa).

Aircraft and fleet data included data concerning type of aircraft, fleet mix, aircraft power plant, operational characteristics and frequency of runway use by aircraft type. Unfortunately, these kind of data were not readily available. In fact, it would be a time consuming task to count and prepare by hand these data from airport raw files. However, starting in 1990 Transport Canada produced a large data file stored on CD-ROM disks with all aircraft movements that operated to/from Canadian airports in a single year. These CD-ROM disks contain data regarding departure and arrival airports, time of departure and

arrival, aircraft type, manufacture characteristics, power plant, etc. These files allowed for exact identification and quantification of each aircraft type operating at a particular airport in a given year. They contained the following field of data: Record Type; Tower Code; Time; Day; Month; Year; Aircraft Identification; Carrier Code; Aircraft Type; Aircraft Weight; Seating Capacity; Power Plant; Review Code; Arrival or Departure; Airport To/From; Time; IFR or VFR; Runway; Type of Operation; and Sector of Operation.

Because the number of complaints started increasing significantly by 1990, it was appropriate to use this set of existing data as a base for the road location method near airports. To this end, a software called PARADOX - Version 5.0 was used to extract aircraft data operating at OMCIA in each year from 1990 to 1995. This is a relational data-based software which can carry out multiple queries producing answer tables with its results. Therefore, all data regarding aircraft type were based on the existing CD-ROM disks with data from 1990 to 1995. The input data related to aircraft and fleet mix data is shown in Appendix H and includes specific set of data for jet, turbo and piston aircraft.

The historical noise contours from 1990 till 1995 were drawn for every NEF level from 20 NEF to 40 NEF and plotted in 1:25,000 scale map. They were also plotted for 20 NEF, 25 NEF, 28 NEF, 30 NEF, 35 NEF and 40 NEF in 1:50,000 scale map. In addition, the NEF plotting system generated .DXF files that were imported into the GIS mapping tool. The GIS maps with these historical noise contours from 1990 to 1995 are shown in Figure 5.1, 5.2, 5.3, 5.4, 5.5 and 5.6, indicating that they have been reduced over that time frame due to the replacement of old noisier aircraft and the reduction in aircraft movements up to 1993. They expanded a little in 1994 and 1995, reflecting the increase in aircraft movements.

Figure 5.1 OMCIA Historical Noise Contours - 1990

Figure 5.2 OMCLIA Historical Noise Contours 1991

Figure 5.3 OMCIA Historical Noise Contours 1992

Figure 5.4 OMCIA Historical Noise Contours 1993

Figure 5.5 OMCA Historical Noise Contours 1994

Figure 5.6 OMCA Historical Noise Contours 1995

Future Noise Contours

To forecast aircraft noise exposure levels and to draw corresponding noise contours on maps, a data collection was required. These initial data contained historical annual and daily aircraft movements at the airport. These data formed the basis to forecast the number of annual and planning peak day movements for the target year.

In this research, the Transport Canada official forecasts for the annual aircraft movements at Ottawa Macdonald Cartier International Airport (OMCIA) are presented in Appendix I. Because there is no official forecast available for the aircraft movements in the planning peak day, an analysis was carried out taking into consideration the aircraft movement data since 1980 (shown in Appendix J). Using this set of data, it is possible to ascertain the historical planning peak day based on 95% of the total annual movement criteria. Only daily aircraft movements for which the sum exceeds 5% of the total annual aircraft movements were not considered.

By adopting the relationship between total annual aircraft movements and observed planning peak day, it is possible to forecast the planning peak day. A linear function explains this relationship using the set of data.

$$Y = b_0 + b_1 t \quad \dots(5.1)$$

where:

Y is the dependent variable - aircraft movements in the planning peak day;

b_0 is a constant;

b_1 is the regression coefficient;

t is the independent variable - total annual aircraft movements.

The regression analysis for the OMCIA data has shown a good linear fit with the following equation:

$$Y = 138.4494 + 0.002636 \times t \quad \dots(5.2)$$

($R^2 = 0.7273$ $DF = 14$ $SE = 14.4854$)

Secondly, in order to forecast noise exposure around OMCIA, it became necessary to ascertain the percentage of runway use and daytime/nighttime operational split according to different types of aircraft. OMCIA is regularly used by a variety of aircraft types including heavy, medium and light turbo and jet aircraft. The most used commercial types are: B747, B767, B737, DC9, B727, A320, BAE 146, Fokker 28, Fokker 100, Dash 8, and ATR 42.

According to the historical data, the runways have had stable use over the past fifteen years. The aircraft fleet data stored on CD-ROM disks, from 1990 to 1995, were used as a basis to determine annual average percentage of daytime and nighttime runway movements for each aircraft type operating at OMCIA in that time period (See Appendix G).

Furthermore, the future aircraft fleet composition operating at OMCIA was adjusted to the mandatory transition, where noisier old aircraft must be replaced by quieter ones by December 31, 2004, from Chapter 2 to Chapter 3 aircraft. To generate the aircraft noise exposure forecast that adheres to this future situation, an analysis of changes that occurred in the fleet composition since 1990 was performed in order to determine how airlines have started this adjustment process.

It appears that for economic, financial and management reasons air carriers would rather replace old aircraft with new ones from the same manufacturer. Thus, airlines which

have air crew, ground maintenance and support personnel trained, as well as machinery, equipment, tools and supply parts from a specific manufacturer would be better off by staying with that company. For instance, an air carrier operating a Boeing 707, Boeing 727 or Boeing 737 - 100 and 200, would most likely change to Boeing 747, Boeing 767, Boeing 757 or Boeing 737-300. This kind of strategy also applies to air carriers flying Macdonnell-Douglas (old) DC9 aircraft, and replacing them by a MD80. In the same way, airlines with the Fokker 28 would change to the Fokker 100, and so on.

Therefore, the basic criteria adopted to ascertain the transitional effects on the fleet composition was to regroup or replace (in the existing fleet mixture) all Chapter 2 aircraft by similar Chapter 3 aircraft according to the manufacturer, operational characteristics, power plant and seat capacity. Following these criteria and using the average annual percentage for each particular type of aircraft operating during daytime and nighttime at OMCIA from 1990 to 1995, the fleet mixture in 2004 and beyond was ascertained (Appendix K).

In terms of runway configuration, neither the latest version of Airport Master Plan (December, 1991) presented any blueprint, nor did Transport Canada - Long Range Planning Group make any observation about changing the runway configuration in the planning horizon till the year 2008.

However, a brief runway configuration capacity assessment was carried out to take a look into the future. This assessment was based on the data provided in the OMCIA Master Plan (1991) and FAA Advisory Circular (1983).

Airfield capacity is expressed in terms of aircraft movements per hour and is affected by factors such as weather conditions, runway configuration, air traffic mixture, air traffic

separation rules and procedures, arrival and departure ratios, IFR/VFR traffic mix, percentage of touch-and-go, and runway exit number and location.

The existing runway configuration is a preponderant infrastructure factor to determine airfield capacity (Ashford, 1984). By definition, runway capacity is the maximum throughput at which the average ground delays do not exceed 4 minutes.

The OMCLIA Master Plan (1991) provided data on the peak hour movements in terms of demand and capacity. These data on OMCLIA runway capacity are based on detailed study undertaken by a consulting company, Aviation Planning Service, in the Spring 1990. Results determined that during 1990 peak hours, the average ground delays exceed 4 minutes meaning that runway system was saturated. The OMCLIA Master Plan suggests that increased time delays should be expected by the year 2005 since demand in the peak hour of the average number of aircraft operations will reach almost 60 movements and runway capacity may not exceed 45 aircraft movements per hour.

The FAA (1991) suggests some capacity and annual service volume for airport long range planning according to the runway configuration diagram/design, basic operational characteristics and hourly capacity. Examination of the a primary runway configuration diagram composed of RWY 07-25 and RWY 14-32 in OMCLIA, indicates that the closest configuration presented in the FAA advisory circular is called "Open V Runways". Table 5.2 presents the runway capacity and annual service volume suggested by the FAA.

Table 5.2 Runway Capacity and Annual Service Volume

Runway Configuration	Diagram (Shape)	Mix Index (C+3D)	Hourly Capacity(VFR)	Hourly Capacity(IFR)	Annual Volume
Single		0-20	98	59	230,000
Single		21-50	74	57	195,000
Single		51-80	63	56	205,000
Single		81-120	55	53	210,000
Single		121-180	51	50	240,000
Open V		0-20	150	59	270,000
Open V		21-50	108	57	225,000
Open V		51-80	85	56	220,000
Open V		81-120	77	59	225,000
Open V		121-180	73	60	265,000

Source: FAA (1983)

Because, the OMCIA primary runways look more like an X shape diagram and they can not be simultaneously operated with the secondary runway 04-22, it is expected that when one runway is used, this operation will affect and reduce capacity of the other runway by the air traffic interference. Therefore, it is possible to determine that the existing runway configuration with no major expansions should be able to handle an annual aircraft traffic between 200,000 to 250,000 movements. This lower limit should correspond to the runway configuration's practical capacity with increasing peaking hour periods where will occur 4 minutes average delay. The upper limit should be the ultimate capacity, which means that average delays would be much larger than 4 minutes during longer time periods.

In airport long range planning, it is always recommended that different growth

scenarios are used to analyze its development. Because of the mandatory aircraft fleet transition from Chapter 2 to Chapter 3, it is also appropriated to define aircraft movements at OMCLIA in 2004 when this transition should be completed. By reviewing and interpolating the existing Transport Canada Forecast, it was ascertained that the total aircraft movements for 2004 would lie between 130,000 movements in the low growth scenario and 170,000 movements in the high growth scenario, although it is most likely to occur at the medium scenario of 150,000 movements. Using the function that relates total annual and peak day aircraft movements at OMCLIA, it is possible to determine the peak day movement for each scenario in 2004 and to forecast the noise levels based on the NEF method. These noise contours for the 2004 low, medium and high growth scenarios are presented in Figures 5.7, 5.8 and 5.9. These figures clearly show that, after the aircraft transition to Chapter 3 is completed, noise contour lines will be much closer to each other and areas situated near to the airport boundaries will be under much steeper gradient in terms of noise exposure levels. Such changes in the length and shape of noise contours may bring about a wrong perception that noise is going to decrease. On the contrary, however, it is likely that the noise contours will be covering a smaller total land area affected by aviation noise, but variation in daily noise dosages can increase substantially over those affected areas, bringing annoyance and disturbance to people.

Transport Canada official records and forecasts for OMCLIA (Appendix I), also allow the preparation of long-range forecast for the total annual aircraft movements. They indicate that by adopting a medium growth scenario (1.7 %), the OMCLIA practical capacity of existing runway configuration which is 200,000 annual aircraft movements will be reached by 2020.

This is the time horizon when major road and land developments are projected in the Official Plan for the Regional Municipality Ottawa-Carleton. Table 5.3 shows the total annual, peak day and average day - historical and forecast - aircraft movements for OMCIA.

Table 5.3 OMCIA Historical and Forecast Aircraft Movements

Year	Total Annual	Peak Day ¹	Average ²
1980	118,504	466	325
1981	113,524	467	311
1982	107,732	437	295
1983	109,016	432	299
1984	111,462	438	305
1985	115,415	422	316
1986	109,447	415	300
1987	115,269	435	316
1988	127,129	461	348
1989	133,333	497	365
1990	136,738	508	375
1991	126,879	469	347
1992	122,817	472	337
1993	114,901	426	315
1994	116,578	433	319
1995	122,326	449	335
2004*	150,000	530	410
2020*	200,000	665	550

Notes: * Based on Transport Canada Medium Growth Scenario Forecast

¹ Peak Day - 95th Percentile Criteria

² Average Day = Annual Total Aircraft Movements / 365 days

Figure 5.7 OMCIA Noise Exposure Forecast 2004 - Low Growth Scenario

Figure 5.8 OMCA Noise Exposure Forecast 2004 - Medium Growth Scenario

Figure 5.9 OMCA Noise Exposure Forecast 2004 - High Growth Scenario

5.3 Complaint Data

The OMCIA administration keeps noise complaint files in its Noise Management Division. The records identify who, when, where, and why people have complained against aircraft operations. Every time that someone makes a complaint, the Noise Management Division fills out an information sheet.

Table 5.4 shows number of complaints received by OMCIA Noise Management Division between 1988 and 1995. The number of noise complaints coming from areas around OMCIA has shown a significant increase in the last eight years, except for 1995. This decline in the number of complaints is most likely because of a restriction during the summer months of the use of runway 32 as applied to jet aircraft nighttime operation from 23:00 to 07:00 hrs (Canada Gazette, 1994).

This increasing number of complaints coming from areas around OMCIA in the first half of the 1990s while the aircraft movements have remained almost unchanged suggests that a significant population growth has happened over its surrounding areas affected by aircraft noise. Such a situation also indicates that land-use control and regulations have not worked properly to avoid incompatible land development and use change.

As a first step for dealing with complaints, a spreadsheet was created with related data using QUATTRO PRO (version 6.0) software. In the spreadsheet each complaint became a line (database row) containing: order number, incident date and time, complainer's name, address and phone number, type of aircraft, operation time, reason for complaint and observation of airport personnel concerning that event. It was used to quantify the number of complaints as well as to identify the areas which they are coming from. Then, with the

name, address and phone number provided, the complaints were individually plotted on a National Capital Region map (scale of 1:25,000) produced by Pathfinder Corporation. All complaint data included in this research work is presented in an aggregate format since complainer's identification data are a confidential information.

Table 5.4 Ottawa Macdonald Cartier International Airport

- Noise Complaint Records 1988/ 1995

Month\Year	1988	1989	1990	1991	1992	1993	1994	1995
January	0	0	2	1	2	9	6	10
February	1	0	0	2	6	11	5	8
March	1	2	5	4	4	19	13	12
April	3	1	4	4	1	11	19	7
May	4	1	4	3	1	12	16	14
June	5	6	2	5	6	23	11	17
July	1	6	11	9	4	34	11	14
August	0	10	10	7	10	33	82	20
September	1	10	7	1	15	33	65	18
October	0	0	5	1	15	12	17	20
November	1	2	2	1	17	8	3	9
December	0	0	2	1	6	10	5	3
Total	17	38	55	40	80	215	253	152

Source: Noise Management Division - OMCIA

There were several problems regarding a proper identification and location of some complaints. Firstly, complainers may not have given a complete address and/or full name, and airport personnel responsible for keeping complaint files may not have filled out the complaint

sheet with all information required. In this research work, a great deal of attention was placed in correctly identifying and locating each complaint. Thus, every complaint was plotted in a map of the research area which already had its historical annual noise contours drawn to the same scale. When there was not enough information to locate it, a software called Canadaphone was used. This software has very helpful features to find any person by searching on a name, in that it can give the address, phone number and postal code, or proceeding backwards from a phone number, it can provide a matching name or address list. Despite the efforts to assure that complaints were fully and correctly located, there still were some complaints that could not be located since there were no basic data such as name or address or phone number. Secondly, some of the complaints came from areas situated outside the 20 NEF noise contour line and, thus it was not possible to have a noise level reading for that particular location. Any repeated complaints reported by the same person within a 24 hours period were also included in this category.

Data regarding complaints in 1988 were not used in this research because of the lack of reliable and detailed records on aircraft movement, fleet composition and runway used required to generate historical noise contours. The complaints in 1989 were plotted on 1990 historical noise contour map since the annual and peak planning day movements were almost identical.

Table 5.5 shows these complaints around OMCIA according to its cause (aircraft or helicopter) and if it were identified, its location and noise level reading.

There were 834 complaints from 1989 to 1995. However, after identifying and classifying them, only 421 were considered useful data points in this research.

Table 5.5 OMCIA - Description of Noise Complaint Data from 1989 to 1995

Year	Total	Helicopter	Aircraft	Not Located	Not Reading	Data Points
1989	42	4	38	9	6	23
1990	55	4	51	13	11	27
1991	40	8	32	12	1	19
1992	80	31	49	5	5	39
1993	215	77	138	14	22	102
1994	250	24	226	48	36	142
1995	152	29	123	32	22	69
Total	834	177	657	133	103	421

Source: Ottawa Macdonald Cartier International Airport - Noise Management Division

Using a GIS software - Environmental Planning and Programing Language Version 7 (EPPL7), the complaint data points for each year were transferred to GIS maps which had lines defining noise contours for that particular year, and census tract boundaries. Figures 5.10, 5.11, 5.12, 5.13, 5.14, 5.15, and 5.16 present noise complaint maps from 1989 to 1995 which have complaint data points identified by an "x" mark. It should be noted that most of the complaints came from areas covered or near the noise contours, or are under the aircraft approach and take-off pathway. Areas within very high noise exposure levels have not presented a significant number of complaints because they are mainly low-populated. The most notable number of complaints came from the region north of the airport. However, in the last two years, 1994 and 1995, complaints started coming from the areas south of the OMCIA.

Figure 5.10 OMCIA Noise Complaint Map - 1989

Complaint Data Points 1990

5.4 Population and Land Area Data

Another set of data that became essential to evaluate the increasing noise complaints in the areas influenced by aircraft noise around OMCI A included in this case study is the evolution of population. The data collected by Statistics Canada (1992) regarding the Ottawa-Hull region in census tracts (neighbourhoods) every five years was the major source of information. These data are published in the "Profiles Series - Part A" containing basic demographic, mother tongue, dwelling, household and family information for all households, that is, on 100% basis. The demographic data also include population and land area for each tract. It allows a calculation of population density for different areas around OMCI A.

The latest census data available from Statistics Canada for the Ottawa-Hull region are that for 1991. It also presented population figures for 1986. Figure 5.17 presents a RMOC map (scale of 1:75,000), enclosed into that document ("Profile Series - Part A"), showing census tract limits and numbers in red. By using this map and respective census tract data, it is possible to determine the 1986 and 1991 population densities for each tract. The census data and tract boundaries are also available in 3½" disk for plotting with GIS.

It was not possible to use official records from 1996 Statistic Canada Census, because the data will not be released until the middle of 1997. Therefore, a demographic study carried out by the RMOC - Planning Department (1993) was used. This study contains projections for 1996 and 2001 with data on population, age group, dwelling, employment and income. These data were used to calculate population density and other data involved in this case study for 1992, 1993, 1994 and 1995. Table 5.6 presents population and land area (km²) for the census tracts included in this study.

Figure 5.17 Statistics Canada Census Tracts Map - Ottawa Hull Region

Table 5.6 Census Tracts Population and Land Area - 1986/1991/1996/2001

CensusTract	Pop1986	Pop1991	Pop1996	Pop2001	Area	PopChange86-91	IncRate86-91
001.01	6570	7443	7002	6722	2.4	13.3	0.0253
001.02	6033	10468	13253	14471	4.8	73.5	0.1165
001.03	44	5033	7241	7826	5.2	11338.6	1.5803
002.01	3654	3406	3209	3122	2.5	-6.8	-0.0140
002.02	3732	3724	3809	3645	1.4	-0.3	-0.0004
002.03	6670	7716	7317	6976	5.6	15.6	0.0296
002.04	1	30	303	698	1.6	29.0	0.0744
003.00	4969	5064	4820	4652	3.0	1.8	0.0038
004.00	3723	3818	3665	3616	1.8	2.6	0.0051
020.01	5905	5800	5485	5291	5.6	-1.9	-0.0036
020.02	2579	2477	2404	2326	1.5	-4.0	-0.0080
021.00	6519	6431	6108	5889	1.9	-1.4	-0.0027
022.00	6104	5852	5563	5365	1.6	-4.1	-0.0084
023.00	6468	6334	5980	5357	1.9	-2.2	-0.0042
024.00	3489	3337	3160	3059	1.2	-4.5	-0.0089
025.00	5511	5376	5095	4919	2.3	-2.5	-0.0049
026.00	5878	5396	5096	4917	1.8	-8.2	-0.0170
027.00	4051	4374	4156	4015	0.7	8.5	0.0164
028.00	6478	6573	6214	5990	1.8	1.5	0.0029
029.00	4964	4972	4715	4552	1.1	0.2	0.0003
030.00	6686	6777	6458	6224	1.9	1.3	0.0027
031.00	5544	5409	5110	4931	0.9	-2.4	-0.0049
032.01	3275	3165	2990	2895	0.8	-3.4	-0.0068
032.02	5397	5375	5151	4951	1.6	-0.5	-0.0008
033.01	4207	4332	4143	4003	1.1	3.0	0.0059
033.02	2908	2950	2798	2711	0.9	1.3	0.0029
123.01	3767	4941	4783	4065	1.8	31.1	0.0558
123.02	4896	5617	5497	5357	4.2	14.6	0.0279
126.00	4389	4356	5233	11022	16.2	-0.9	-0.0015
127.00	4693	4596	4656	4541	18.5	-2.2	-0.0042
130.01	3871	3620	3743	3906	10.6	-6.5	-0.0153
130.02	4406	5038	4923	4832	1.2	14.3	0.0272
131.01	5081	5830	5698	5666	1.5	14.6	0.0279
131.02	5126	5136	5037	5012	1.5	0.2	0.0004
132.00	6529	6052	5894	5860	1.9	-4.5	-0.0089
133.00	6437	5837	5660	5628	2.2	-9.4	-0.0194
134.00	4544	4130	4062	4046	2.0	-9.1	-0.0189
135.01	6231	6986	6828	6716	1.7	12.0	0.0231
135.02	5772	5877	5741	5611	3.6	1.8	0.0056
135.03	2378	2141	2089	2202	1.6	-10.0	-0.0208
137.01	3834.00	6650	8314	8452	2.8	0.7	0.1158
140.01	1	10	13	16	9.0	9.0	0.5849
140.02	7667	7911	7636	7279	1.0	3.2	0.0063
140.03	3118	3104	3192	3049	0.8	-0.5	-0.0009
140.04	1	5125	5386	5215	1.2	5125.0	4.5200
140.05	2417	5088	4914	4735	1.0	110.5	0.1605
141.00	3316	3394	14934	30928	149.4	2.3	0.0047
200.00	7040	7540	7918	8100	406.6	0.1	0.0138
201.00	3231	4238	4426	4383	4.7	0.3	0.0558

Source: Statistics Canada - Census 1991 and RMOC Planning Department 1993

5.5 Access to the Roadway System

The roadway system regarding major and minor road locations can be an important factor for land development since it increases accessibility for specific sites. Land development in the Ottawa-Carleton is particularly attached to the road network since all utilities and services are implemented or expanded within the road right-of-way. In addition, according to the regional zoning and by-laws no new development is allowed if there is no access to that particular site.

An official road map at in 1:25,000 scale provided by the Transportation Planning Division from Regional Municipality Ottawa-Carleton (RMOC) together with a Pathfinder City Map on the same scale were used as a basis to locate and to measure the orthogonal distance from the complainer's dwelling and the nearest road.

In addition, a license obtained from the RMOC (July, 1996) allowed the use of a database with .DXT format file containing geographic information covering the regional road network. The file contains all the roads within the borders of the region and the proper Universal Transversal Mercator (UTM) co-ordinates. This file was incorporated into the digitizing module and adjusted to fit the size of the study area around OMCIA using a GIS software package (EPPL7). The road network could then be overlaid onto any of the raster images for plotting purposes.

The shortest orthogonal straight-line distance to the nearest regional road from the location of each complaint was measured on the road map. This was done for each complaint in each census tract and for each year of the data. An average distance to the nearest road was calculated for all census tracts that had complaints in a particular year.

5.6 Data Analysis

5.6.1 Aircraft Movements and Noise Complaints

The aircraft movements at OMCIA have been quite steady with an annual growth rate of 1.0 % over the last 15 years. On the other hand, according to Transport Canada records (1985) in the beginning of the 1980's, the number of complaints around OMCIA were stabilized at an average of 25 complaints per year. However, the number of complaints has increased significantly in the last 7 years.

Figure 5.18 shows that, apparently, there was another factor or factors affecting complaints from surrounding areas. It can be noted by the changes in the rate of complaints. There used to be one complaint for every 5,000 to 6,000 aircraft movements in the 1980's. This rate started increasing to one complaint for every 1,500 to 3,000 in the early 1990's. By 1993, it increased again to one complaint for every 500 to 1,000 aircraft movements. In 1995, there was a reduction in the number of complaints coming from Nepean on the north side of the airport.

This research work is aimed at gathering empirical data to analyze if urban development, particularly towards the OMCIA north boundaries, has increased in population density in its vicinity and, consequently affected the level of complaints against aviation noise.

It is also argued that this urban encroachment of the airport may have been fostered by increases in the road access system capacity.

Figure 5.18 OMCIA Total Annual Aircraft Movements and Noise Complaints

5.6.2 Population Density Study

Factual Analysis

In order to initially evaluate the evolution of population density in the OMCIA region, a review based on aerial photos taken by the Canadian Air Force, (acquired at the National Air Photo Library), allowed a *de facto-analysis* of the land development and urbanization process. The photos covered the southern area of Ottawa-Carleton (South of Ottawa River) from 1952 to 1994.

The first set of photos marked on map number A13510, taken in 1952, was only available at the 1:1,320' scale. All other photos were taken on the 1:50,000 scale. The 1952

photos (see Appendix L) show the OMCIA after the construction of runway 07-25 and 14-32. It can be seen that the natural vegetation cover of the terrain adjacent to these new runways has been removed, probably because of the construction works. It also shows on these pictures that Bowesville Road's and Uplands Road's initial alignments crossed over runway 07-25. Land development was mostly concentrated adjacent to Carling Avenue. A few development pockets started close to Merivale and Baseline Road, that had just been built. At that time there was no development near OMCIA.

The second set of aerial photos was taken in 1977. It is comprised of five photos that were superimposed over each other creating a mosaic depicting an aerial view of the study case area in that year (see Appendix M). From these aerial photos, it can be observed that development has started in the areas south of Baseline, particularly between Merivale Road and Highway 16, and was just beginning between MacFarlane Road and Fallowfield Road west of the Rideau River. Barrhaven is under an initial development phase as well. The development process of Hunt Club Area has also begun. The southern part of Hunt Club Road is rural with few farm houses. It is important to point out that the first version of the Guidelines for Land-Use Planning around Airports (Transport Canada, 1973) was already published. At that time, there was adequate technology to forecast aircraft noise and to draw noise contours lines using large computer hardware receiving input from card deck and output and drawings on small paper (8.5"x11") and large scales around 1:200,000.

In the third set of photos taken in 1988 (Appendix N), it is clear that the development process has been completed in the area between Merivale Road and Highway 16, and it has moved west towards Woodroffe and Greenbank Road. Barrhaven residential development

has been fully established. The Hunt Club area is going through a fast development process, but a few vacant land sites still remain. Land development has also occurred in Gloucester near Albion Road, Highway 31 and Hunt Club Road including Blossom Park and Kemp Park to the east and southeast of the OMCIA. Further development growth occurred in the southwest in Manotick. New houses were also built on the east side of Rideau River. These developments and increasing density over the north side of the airport could have precipitated the increases in noise complaints that started in 1990.

Examining the last set of aerial photos taken in 1994 (see Appendix O), the actual conditions of the development process can be visualized. The OMCIA region has become more dense and sometimes crowded, particularly in the north (Nepean), west (Nepean and Barrhaven), and east (over Gloucester). The land development has led over the years to a continuous urban encroachment of the airport surroundings. This situation brought people and new communities to areas influenced by aircraft noise, and reflected in the number of complaints.

By reviewing these aerial photos covering a span of more than 40 years, it can be argued that a continuous urban development trend has definitely been heading south guided by roadways. Moreover, city limits have been expanding from previous delimitations (Carling Avenue) to new ones further south (Hunt Club Road). According to the RMOC Official Plan (1994), it appears that this urbanization process will soon reach Regional Road 8 to include Barrhaven and southern parts of Gloucester.

Census Tracts Analysis

The census tracts located in the OMCIA region were listed and their population density calculated for 1986, 1991, 1996 and 2001 (Figure 5.17 and Table 5.6), to produce numerical data corresponding to the variation/increasing of population density over the last decade.

Reviewing Statistic Canada census tracts near OMCIA, for the period 1986 to 1991:

- areas in Hunt Club with census tract numbers 001.01, 001.02 and 001.03 experienced very large average annual population growth rates up to 158%;
- other tracts still in the Hunt Club area such as 002.03 and 002.04 show an annual growth rate of 3% and 97%, respectively. The latter census tract is located at the end of runway 32 and it should certainly be under very heavy impact of aircraft noise (see Figures 5.1, 5.2, 5.3, 5.4, 5.5 and 5.6);
- areas located in Nepean, across the Rideau River on the extension of the runway 32 centerline such as census tract number 131.01 and 130.02 had an average annual growth of approximately 2.7%;
- on the east side of the airport, in Gloucester, census tract 123.01 and 123.02 experienced an average annual population growth of 5.6% and 2.8%, respectively; and
- another large population increase occurred in Barrhaven, where census tracts 140.04 and 140.05 show an annual average growth of 452% and 16% respectively.

Adopting the RMOC - Planning Department Demographic Study (1993), population growth in the census tracts near OMCIA can be analyzed for the time frame from 1991 to 1996:

- areas in Hunt Club with census tract numbers 001.02 and 001.03 have continued to grow at an annual average rate of 4.8% and 7.6%;
- census tract 002.04 in Hunt Club, a few hundred metres from the end of runway 32, has also shown an annual average population growth of 58.8%;
- census tract 140.04 in Barrhaven has grown an annual average rate of 1%;
- and
- rural areas on the south and southwest of the OMCIA covered by census tracts 126.00 and 141.00 have respectively presented an annual growth rate of 3.7% and 34.5 %.

The population change for areas around OMCIA can be visualized by looking at the maps shown in Figures 5.19, 5.20, and 5.21. These maps (derived via GIS techniques) present census tracts covering the study area with changes that occurred from 1986 to 1991, 1991 to 1996, and RMOC projections from 1996 to 2001. Figures 5.22, 5.23, 5.24 and 5.25 present the evolution in terms of population density observed and projected for the census tracts affected by aircraft noise in the OMCIA region. In these figures, census tracts showing high population growth over the last ten years are exactly the ones that have also generated most of the complaints. In addition, the population growth projected to the year 2001 may just intensify the complaint activities coming from the south of OMCIA.

Figure 5.19 OMCIA Region - Population Change from 1986 to 1991

Figure 5.20 OMCI Region - Population Change from 1991 to 1996

Figure 5.21 OMCIA Region - Population Change from 1996 to 2001

Figure 5.22 OMCIA Region - Population Density 1986

Figure 5.23 OMCIA Region - Population Density 1991

Figure 5.24 OMCLIA Region - Population Density 1996

Figure 5.25 OMCIA Region - Population Density 2001

Figures 5.26, 5.27, 5.28, and 5.29 present four maps with population density data over the same census tracts based on the growth scenarios defined by the RMOC - Planning Department in the document "How Should We Grow ?"(RMOC 1995). Each growth scenario presents a specific focus to the regional development indicating particularly population change projections in 2021.

In the Current Plan scenario, according to the RMOC Official Plan (September, 1994), three suburban areas are designated as growth areas. If the projected population of 1 million in the year 2021 were accommodated within currently-designated urban land boundaries, population should be distributed as follows:

- Suburban Areas: The West would triple in size to a population of 125,000.
The South would grow to five times its current size to 112,000.
Orleans would double its current size to 135,000.
- All other urban population growth(55,000 people) would occur inside the Greenbelt.
- The rural area would continue to get the same share of growth as it has in the 1980's.

In the West Focus scenario, the western suburbs grow to five times what they are today reaching a population 185,000 by the year 2021. South Nepean and Barrhaven will more than double from 22,000 to 51,000. In the South of OMCIA, population will increase thirty times going from 1,000 to 30,000.

The Southwest Focus scenario concentrates growth in South Nepean and represents approximately 105,000 people in the Barrhaven area above population for a new total of 127,000 people. The rural areas population will go from 64,000 to 101,000. In the south of the OMCIA, population will be thirty times higher from 1,000 to 30,000 people in 2021.

Figure 5.26 OMCA - Population Density 2021 - Current Plan

Figure 5.27 OMCIA - Population Density 2021 - Southwest Focus

Figure 5.28 OMCA - Population Density 2021 - West Focus

Figure 5.29 OMCA - Population Density 2021 - Southeast Focus

The Southeast Focus scenario emphasizes a development strategy on the Gloucester side of the Rideau River, south of the airport, where the population will jump from 1,000 to 105,000 people by 2021. South Nepean and Barrhaven will experience a population increase from 22,000 to 51,000.

A brief analysis of these four growth scenarios for the RMOC suggests that, for the lowest growth scenarios over the areas near OMCI, there will be an additional 29,000 people living on lands south of the airport. Another 29,000 people will be moving to the South Nepean and Barrhaven areas. Despite these areas being respectively located south of the Leitrim Road, that is the OMCI property boundary, and over the extension of runway 25 across the Rideau River, the only related observation made in that planning document (RMOC, 1995) for the Southeast Focus scenario is that there will be airport noise impacts in areas west of Leitrim. However, and as was seen in the past, in the areas to the north of the airport (particularly in Nepean and Hunt Club), land development west and south of Leitrim Road will allow people to move into areas affected by aircraft noise.

In the lowest growth scenarios (West Focus and Southwest Focus) that kind of development indicates a total population increase of 2,800% up to the year 2021. This population growth, for census tract 126 located south and census tract 141 on the west of airport boundaries, will represent densities between 1,500 to 3,500 people per square kilometre in the 2020's. As a result, aircraft noise problems with neighboring communities will tend to be drastically aggravated since many more people will be exposed to high levels of noise. In addition, people moving to these areas south of the airport southern areas will be expecting a calm and quite rural kind of life and, thus, they will be more likely to complain

about any disturbance caused by aircraft noise.

Unfortunately, it was not possible to find in the literature a methodology to ascertain the aircraft noise impacts in terms of complaints to land development and subdivision proposals. Moreover, road system changes included in the Official Plan (September, 1994) over those areas in the south of OMCIA, particularly the alignment of Limebank Road and Bowesville Road extensions have not addressed its effects on the development of its adjacent land. Consequently, population density will likely increase over time bringing more people to live in noisy areas.

5.6.3 Assessment of Roadway Location on Population Density

The effects of roadway location around airports in terms of fostering land development and increasing population density over adjacent areas needs to be assessed. In this research work, information regarding orthogonal distance from a complainant's dwelling location to the nearest road was gathered as a "proxy" variable to that specific site accessibility measure. Population density to that same site was also calculated based on available data for the census tract in which complainant's dwelling was located.

After classifying population density in intervals, as presented in the Table 5.7, the average orthogonal distance from the nearest road for specific density intervals using data observed in the OMCIA region was calculated.

Table 5.7 Population Density and Distance to Nearest Road - OMCIA Region

Population Density (people/km ²)	Distance to Nearest Road (km)
0 - 999	0.18
1000 - 1999	0.25
2000 - 2999	0.34
3000 - 3999	0.27
4000 - 4999	0.30
> 5000	0.45

Using SPSS software, the density and distance variables were analyzed to find the best functional relationship between the distance from the nearest road and population density. Taking the middle point in the population density interval as an independent variable and distance to the nearest road as dependent variable, it was found that a cubic and a power model provide a good fit for the data obtained in the areas around OMCIA. As presented in the Appendix P, the best coefficient of determination was found for a cubic model ($R^2 = 0.92$). However, it was noticed that the level of significance for Fischer test ($\text{Sig} = 0.119$) indicated large variance between observed and estimated values. Therefore, applying the equation at high population density levels would not produce coherent results. Thus, taking into consideration that, on average, in RMOC urban/suburban settings, roads are situated between 800 metres (half mile) and 1,600 metres (1 mile) from each other and, consequently, people will not be farther than 800 metres from roads, and that usually people living in rural areas would settle near to the existing roads, it was decided to adopt the power model that explain

better the relation between average distance to the nearest road and population density. These two models and the data collected in this research are shown in Figure 5.30. The power model can be expressed according to the following equation:

$$Y = b_0 (t^{b_1}) \Rightarrow Y = 0.027444 (t^{0.302599})$$

$$R^2 = 0.7512 \quad F = 12.33 \quad \text{Sigf} = 0.024$$

where:

- Y is the dependent variable, in this case distance from the nearest road (km);
- b_0 is the regression coefficient;
- b_1 is other regression coefficient; and
- t is the independent variable, in this case population density (people/km²).

The data from the areas around OMCIA did not allow for a consistent analysis for population density over 5,000 people per square kilometre, because the size and location of the study case region, mostly comprised of suburban and rural areas. The power function expressing the relationship between distance from the nearest road as a function of population density will be used as a part of the road location model near the airport to identify the areas adjacent to the alignment of new, extended or improved (paved or enlarged) road that can have its development affected by this road. Further analysis can be performed based on proposed future development and population density presented in the latest RMOC Official Plan (1994).

Figure 5.30 Distance to the Nearest Road vs Population Density Around OMCIA

5.6.4 Analysis of Aircraft Noise Levels, Complaints and Population Density

In the present analysis, levels of noise which people had been exposed to were defined by the historical noise contours based on the NEF method for each year from 1989 to 1995. The percentage of people who had complained was calculated by dividing the number of complaints by the population of that area, as defined by noise contours and census tract limits. To determine the percentage of people who complained under specific levels of noise exposure, an assumption had to be made that accepted an uniform spatial distribution of population within a census tract. The noise contours lines were drawn defining unit levels of exposure in NEF(s) from 20 NEF to 40 NEF. Because of the irregular shapes of noise

contours and census tract boundaries, as well as the spreading of complaints over different areas around OMCIA, these files were superimposed using a GIS software - Environmental Planning and Program Language - Version 7 (EPPL7) available at Carleton University. Noise contours, census tract boundaries and complaints files were prepared/digitized to be used in this computer program.

At first glance, one could imagine that the number of complaints would increase proportionally to the population density under the same level of exposure to aircraft noise. However, population density seems to be a valuable "proxy" to reflect people's way of life. Hence, a population density below 1,000 people per square kilometre may indicate that there is a rural setting or large suburban lots which means an appreciation for a secluded and more private way of life. Of course, people who enjoy such rural or suburban settings should also like the quietness and calm environment where they choose to live. Therefore, they would more likely complain against any disruption, and much more often even under lower levels of noise than people living in urban areas with more crowded and noisier conditions.

Table 5.8 presents the data regarding noise levels and complaints according to the population density compiled by the EPPL7 package software. In the EPPL7, each specific area under particular noise level was calculated, and then multiplied by its density to determine the number of people exposed to that noise level. After, the number of complaints in that specific area was divided by the number of people exposed to find the percentage of complaint. There are missing values in this table because no complaint was found for that specific noise level and population density in the OMCIA region. When looking at the first range of population density (<999 people/km²), it is possible to realize that percentage of

complaints become much higher than can be noted from other higher density levels. Over this first range of population density, a great variation in the percentage of complaints can be attributed to a large difference verified in the density levels from 5 to 926 people per square kilometre. This variability can suggest the environment and physical settings where complainer is living which may reflect on his/her perception and response to aircraft noise. In addition, a complaint in a very low population density area could cause a much greater impact on the percentage of complaints since the total population in that area is quite small.

Table 5.8 Percentage of Complaints as Function of Noise Levels and Population Density

NEF	Density (<999)	Density (1000-1999)	Density (2000-2999)	Density (3000-3999)	Density (4000-4999)	Density (>5000)
< 20	1.07419	0.05746	0.04502	0.04701	0.03722	0.02282
20 - 21	2.5526	0.17680	0.26048	0.33563	0.17218	0.03519
21 - 22	0.64263	0.16183	0.15331	0.24022	0.14399	
22 - 23		0.32696	0.59718	0.17299	0.08525	0.12572
23 - 24			0.25327	0.18234	0.16900	0.04363
24 - 25	3.48595	0.16086	0.2375	0.29987		0.06609
25 - 26	18.6237	0.18252	0.30783	0.38523	0.21174	0.10082
26 - 27	48.0925	0.22972	0.32858	0.33764	0.33575	0.0630
27 - 28	1.04751	0.27090	0.44612	0.19696		0.07114
28 - 29	1.57388		0.68284	0.42197		
29 - 30	2.65576		0.86401	0.70000		0.25929
30 - 31	63.8280		0.90550			
31 - 32	87.8920					

A statistical regression analysis was carried out for each population density interval taking into consideration that in this research the intervals expressed specific lifestyle patterns. This analysis was supported by the SPSS software for Windows, release 6.0, that performed multiple curve-fitting models based on the numerical values shown in Table 5.8. In this work, it is specified that the percentage of people who complain against aircraft noise is a dependent variable, and the aircraft noise level in NEF is the independent variable under specific land use represented by the population density. The results of the statistical regression analysis are presented in Appendix Q.

The regression analysis of this data explored functional relationships among these variables to be used as an analytical tool in the GIS-based road location method. The SPSS software tested data from Table 5.8 with linear, logarithmic, quadratic, cubic, power and exponential functions.

Taking into consideration that people's perceptions and reactions to aircraft noise is quite subjective, and the variations between the forecasted noise levels and the real noise climate to which the individuals were actually exposed, the best curve fit was found to be the cubic function with correlation of determination (R^2) varying from 0.55 for the lowest population density interval (<999 people/km²) to 0.76 for the density between 2,000 and 2,999 people/km².

Therefore, it was adopted the cubic function for transformation of the levels of exposure to aircraft noise, as a stimulus, into the subject response represented by the percentage of complaints.

$$Y = b_0 + b_1 t + b_2 t^2 + b_3 t^3$$

where: Y is the percentage of people who complaint against aircraft noise;

b_0 is a constant;

b_1 is a coefficient;

b_2 is a coefficient;

b_3 is a coefficient; and

t is the level of exposure to aircraft noise measured in NEFs.

As explained in Chapter 4, this functional relationship was applied to specific ranges of population density that mean variations observed in the land-use. Later, the following two equations were implemented as friction factors in the GIS-based road location method.

Rural areas and large suburban lots (very low density) => density from 0 to 999 people/km²

$$C = 141.573 + (0.0000866 \text{ NEF}) + (-0.797 \text{ NEF}^2) + (0.023 \text{ NEF}^3)$$

$$R^2 = 0.55 \quad SE = 23.24 \quad F = 4.90$$

Suburban (low density) => density from 1,000 to 1,999 people/km²

$$C = 0.1209 + (0.0017255 \text{ NEF}) + (-0.00047 \text{ NEF}^2) + (0.0000235 \text{ NEF}^3)$$

$$R^2 = 0.66 \quad SE = 0.04 \quad F = 4.92$$

Suburban (medium density) => density from 2,000 to 2,999 people/km²

$$C = 1.012 + (0.00052 \text{ NEF}) + (-0.0056 \text{ NEF}^2) + (0.000182 \text{ NEF}^3)$$

$$R^2 = 0.76 \quad SE = 0.15 \quad F = 14.20$$

urban (high density) => density from 3,000 to 3,999 people/km²

$$C = 0.944 + (0.0000858 \text{ NEF}) + (-0.00485 \text{ NEF}^2) + (0.00015 \text{ NEF}^3)$$

$$R^2 = 0.59 \quad SE = 0.12 \quad F = 5.678$$

urban (very high density) => density from 4,000 to 4,999 people/km²

$$C = 0.744 + (0.00001678 \text{ NEF}) + (-0.0046 \text{ NEF}^2) + (0.000152 \text{ NEF}^3)$$

$$R^2 = 0.74 \quad SE = 0.059 \quad F = 5.80$$

urban (extremely high density) => density from 5,000 people/km² and up

$$C = 0.4498 + (0.000131 \text{ NEF}) + (-0.0025 \text{ NEF}^2) + (0.0000763 \text{ NEF}^3)$$

$$R^2 = 0.63 \quad SE = 0.050 \quad F = 5.08$$

Figure 5.31 presents the plotting of aircraft noise response (complaint) functions that resulted from the regression analysis according to the population density intervals adopted in this research.

Figure 5.31 OMCIA Aircraft Noise Response (Complaint) Functions

The noise response function found for the population density below 999 people/km² does not agree with the other functions. The function transformation of aircraft noise in terms of complaints for population density below 999 people/km² is plotted on the right Y axis while all others are indicated on the left Y axis.

5.6.5 Sensitivity Analysis of the Transformation Response Functions

Sensitivity analysis can be used to estimate the accuracy of the functions to transform aircraft noise stimulus in the people's response in terms of complaints for specific land-use represented by population density levels. In this case, the sensitivity analysis is performed by varying the input variable - level of exposure to aircraft noise measured in NEF - and verifying the outcome of each transformation function in terms of projected number of complaints. This analysis allows a determination of how accurate these functions are, before applying them in the GIS-based road location method for the OMCIA.

In this analysis, the cubic functions were tested to reproduce the data in terms of number of useful complaint data points that this research has gathered. Each function was used for calculating the number of complaints that originated from a census tract that falls within defined population density intervals and aircraft noise exposure levels.

The sensitivity analysis calculation process was also performed using EPPL7 capabilities. As a result, the projected number of complaints found by using those cubic functions are presented (right columns) in Table 5.9 which also contains the observed initial set of data points (left columns) to allow a better visualization of the replication accuracy.

Table 5.9 Sensitivity Analysis Results

NEF	Density (< 999)		Density (1,000-1,999)		Density (2,000-2,999)		Density (3,000-3,999)		Density (4,000-4,999)		Density (>5,000)		Total	
	Obs	Proj	Obs	Proj	Obs	Proj	Obs	Proj	Obs	Proj	Obs	Proj	Obs	Proj
<20	19	897	29	83	22	155	39	188	1	3	5	13	117	1339
20-21	2	4	1	1	9	8	5	11	1	1	1	1	19	26
21-22	2	7	1	1	7	7	8	8	2	3	-	-	20	26
22-23	-	-	3	2	5	2	8	11	4	7	2	1	22	23
23-24	-	-	-	-	5	6	5	8	7	6	1	1	18	21
24-25	2	3	1	1	4	5	21	17	-	-	2	2	30	28
25-26	4	21	2	3	6	8	20	16	1	1	1	1	34	50
26-27	6	55	3	4	3	5	22	16	2	2	1	2	37	84
27-28	5	98	2	3	8	10	5	12	-	-	3	6	23	129
28-29	20	361	-	-	8	7	5	10	-	-	-	-	33	378
29-30	14	203	-	-	3	3	2	4	-	-	2	2	21	212
30-31	12	43	-	-	1	11	-	-	-	-	1	4	14	58
31-32	10	9	-	-	1	5	-	-	-	-	-	-	11	14
32-33	5	11	-	-	-	-	3	19	-	-	-	-	8	30
33-34	5	30	-	-	-	-	-	-	-	-	-	-	5	30
34-35	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35-36	1	187	-	-	-	-	-	-	-	-	-	-	1	187
Total	109	1929	42	98	80	232	151	320	20	23	19	33	421	2635

The overall outcomes for those transformation functions are not consistent with the 421 points observed in the initial data set presented in section 5.3 (Table 5.5). Examining Table 5.9, the source of the major discrepancies becomes clear. Major errors are concentrated in the lowest population density interval (<999 people/km²) and from the areas with noise level below 20 NEF as well as above 30 NEF.

The result and deviations in the population density below 999 people/km² could be anticipated by the curve-fitting test which was not satisfactory. The data set obtained from the OMCA complaints records for this density interval did not produce a meaningful result upon critical review. This set of data presented an ambiguous behavior and produced a large standard error and a low correlation coefficient. Therefore, it was expected that the number

of complaints generated by adopting this function (density<999) will not reproduce well when performing a sensitivity analysis. Thus, caution must be taken when dealing with such low population density areas.

In addition, data referring to aircraft noise levels below 20 NEF may be compromised by the number of hypersensitive people who complain no matter what the noise levels are, as pointed out by Schultz (1978), and difficulties/errors associated with the definition of the noise levels since noise contours were drawn starting from 20 NEF. On the other hand, the small number of complaints coming from areas under high levels of exposure to aircraft noise which are mostly concentrated in the very low density population interval (<999 people/km²) did not produce a good agreement over 30 NEF.

Therefore, after reviewing these results it occurred that discarding the data regarding the population density below 999 people/km² and focusing on specific noise levels between 20 and 30 NEF might produce a much better approximation to the initial data set. Table 5.10 shows the set of data/result extracted from Table 5.9 which produced a consistent adherence between observed and projected number of complaints.

It should be pointed out that only two people's response functions concerning aircraft noise are used into the GIS-based method application to the OMCIA region based on the RMOG Official Plan population growth scenarios. These two functions referred to densities between 1,000 and 1,999, and 3,000 and 3,999. Therefore, in this research there will be no problem not considering that function (below 999 people/km²). Moreover, the areas around OMCIA, where roads are proposed according to the Official Plan, will probably be exposed to levels of noise between 25 NEF and 30 NEF, as shown in Figures 5.26, 5.27, 5.28, and

5.29 (section 5.6.2).

Table 5.10 Specific Sensitivity Analysis

NEF	Density (1,000-1,999)		Density (2,000-2,999)		Density (3,000-3,999)		Density (4,000-4,999)		Density (≥5,000)		Total	
	Obs	Proj	Obs	Proj	Obs	Proj	Obs	Proj	Obs	Proj	Obs	Proj
20-21	1	1	9	8	5	11	1	1	1	1	17	22
21-22	1	1	7	7	8	8	2	3	-	-	18	19
22-23	3	2	5	2	8	11	4	7	2	1	22	23
23-24	-	-	5	6	5	8	7	6	1	1	18	21
24-25	1	1	4	5	21	17	-	-	2	2	28	25
25-26	2	3	6	8	20	16	1	1	1	1	30	29
26-27	3	4	3	5	22	16	2	2	1	2	31	29
27-28	2	3	8	10	5	12	-	-	3	6	18	31
28-29	-	-	8	7	5	10	-	-	-	-	13	17
29-30	-	-	3	3	2	4	-	-	2	2	7	9
Total	13	15	58	61	101	113	17	20	13	16	202	225

In general, the number of complaints for each population density interval reproduced well the initial data set. However, specific values have been on average replicated with 80% of accuracy when there are more complaints, despite the fact that some may have just produced around 50 % when number of complaints are low. Because these functions deal with people's perception and reaction to noise, this should be expected when applying its results into the GIS-based road location method.

Chapter 6

GIS-Based Road Location Method Near Airports

6.1 Introduction

The land-use and development implementation strategy requires a long term view of the planning goals to be achieved at the very early stages of its development. It has been mainly emphasized that roads and highways should serve land-use planning instead of dictating it (Leung, 1989). In fact, roadway planning regarding location and alignment have not supported official land-use planning. This situation has been particularly true in the context of urban fringes near airports in medium-sized cities where roads are built over vacant land without an effective consideration of the development impacts on adjacent corridors.

The geographical information system (GIS) technological evolution has brought new opportunities to the study of land use and roadway system. This thesis used two GIS software packages: the Environmental Planning and Programming Language (EPPL) Version 7 and IDRISI Version 1.01 to develop a road location method near airports.

This chapter presents the development and application of the GIS-based road location method to areas around OMCIA, where new links (roads) have been included in the RMOC Official Plan (see Appendix B).

6.2 Framework for the Method

6.2.1 Preliminary Considerations

Traditional land use-transportation models have sought to predict the location and travel consequences of an existing, proposed or assumed future network and forecasts of variables such as population, households, employment, car ownership, and others. These models take roadways (network), in particular, a road system, as input. In addition, when an increment on the road network is required to attend a specific growth or new activity/development a link is added between an existing node and the centre of that growth/new zone. Little or no attention is paid to the specific location/alignment of this new link. The basis for the development of the road location method near airports comes from fundamental principles that interrelate land use and transportation:

“Urban form is largely a function of the underlying transportation network. *Development occurs adjacent to the transportation network where it can most easily be served.* Transportation networks are influenced by many factors that shaped our urban areas. Topography and natural features are major criteria for network locations as well as historical factors. In most cases transportation networks evolve over many years and therefore get built incrementally. The first piece of a network may largely dictate what the rest of the network will look like for many years to come.” (ITE, 1992:35)

6.2.2 Variables Studied

There are two approaches to the model development: deductive (building a model and testing the predictions against observations) and inductive (start with data and try to infer the general model). In the present case, an inductive approach was used by starting from existing data to achieve the final formulation. The location method for roadway near airports is proposed as a mean to produce the best path for a new or extended road alignment near an

airport to minimize the “associate costs” with land development in areas under high aircraft noise levels.

The alignment of a new or extended roads through rural areas close to urban fringes is usually defined by analyzing specific site situation, construction and environmental conditions (Garber and Hoel, 1988):

- existing vacant land for the road alignment (buildings or other structures);
- land ownership (government, local or single-multiple private owners);
- topography of the terrain (flat or rolling);
- soil characteristics;
- natural or physical features (existence of rivers, lakes or other barriers);
- environmentally sensitive areas (wetlands, in dangered species habitats); and
- distance between existing road nodes (minimizing link distance/ length).

In the road location method near airports, two specific characteristics are added in order to account for the aircraft noise impacts over surrounding areas: 1) Peoples’ reaction to different levels of exposure to aircraft noise expressed in terms of percentage of complaints according to the variation in population density; and 2) the effects of road location over adjacent areas (corridors) affected by population density increases.

A GIS software package called IDRISI developed at the Clark University was used in conjunction with the EPPL7 software package to develop this method. Data that are usually analyzed when studying a road alignment/location (such as topography and soil conditions, as well as other environmental characteristics), were kept constant, and thus, did not affect the calculation of “associated cost” regarding to the proposed and alternative links.

Therefore, this application of the proposed method to the OMCIA Region only accounts for the distance between nodes (link length), population density (effects on the road corridor), people's response (percentage of complaints), as shown in Figure 6.1, to define the best pathway according to friction factors. These friction ("cost") factors for the location analysis are provided by the empirical results obtained for the OMCIA region.

Hence, "costs associated" with the percentage of complaints are defined according to the noise levels and population density function. Friction or "cost" factors related to the width of the corridor adjacent to the road alignment are based on the distance to the nearest road and population density function presented in Chapter 5. This GIS-based location method evaluates these variables by summing the "costs" for each possible path to go from one node to another. The GIS pathway solution is the path with the minimum total "associated costs". This method applied to the OMCIA region, indicates the best location for proposed roads which will minimize the potential impacts in areas affected by aircraft noise. The roads location/alignment are plotted as a GIS image. The total "cost" can be presented in a table by cross-tabulating the pathway image and the friction image. Alternative routes to that link can also have their costs calculated/tabulated and their location plotted as an image as well. In the present research work, this alternative solution is represented by the locations proposed in the RMOC Official Plan (Appendix B).

Figure 6.1 GIS General Framework for the Road Location Method

6.3 GIS Softwares - Overview

6.3.1 EPPL7 - Package

EPPL7 was developed at the University of Minnesota in the 1980's. It is a raster-based GIS software specifically designed for geographic decisions, particularly related to environment, land-use and transportation studies.

In EPPL7, a data file (*.EPP) containing information on variables for a given region such as boundaries, population density, road network, land-use, forest cover, elevation, soil characteristics can be assigned a value that represents a class or data level. These classes are stored as rows and columns with each cell representing, in this research, an area of 25 square metres. For the purpose of printing or display, EPPL7 can combine data file with vector overlay files such as roads or boundaries, text files (to label lakes/topographic or other features), and legend files describing the data classes that are displayed.

The EPPL7 package is comprised of four programs : EPPL, DOTPLOT, DISPLAY, and DIGITIZE. It provides the user with capabilities to resize, combine, create and analyze data files. The IMPORT and EXPORT commands allow a user to convert between EPPL7 file formats and file formats created by other packages such as AutoCAD or Quattro Pro.

The DOTPLOT program makes hard copy output of EPPL7 files using a black-and-white or color printer. It also has features to design and include titles, legends and other text.

The DISPLAY program allows a user to produce screen display of EPPL7 files on supported display devices. DISPLAY allows the examination of data files at different scales, in different colors, and using various regrouping of the data classes. For example, by using the LOOK tool, the user can choose an area of interest and by “clicking” on that area, have

all of its characteristics displayed on screen (soil type, climate, population, etc.)

The DIGITIZE program provides a means of data entry for the user. This program has the capability of digitizing maps that match existing data sets or create new data sets. It can also register maps with table or real world coordinates (such as UTM - Universal Transverse Mercator), latitude and longitude, or state plane.

6.3.2 IDRISI Package

To set up the method application another GIS software needed to be adopted. The IDRISI software, developed as a project by the Clark Labs for Cartographic Technology and Geographic Analysis, at Clark University. It has similar capabilities to the EPPL7 program, but also includes several advanced features required for the "costing" and pathway analysis of the proposed roads near OMCIA.

DOCUMENT is one of the most basic commands in the IDRISI software package, which creates and updates documentation files accompanying IDRISI for Windows image, vector and attribute values files.

RECLASS is used to classify or reclassify the data stored in image file into new integer categories. An input regarding the new class (which must be an integer) and the range of old values to be assigned to this new class must be input. The class includes all values equal to or greater than the lower one, and just less than the higher one.

COST is an IDRISI command that generates a distance/proximity surface (also referred to as a "cost" surface) where distance is measured as the least effort in moving over a friction surface. The unit measurement is "grid cell equivalents" (gce). A grid cell equivalent

of 1 indicates the cost of moving through a grid cell when the friction equals 1. A cost of 5 might arise from movement through 5 cells with a friction of 1, or cell with a friction 5. Costs are determined radially from a set of source targets to the edge of the image.

The PATHWAY command determines the least cost route between one or more target cells and one or more lower terminal cells on an accumulated cost surface. PATHWAY is used in conjunction with the COST command. COST determines the "cost" distance from one or more cells to every other cell in a image. Working with this "cost" surface, PATHWAY determines the cheapest route linking the terminal cell and target cell by following the steepest downhill route until no further movement is possible.

Distances are measured according to the minimum number of cells that must be traversed to move from that cell to the nearest source target. Movements are in 8 directions from any cell, and diagonal movements produce a cost of 1.41 times the friction value.

There are two algorithmic procedures incorporated in COST to determine cost distances - a pushbroom algorithm (COSTPUSH) and a growth algorithm (COSTGROW).

The COSTPUSH was used in this research and is considerably faster than the growth algorithm. For this algorithm, it is necessary to input the source image name, the one that indicates from which "costs" the cells should be determined. The source image must be in integer form, with the source point (source node) given a value of one and all other cells given a value of zero. The name of the friction image is also required and must contain real values, with frictions relative to one. Thus a friction of 2.0 indicates twice the base cost to move through that cell. Likewise, a friction of 0.5 indicates half the base cost. Barriers are entered as extremely high relative frictions in the friction image.

6.4 GIS-Based Method Development

6.4.1 Mapping the Variables

Airport Data

The first step for modelling using a GIS software is mapping the variables to be considered. The EPPL7 not only allows for the creation of high-quality maps for presentation or display, but can also perform numerical analysis on the maps as well. The program uses raster images as the basis for any operation. To carry out numerical analysis and comparisons, it is necessary to group all the existing data into very small but similar areas, called mapping the variables. Figure 6.2 shows a diagram of how the data related to the airport activities was mapped.

The ACNOICO*.WB1 table contains all the complaint data for each year from 1989 till 1995. Complaints are numbered in two ways: the census tract area number and the polygon area number used by the raster maps according to the complainer's dwelling address. The COMPFREQ.WB1 contains the data for the number of noise complaints for each census tract and for each year of the study. This was exported to the table file used by EPPL7. The average percentage of complaints was then calculated by defining the number of complaints for a specific noise level (NEF.EPP) and calculating the population for that census tract area using the population density data coming from the census (DENS*.EPP).

Figure 6.2 Airport Activity Mapping

Noise contours for the OMCIA were produced adopting the NEF method. These noise contour drawings were generated as output and stored in YOW*.DXF files. As

described in Chapter 5, historical noise contours from 1990 through 1995, as well noise exposure forecasting for the year 2004 under three scenarios - low, medium and high growth to the aircraft movements - were created as well as noise contours for the aircraft movements equivalent to the existing runway configuration at capacity. The YOW*.DXF files were not spatially referenced, and used arbitrary coordinates based on the end of the runways. In order to incorporate these files into the existing data, latitude and longitude coordinates for each runway end were used. The noise contours had to be rotated to match the correct orientation of the airport, re-scaled to convert from feet to metres and then moved onto the same UTM co-ordinate system used by the census tract boundary files and regional road network information. This was accomplished by importing the .DXF files into AutoCAD, performing the necessary operations to each contour file, and then exporting the converted files back out in .DXF format. The YOW*.DXF files were imported into the EPPL7 program and edited in the program's digitizing module. They were sized to fit the study case area and then rasterized. Only the 1:25,000 scale plots showing the noise contours representing 20NEF, 25NEF, 28NEF, 30NEF, 35NEF and 40NEF were used for printouts since they provided the level of detail necessary for visualization of the noisy areas. Because of the size of the screen and paper (8.5"x11"), noise contours from 20NEF to 40NEF in the 1:50,000 scale maps, were defined and drawn for use in the calculation and analysis process.

A complete series of raster images (.EPP files) were created showing the NEF contours for each year. These images could then be displayed independently or layered with other images related to density, complaint, and distance to the nearest road.

Population Data

Population density was obtained by taking the population and dividing by the area of the tract. Populations for all years from 1986 to 2001 were interpolated from Statistics Canada Census and RMOC Planning Department figures. Maps showing the population density in each census tract for each year were then prepared (DENS*.EPP). Population density maps based on projections for the year 2021, also produced by the RMOC Planning Department in the report "How Should We Grow ?" (1995), were done. This report presented different alternative growth focus scenarios for the region. Figure 6.3 shows the population data and airport base mapping.

Statistics Canada provided basic census boundary file showing all census tracts for the Ottawa-Hull region from 1986 census. This file came geo-referenced in a Universal Transverse Mercator (UTM) co-ordinate system, and was imported directly into the EPPL7 digitizing module. Boundaries had to be defined in areas where 1986 census tracts were split into new census tracts for the 1991 census. Because of the distribution of complaint data and large distances from the airport, it was not necessary to study many areas of the city for this research. Thus, the case study involved census tracts that extend from just south of Manotick to north of the Ottawa River, to Moodie Drive in the west and to Highway 417 in the east.

Figure 6.3 Population Data Mapping

The digitized line work was then rasterized in the EPPL7 program, which allows for every cell (25m²) of each census tract to be assigned a value. These values were then linked to the census tract number. This forms the basis of all the maps that were created for each variable in this research work. The INTABLE function was used to assign new values from a data table to a particular census tract number.

Roadway System Information

A copy of the regional road network was provided by the Information Services branch of the RMOC in .DXF format. The file contained all the roads within the borders of the region and was in the proper UTM co-ordinates. The road network was imported into EPPL7's digitizing module and was sized to fit the study area. This road network could then be overlaid onto any of the raster images for plotting and display purposes.

The shortest straight-line (orthogonal) distance to the nearest regional road from the location of each complaint was measured on a road map of the city. This was done for each complaint in each census tract and for each year of the data. An average distance to the nearest road was calculated for all census tracts for which complaints were registered in a particular year. These data was brought into EPPL7 where the average distances for specific population density ranges was calculated using COUNT.

Based on the Official Plan, proposed regional roads near OMCI A were digitized onto the existing network file ROAD.DXF to support further analysis related to these roadway locations. Figure 6.4 presents the roadway system mapping - existing network, proposed roads and distance from nearest road.

Figure 6.4 Roadway Infrastructure Data Mapping

6.4.2 Data Assessment

To assess data available and perform calculations, EPPL7 files produced when mapping the variables were sorted and calculated using the COUNT command. The results of the COUNT command were then brought into QuattroPro software and edited. These values were imported into SPSS for Windows Base system, version 6.0, with the .MK3 extension to carry out a statistical data analysis. Figure 6.5 shows the steps for the data assessment procedure.

Figure 6.5 Data Assessment Procedure

The EPPL7 COUNT command was again used to sort and calculate the average percentage of complaints for specific levels of exposure to aircraft noise under selected ranges of population density in the study area around OMCIA. This command also produced data

relating to the average distance from a complainer's dweller to the nearest regional road according to certain ranges of population density.

It was then imported into the QuattroPro spreadsheet and formatted to be used for the SPSS software package. Then, as presented in Chapter 5, two functions were developed. The first, represented how areas adjacent to new roads (links) will be occupied. And, the second represented how people will perceive and react to aircraft noise under specific levels and different land use expressed by intervals of population density.

The power function related to the distance from complainer's dwelling location to the nearest road is represented by the following equation:

$$Y = b_0 (t^{b_1}) \Rightarrow Y = 0.027444 (t^{0.302599})$$

where:

- Y is the dependent variable, in this case distance from the nearest road (km);
- b_0 is the regression coefficient;
- b_1 is other regression coefficient; and
- t is the independent variable, in this case population density (people/km²).

The second function, a cubic equation for transformation of the aircraft noise stimulus into the peoples' response, was implemented as friction factors in the GIS for population density intervals that represented land use change from rural to suburban to urban:

$$Y = b_0 + b_1 t + b_2 t^2 + b_3 t^3$$

where: Y is the percentage of people who complaint against aircraft noise;

b_0 is a constant;

b_1 is a coefficient;

b_2 is a coefficient;

b_3 is a coefficient; and

t is the level of exposure to aircraft noise measured in NEFs.

As explained in Chapter 5, this functional relationship was applied to specific ranges of population density that mean variations observed in the land use. The two specific cubic functions implemented into the GIS-based road location method near airports is presented below:

suburban low density => density from 1,000 to 1,999 people/km²

$$C = 0.1208 + (0.0017255 \text{ NEF}) + (-0.00047 \text{ NEF}^2) + (0.0000235 \text{ NEF}^3)$$

urban high density => density from 3,000 to 3,999 people/km²

$$C = 0.944 + (0.0000858 \text{ NEF}) + (-0.00485 \text{ NEF}^2) + (0.00015 \text{ NEF}^3)$$

6.5 - Method Application to OMCA Region

6.5.1 Historical Perspective

The Ottawa Carleton region is located at the junction of the Rideau, Ottawa and Gatineau Rivers. These three rivers were used as a major mean of transport up to the middle of last century. The area north of the Ottawa river was known as Lower Canada and Upper Canada on the south. At that time, development took place on the south of Ottawa River and

west of Rideau River that acted as a barrier due to few bridge crossings. People used to live within walking distance of work and shopping.

In 1857, Ottawa was chosen as the capital of Canada. The development of transportation infrastructure related to the construction of railways (Ottawa and Prescott, St. Laurent, Canada Atlantic and Canadian Pacific) fostered a large growth of built up areas in the second half of last century. These railways increased accessibility towards outlying areas expanding the city core.

It is possible to trace the land development process in the Ottawa-Carleton Region since the beginning of last century based on existing maps from the National Map Collection available at the Public Archives Canada. These maps (see Appendix F) show the evolution of transportation infrastructure and built up areas in the Ottawa-Carleton region. Table 6.1 present the size and population of built up areas from 1810 to 1890.

Table 6.1 - The Built up Areas in the Ottawa Carleton Region from 1810 to 1890

Year	1810	1835	1845	1865	1890
Area (acre)	16	213	563	884	2753
Area (km ²)	0.06	0.86	2.28	3.58	11.14
Population	150	5100	11800	27500	64500
Density (pop/km ²)	2500	5930	5175	7681	5790

Source: Maps - Public Archives Canada

By 1900, Ottawa Electric Railway (street car) started run a east-west line through the Villages of Britannia, Woodroffe and Westboro. Urban growth occurred at a faster pace over

that line. In addition, roads and private cars brought new forces to the urban and regional development. Highway 16, built in 1920, guided development to the southern areas. In the 1950's major roads such as Bronson Ave, Carling Ave and Laurier Street were built in order to accommodate increasing traffic. Land development was still concentrated west of Rideau River. Another important transportation infrastructure, the airport runway system at the Uplands site, was expanded in 1951 with two longer runways (14-32 and 07-25)

The influence of automobile has changed development pattern over the first half of the century. Land development was no longer restricted by distance and has become more disperse, and thus, population density began to fall. Table 6.2 shows the extent of urban growth in the Ottawa-Carleton during this century

Table 6.2 Extent of Urban Growth in the Ottawa-Carleton Region from 1906 to 1991

Year	1906	1925	1955	1967	1984	1991
Area (acre)	3830	5808	13963	27987	45780	54120
Area (km ²)	15.50	23.50	56.50	113.25	185.25	219.00
Population	81700	133300	261500	389100	526500	608900
Density (pop/km ²)	5271	5672	4628	3436	2842	2780

Source: Urban Development in Ottawa-Carleton - RMOC Planning Department, 1993

In 1964 the Highway 417 - Queensway was opened on an old railway right-of way allowing east-west motorized vehicular movement. Ottawa River Parkway and Colonel By Drive Parkway were also established using abandoned railway rights-of-way. By 1967, the Ottawa Electric Railway (streetcar) line has been replaced by buses.

The Transitway system was introduced in 1984 to solve increasing traffic congestion problems aiming to minimize the low occupancy use of private cars. The first Regional Official Plan (1974) designated three areas outside the Greenbelt as a major urban centres - Orleans, Kanata and Barrhaven.

6.5.2 Airport Development History

The Ottawa Macdonald Cartier International Airport (OMCIA) was originally known as the Hunt Club Air Field. This Air Field was owned by Uplands Realty Co. Intermittent flying activities started in 1919 when private airplanes landed and took-off near the Ottawa Hunt and Golf Club, in the Uplands area.

After Charles Lindbergh landed his Spirit of St. Louis at Hunt Club Airfield on July 2, 1927 greeted by a large crowd, the airfield situation changed. The aerodrome was then named for him: Lindbergh Field. The location of Lindbergh Field far from the city core was used as a basis for refusing many requests for government financial support under the justification that "*the site was too far from the city*" and the soil too poor to maintain a good turf surface" (Department of National Defense, 1927).

The Canadian government through its Department of Transport acting on the advise of the Civil Aviation Branch got involved with the Uplands Aerodrome in May 1938 buying the 300 acres piece of land from the Laurention Co. that had purchased it from Uplands Realty Co.. When the Department of Transport took over and developed Uplands Aerodrome its main concern was to provide aeronautical infrastructure for large high-speed aircraft that would be used in the so called Trans-Canada Airway (TCA).

Commercial aviation services brought a large growth to the Ottawa Airport. During the II World War Ottawa Airport continued to service both civil and military activities. As a civil airport with its civil operations controlled by the Department of Transport and military operations by the Royal Canadian Air Force (RCAF). Immediately after the war, civil aviation began an intense development fostered by war surplus equipment and man power. Hangars and other facilities built for the war became available for civilian activities. Thus, flying club, airlines, customs and immigration converted those buildings to their uses. Since then, combined civil and military operations have co-existed at the Ottawa Airport.

In 1951, a large section of the township of Gloucester was expropriated to allow the construction of runway 14-32 with 2,682 metres and 07-25 with 1,829 metres. These main runways were extended in 1961 to 2,957 metres and 2,438 metres, respectively.

Other major developments occurred in May 1959 when the new modern air terminal building opened. The official designation of the airport changed to Ottawa International Airport on August 24, 1964. The Airport Parkway opened in 1972 completely changed the ground access to the present terminal area. The last major expansion of the airport was completed in December 1987. This expansion included the renovation of the air terminal east wing with new Customs and Immigration facilities, a new three-track baggage claim

The main change affecting Canadian airports and OMCA in particular, arose with the National Airport Policy (July 1994) which established options to create a local airport authority for operation of 26 major airports in this country. These airport authorities will be able not just to run Canadian airports in a more commercial and cost-efficient manner, but also be more responsive to local needs with the local government participation in its direction

6.5.3 Recent Development Trends in the South of Ottawa-Carleton Region

Land development trends in the South of Ottawa-Carleton have allowed continuous urban encroachment towards the OMCIA limits over the last decades. These development patterns have followed major provincial roads (Highway 31 and 19). Such developments have already produced changes to urban limits from Carling Avenue to Hunt Club Road just North of the Ottawa Macdonald Cartier International Airport (OMCIA) boundary. People's complaints regarding aircraft noise already coming from northern sector of the airport (Nepean, Ottawa-Hunt Club and Gloucester) may well be significantly increased with further land development towards its southern rural areas.

In addition, according to the Official Plan of the RMOC adopted in 1988 almost 50 amendments have been proposed by the regional council and approved by the Ontario Municipal Board. In this way, some regional roads have also been built and extended adding to the access to the airport region, particularly in the Hunt Club area, and parts of Nepean and Gloucester. The latest official plan (September 1994) shows proposed regional roads such as the Alta Vista Parkway, Lester Road (RR24) extension, Hawthorne Road extension, Bowesville Road extension, and the Limebank Road extension which will impact on the lands surrounding the airport. Appendix A and B referring respectively to the 1992 Official Plan and the 1994 Official Plan, present these north-south bound roads location in the vicinity of OMCIA. Particular attention should be paid to the *Bowesville Rd* and the *Limebank Rd* extension that did not appear on the 1992 Official Plan, but it is included in the 1994 version. Such changes in the road system around OMCIA may bring undesirable pressures for land use change in areas under the impact of aircraft noise.

6.5.4 Overall Research Setting

This research carried out a case study to the OMCIA region, using existing basic data, to assess previous impacts of aircraft noise on communities located mostly to the north of the airport. These data were used to ascertain the future effects of land development south of OMCIA. The results in terms of the percentage of complaints for different levels of population density, as well as the effects of road location, produced specific functions to explain people's reaction towards aircraft noise observed in the Ottawa-Carleton. These functions were then applied to the forecasted noise levels generated by OMCIA at runway system capacity. An associated noise "friction" map was created and the proposed and existing roadway system was overlaid on top of it.

The GIS-based road location method near airport analyzed all possible pathways between two nodes representing a proposed link in the RMOC Official Plan for 2021. The pathway that minimized the "associated costs" related to land development and population growth in areas affected by aircraft noise which consequently increases the number of complaints was found.

6.5.5 Method Implementation to the OMCIA Region

The digitized road network information as provided by the RMOC was edited using EPPL7's DIGITIZER module. The proposed regional roads as laid out in the current Official Plan were also added to this new road file. Using the CLIP command, the NEF values for the aircraft movement (total annual = 200,000 operations and planning peak day = 660 movements) representing the actual runway configuration capacity were laid out or "clipped"

onto the roadway system map. The road took on these NEF values and was then exported into the IDRISI software package as a raster image for further analysis. A blank road network with no values, as well as noise contours corresponding to the aircraft movements at runway system capacity were also exported to IDRISI as .IMG files.

Four major routes proposed for areas near the airport were identified in the Official Plan (RMOC 1994), which are shown in Figure 6.6, and described below:

- Bowesville Road Extension from the end of the Airport Parkway (Node 1) south to Leitrim Rd. (Node 2);
- Limebank Rd. from River Road (Node 3) south to Armstrong Rd (Node 7);
- a new link connecting the intersections of Limebank Road and Leitrim Road (Node 5) west to a point on the River Road (Node 4); and
- Armstrong Road construction from Bowesville Road to Limebank Road situated south and almost parallel to Leitrim Road (not included in this research).

The co-ordinates of the starting and ending nodes of each of these roads were calculated and the single point was digitized in its own .DXF file to be used with IDRISI COST and PATHWAY commands. All files were imported into IDRISI by using the DOCUMENT command to properly size and orient the different nodes, road linework, and noise images.

Figure 6.6 RMOC Official Plan - Proposed Roads for Areas Near OMCIA

Previous data analysis yielded a set of cubic functions linking NEF values with percentage of complaints for six different population density levels. Based on the RMOC planning reports (1995) the areas surrounding the airport are projected to reach certain density levels by the year 2021 according to the focus of each RMOC proposed development scenario. The airport runway system will also be reaching its capacity at this time. Under the current proposal and some of the RMOC Official Plan development scenarios, the density of the southeastern sector of the region is expected to reach a population between 1,000 to 1,999 people/km². On the other hand, under a southeast development focus scenario, the population density is expected to reach between 3,000 and 3,999 people/km².

The cubic functions for these two density forecasts were used as the basis for the friction cost maps generated in IDRISI. The noise contour map for the runway system at capacity and the “clipped” road map with the NEF values were both put through the RECLASS command. The NEF values of each cell on both maps was replaced with the corresponding percentage of complaint values from the cubic functions. Two cost maps were produced for both the noise and road maps. Using nodes 1 and 5 as base points, the COST command calculated the “cost” of going from the base nodes to every other cell on the maps.

These “cost” maps were then used by the PATHWAY command to find the least “costly” (the steepest slope/gradient) path from the base node to another selected node. Once the new pathway was generated, it could be compared with Official Plan proposed location/alignment. Figure 6.7 indicates the process used when applying the GIS-based road location method near airport to the OMCIA region.

Figure 6.7 GIS-Based Road Location Method - Application Process

6.5.6 OMCA Application Results

The “costs” resulting from the application performed on the road locations (links) proposed by the RMOC Official Plan (Appendix A) and the pathway solution resulted from the GIS-based method are shown in Table 6.3 and Table 6.4. These tables referred to the figures for RMOC growth scenarios concerning the Southeast Community where the OMCA is located. In the Current Plan, and in the Southwest and West Focuses, population density is projected to be between 1,000 and 1,999 people/km² in that area by the year 2021. In the Southeast Focus scenario, population density is expected to reach between 3,000 and 3,999 people/km².

Table 6.3 Method Application Results - Current Plan, Southwest and West Scenarios

Population Density Projection: 1,000 to 1,999 people/km ²			
From Node	To Node	RMOC Official Plan “Cost”	GIS-based Method “Cost”
1	2	27.0544	18.4053
3	5	16.5600	13.8224
4	5	7.1832	5.9923
5	7	7.5416	5.8646

Table 6.4 Method Application Results - Southeast Focus Scenario

Population Density Projection: 3,000 to 3,999 people/km ²			
From Node	To Node	RMOC Official Plan “Cost”	GIS-based Method “Cost”
1	2	70.8306	42.1791
3	5	26.0884	25.6955
4	5	11.5821	8.7690
5	7	10.0619	7.9623

The “costs” were found by multiplying each cell along on a proposed or existing link by the complaint value contained in it. The sum of all these cells gives an indication of relative noise “cost” of following a particular route. The units are essentially meaningless but its magnitude is useful for comparison against the other routes. This dimensionless number is useful to compare the potential impact of a route location to support land development in areas affected by aircraft noise, and consequently generate complaints.

A further step can ascertain the number of complaints expected from the development corridor along the proposed road location. In this step, the power function (developed in section 5.6.3 regarding the distance from the complainer’s dwelling to the nearest road) is used to determine the size/width of the development corridor along the roads proposed by the RMO Official Plan and the GIS-based method. According to the population density of the OMCI region, in the year 2021, under the growth scenarios for population projection, the corresponding corridor would reach between 500 metres (current plan, southwest and west focuses) and 600 metres (southeast focus).

The area equivalent to this potentially developable corridor can be isolated and the forecasted noise contours overlaid on top of it. From the cubic functions found in Section 5.6.4, that transform aircraft noise stimulus into percentage of complaints for different population density levels, the expected number of complaints can be determined. In this way, the number of complaints can be calculated and compared for similar development corridors along different link (road) locations.

6.6 Interpretation of the Results

The GIS-based road location method, when applied to the area around OMCIA, makes some comparisons with the proposed roads that are included in the latest RMOC Official Plan (see Figure 6.6).

First, it is clear that the scenarios for future development will certainly double or triple the population density over that region. This population growth may very well spread towards noisy areas if there is an easy access to those pieces of land. By analyzing the proposed locations for new or extended roads, it is clear that the proposed alignment of new roads according to the Official Plan will bring tremendous development pressures which may not be adequately controlled by zoning and other regulations. This will then be reflected in peoples' annoyance and ultimately the number of complaints will increase. Therefore, the GIS-based road location method near airports can assign some "costs" associated with peoples' response (complaints) related to aircraft noise to carry out an efficient pathway alignment for those proposed roads which will minimize future residential development and the number of noise complaints.

Figure 6.8 and 6.9 show maps generated by the IDRISI software with existing roads, proposed links and GIS-based method pathway (indicated by a blue line for the scenarios with density between 1,000 and 1999 people/km² and a green for the scenarios with density between 3,000 and 3,999 people/km²) as well as the respective nodes included in this research.

The interpretation of the results presented in Table 6.3 and 6.4 and the maps presented in Figure 6.8 and 6.9 reveal some interesting points about the Official Plan proposed roads location and the pathway indicated in the OMCIA application of the GIS-based method.

Figure 6.8 GIS Map Results - OMCIA Southeast Area

Figure 6.9 GIS Map Results - OMCA Southwest Area

In the OMCLA southeast area (Figure 6.8), the GIS-based method pathway suggested a straight line for the link 1-2 which makes sense since it minimizes the distance between two nodes that are in an area already under heavy impact of aircraft noise (~35NEF). On the other hand, in the OMCLA southwest area (Figure 6.), for the link between node 3 and node 5, the GIS-based method produced an almost L shaped road to connect them. This shape should have been caused by the high levels of aircraft noise over the area where that road was located according to the RMOC Official Plan.

The “costs” associated with link 3-5 can be reduced by keeping the existing link 3-4 alignment (River Rd.). The L shaped road location indicated in the GIS-based method suggested that no new road should be built in the alignment proposed in the RMOC Official Plan. This position is further supported by the shape of the GIS-based method pathway delineated for the link 4-5 which suggests that the link should be bent south towards an existing road (Leitrim Rd).

Finally, the proposed road represented by the link 5-7 does not need significant change and its airport noise impacts are at a minimum especially when nearing node 7.

Chapter 7

Conclusions and Recommendations

7.1 Summary

Many hectares of land become available for development every time a new road is built or extended near urban fringe airports. In these urban fringe areas, little attention tends to be paid to the development effects of new or extended road locations and alignments on vacant lands affected by aircraft noise, particularly in medium-sized cities. Roadways are primarily responsible for guiding land development and shaping urban form in these cities, yet traditional transportation/land-use models have not been location-sensitive to determine effects of development over road corridors. Government authorities, provincial and municipal, have tried to control incompatible land-use, particularly residential, in areas affected by aircraft noise. It has not worked out well. Complaints still come from neighbouring communities, and land development pressures from interest groups such as developers, landowners and speculators have brought people into noisy areas.

In addition, a significant reduction in aviation noise because of replacement and mandatory phase-out of aging noisy aircraft will shrink contour lines, bringing high levels of aircraft noise exposure to areas near airport boundaries. As these contours shrink, the levels of exposure to aircraft noise felt by people on the ground will increase not in terms of kilometres, but in hundreds of metres toward the airport boundaries. This will make more difficult to implement airport-compatible land use planning based on development control and zoning limits defined by noise contours. As a result, specific levels of exposure to aircraft

noise used as a boundary for land-use control may have to be reviewed due to a change in the noise contour span.

This research presents a complimentary approach to the implementation of an airport compatibility land-use planning based on action-oriented measures to be considered in the initial development phase. This action-oriented approach consists of guiding new or extended roads away from noise sensitive areas, and consequently, to prevent land-use change at the early stages of land development from rural/agricultural to urban/ residential

In order to implement an action-oriented approach for land-use planning around airports in medium-sized cities, a road location method was developed using Geographical Information System (GIS) software capability. Data gathering and coordination involving airport, road and land-use planning became essential in making such a method a tool to address the aircraft noise problem. A statistical analysis using mathematical models was proposed to study basic variables involved in the transportation-land development process near airports such as level of aircraft noise, distance to the nearest road and population density. This analysis determined functions that explain local people's response to aircraft noise in terms of percentage of complaints and effects of roads on the development of adjacent land corridors for particular land-use expressed as a function of population density. It was found that, particularly in low population density areas below 1,000 people per square kilometre (rural or large suburban lots land-use), residents become very easily disturbed by noise. Levels of complaints are not consistent over different land tracts, but are clearly much higher than in other suburban and urban settings.

The functions that transformed noise stimulus of peoples' responses can be used as

an analytical input into the GIS-based road location method near airports to define the best pathway for a proposed new or extended link (road).

This road location method near airports, for land use planning in medium-sized cities, based on an action-oriented approach, was applied to the OMCIA region. This region has been under very intense land development over the last twenty years, supported by increasing access to the areas surrounding the airport. In particular, over the last ten years, according to Statistics Canada data, population growth has been extensive on the north side of the airport bringing people closer to noisy areas. The RMOC official plan provided evidence that such a trend is expected to continue to the south of the airport and even intensify in the next century.

The functional relationship explaining how people react to aircraft noise and the influence of road corridors for observed population density levels in the OMCIA region were used in the GIS software. The results produced by the GIS-based method pathway minimizes friction “costs” associated with complaints in adjacent development corridors when linking two existing nodes according to the RMOC official plan. Analyzing these costs and mapping results, it becomes clear that for the Bowesville Road (on the west side of the airport), an almost straight-line connecting the two nodes would produce the least “cost”, while an “L” shaped curve was indicated as a best location for the Limebank Road extension.

If these locations were adopted to minimize reactions/complaints associated with development along these road corridors, instead of building Limebank Rd, vehicular traffic would continue on existing River Rd, located on the GIS pathway solution. On the other hand, the Limebank Road straight-line connection between existing nodes indicated by the

GIS-based method pathway solution would reduce overall corridor impact which is all situated in a very noisy area.

7.2 Conclusions

This research has proposed an action-oriented approach to deal with aircraft noise problems around airports located in the rural/urban limits of medium-sized cities. This approach is based on the location of roadway, a primary government decision, to reach the goal of airport compatible land-use development. The proposed methodology for road location near airports can become a powerful tool to drive development away from noise sensitive areas and to achieve a compatible airport land use development in that urban fringe region.

The practical and effective use of this road location method in airport surroundings depends upon a great deal of coordination among airport, road and land use planning activities. However, with the recent Canadian Airports Policy (1994) which brought municipal governments to participate and play a major role on the boards of directors and administration of local airports, the time has come to fully integrate airport, road and land-use developments to benefit the communities they serve.

The major contributions and conclusions of this research are:

- This research has contributed to broadening the planning focus in the airport region. In particular, it proposed a state-of-the-art GIS-based method to support land-use planning and decision making process regarding road location effects on development.

- The proposed method can assist transportation engineers and city planners in evaluating the effects of alternative road locations in airport surroundings in terms of future development impacts and peoples' responses to aircraft noise. This method requires basic data gathering, much of which is available or can be generated by local planning agencies.
- This method addresses important aspects involved in the airport/land-use compatible development process, particularly being location-sensitive. It can take into consideration several alternative ways to link one node to another under specific real life situations, and provide an evaluating technique to compare the alternatives.
- In addition, this method can be incorporated into a much larger location analysis for roadway planning near the airports which can account for other variables related to the local physical and environmental characteristics (topography, soil, vegetation, and other sensitive features).
- This method can be adopted with transformation functions to explain people's response to aircraft noise by deriving equations from complaint records or from noise attitude surveys which produced particular set of functions to an airport region. If time or funding resources are limited, the proposed GIS-based road location method can also be applied by using average noise response curves developed as a synthesis

of many research in this field carried out worldwide (Schultz 1978 and Kryter 1982).

- The identification of affected corridors along proposed roads can be assessed by analyzing local development patterns on the existing roads under different levels of population density. It is expected that as population density increases on average road corridors will be wider. In general, these road corridors will be a function of local land use planning and regulations such as the floor-area ratio and permitted densities.
- The proposed method does not interfere with traditional urban transportation models, but can complement them in finding and fine tuning road locations for rural/urban fringe areas near airports.
- An efficient road location based on the proposed method can be applied in the initial development phase as an action-oriented approach for land-use planning, but it does not exclude the further adoption of control-oriented measures such as zoning by-laws, subdivision permits and building codes.
- This research provides basic background methodology to apply an action-oriented approach for land-use planning in medium-sized cities, and calls for specific attention in government planning and policy guidelines concerning to development around airports. It emphasizes the need for clear directions in the official documents about the importance of road location/alignment to implement a compatible land-use

planning in urban fringe airports, as well as asks for closer coordination among agencies involved.

7.3 Recommendations

This research has demonstrated that much remains to be done to explore the possibilities of the action-oriented approach for land use planning near airports, particularly adopting the proposed conceptual basis for this GIS-based road location method in medium-sized cities.

However, better analytical strategies may be incorporated in the future. Possibilities to do spatial-oriented analysis is a research field still not adequately explored. Many venues can be pursued to add new enhancements to this method based on the GIS software, a powerful planning tool that has recently expanded the frontiers for transportation and land-use planning.

Thus, a few list of recommendations for further research are presented below.

- Incorporating GIS aerial photographic reading capabilities may shorten the time and resource to gather physical information. Aerial photos are now available for almost any land on Earth by satellite picture or old aerial photos. It is a broad area that can produce essential data about transportation and rural/urban planning.
- Analyzing long term effects of noise on people's response is also a field still not completely understood including annoyance, disturbance and reaction under specific settings associated with field conditions. This research has shed some light on these

differences in terms of complaint reactions, but much more can be done with a deeper research in the effects of population density representing variation of land-uses and people's response, particularly in very low density levels associated with rural and large suburban lots land-uses.

- Further research is recommended to evaluate the effects of verticalization since it was observed that people living in high-rise apartment buildings may be more exposed to aircraft noise than others in the same level of population density but in horizontal developments.
- Study should be undertaken to examine OMCIA runway capacity beyond the year 2020, when a new parallel runway will probably be required. This new runway will most likely be located between Rwy 07-25 and Leitrim Road in which case it will have a great effect on the development proposed to the south of OMCIA. In particular, attention should be paid to the Armstrong Road proposed location in the south of OMCIA.
- A recommendation for caution when planning construction, extension or pavement of roads near urban fringe airports could facilitate the work of many engineers and planners not familiar to the airport noise problems. As a suggestion, Transport Canada, Ministry of Housing and Municipal Affairs, Ministry of Environment and Ministry of Transportation should include in their policies and guidelines that: "When

planning roads - construction, extension or pavement - near airports located close to the urban/rural limits, particularly in medium-sized cities, government officials, engineers and planners should pay attention to the long-term effects of road location that goes through areas affected by airport noise and consequently fostering further land development and use change. Any roadway planning to support the airport development or industrial and commercial enterprises in nearby areas should proceed in incremental segments only when demand for those kind of airport compatible land development's is clearly demonstrated. In all cases, a continuous consultation and co-ordination should be maintained among airport, transportation and land-use planners."

In summary, planning means looking ahead, thinking and speculating on the future, broadening the perspective and discussing long term goals, objectives and trends, making flexible and open options to follow in the next moment, but always adjusting, regrouping and rethinking.

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Appendix A

Official Plan - Regional Municipality Ottawa Carleton

Future Urban Regional Roads

November 1992

Appendix B

Official Plan - Regional Municipality Ottawa Carleton

Future Urban Regional Roads

September 1994

Appendix C

Land Use in the Vicinity of Airports

Part IV - Aircraft Noise

Transport Canada - March 1989

PART IV

AIRCRAFT NOISE

4.1 GENERAL

An accurate assessment of the annoyance resulting from exposure to aircraft noise is essential to both aviation planners and those responsible for directing the nature of development of lands adjacent to airports.

This Part will discuss noise measurement, annoyance prediction, the Noise Exposure Forecast and the Noise Exposure Projection. It also contains an assessment of various land uses in terms of their compatibility with aircraft noise.

4.1.1 Noise Measurement

The sound pressure level created by an aircraft (or any other noise source) can be measured by means of a sound level meter. The microphone of the sound level meter senses the pressure fluctuations over a short period of time. The sound pressure is the root mean square value of the difference between atmospheric pressure and the instantaneous pressure of the sound, the mean being read over several periodic cycles. For mathematical convenience, the logarithmic parameter called sound pressure level (SPL) is used. The unit of sound (noise) measurement is the decibel (dB).

A particular sound signal may comprise several different frequencies to which the human ear may respond in various ways. In order that noise measurements may relate more closely to loudness as judged by the average person, sound level meters are equipped with weighting networks which make use of information related to the frequency response characteristics of the human ear. Some sound level meters have the capability of reading on A, B, C, and D weighting scales, and decibel values are correspondingly indicated as dB(A), dB(B), dB(C) or dB(D), according to the weighting network used. However, the dB(A) is the most common. The dB(D) value was designed as the preferred measuring unit for aircraft noise, but dB(A) is widely used since it has been found to have good utility in determining annoyance reactions to a wide variety of noises occurring in communities.

The noise metric known as Perceived Noise Level (PNL), measured in the unit PNdB, provides a frequency weighting system which attempts to more closely approximate the subjective reaction of the human ear to an aircraft noise stimulus. Although weighting networks are available which provide a means of directly measuring approximate PNL values, i.e., dB(D), true PNL values are determined by the analysis and treatment of sound pressure levels in various 1/3 octave bands.

A more sophisticated noise metric, the Effective Perceived Noise Level (EPNL), expressed in the unit EPNdB, was developed specifically for use in the measurement of aircraft noise. This metric is basically similar to the PNL except that corrections have been applied to account for the effects of discrete tones and the duration of the noise event, i.e., factors which contribute to the annoyance of the listener.

4.1.2 Predicting Annoyance

In addition to the annoying characteristics of an individual noise signal, overall subjective reaction to noise is dependent on the number of times the disturbance occurs as well as the daily distribution of these events. These factors must be included in any noise forecasting system if it is to be applicable to the communities located in the vicinity of airports. The Noise Exposure Forecast (NEF) system used by Transport Canada takes into consideration all of these factors.

The NEF system provides for the summation of noise from all aircraft types operating at an airport based on actual or forecast aircraft movements by runways and the time of day or night the events occur. The large number of mathematical calculations necessary for the construction of NEF contours requires the use of computer techniques for the practical application of this system.

4.1.3 The Noise Exposure Forecast System (NEF)

Effective Perceived Noise Level is the basis for estimating noise annoyance in the Noise Exposure Forecast system.

The data required for determining NEF contours consist of EPNL (see 4.1.1 - last paragraph) vs distance information for various aircraft types, along with generalized aircraft performance data. In calculating NEF at a specific location, the EPNL contribution from each aircraft operating from each runway is assessed by considering the distance from the point in question to the aircraft, and then obtaining EPNL values from the appropriate EPNL vs distance curve. The noise contributions from all aircraft types operating on all runways are summed on an anti-logarithmic basis to obtain the total noise exposure at that one location. Thus, the determination of NEF contours is strictly a numerical calculation procedure. As stated previously, due to the large number of mathematical calculations involved, computer techniques provide the only practical means of constructing NEF contours.¹

4.2 NOISE EXPOSURE CONTOURS

There are three types of noise exposure contours produced depending on the time element involved. These are Noise Exposure Forecasts (NEFs), Noise Exposure Projections (NEPs) and Planning Contours. Both NEFs and NEPs undergo a rigorous review and approval process within Transport Canada Aviation before public release.

1. Kingston, Beaton and Rohr, *A Description of the CNR and NEF Systems for Estimating Aircraft Noise Annoyance* (R-71-20, Department of Transport, 1971).

4.2.1 Noise Exposure Forecast (NEF)

The Noise Exposure Forecast (NEF) is produced to encourage compatible land use planning in the vicinity of airports. NEFs are approved (official) contours and Transport Canada will support them to the level of accuracy of the input data. Accordingly, the input data must be as accurate as current technology permits. Traffic volume and aircraft type and mix used in calculating the noise contours are normally forecast for a period of between five and ten years into the future (See NOTE). Runway geometry must be the current layout, except that new and approved projects involving changes in the runways may be included, when the completion date of the project lies within the forecast period.

NEFs are made available to provincial and local governments for use in conjunction with Transport Canada's recommended Land Use Tables (Table 3) which will enable planners to define compatible land use in the vicinity of airports over the short term.

NOTE: These forecasts are prepared and/or approved by Statistics and Forecasts Branch of Transport Canada, Policy and Co-ordination.

Transport Canada retains copies of NEFs and NEPs, both regionally and at headquarters, in order to:

- (a) provide municipalities and local governments with a basis for zoning; and
- (b) inform the public of noise sensitive areas in the vicinity of airports.

Local Variances From NEF Contours

The procedure for dealing with requests for local minor variances from the published NEF contours will be as follows:

- (a) the proponent of the change (property owner, developer) determines from the municipalities that a variance from the present zoning, established on the basis of Transport Canada's applicable official NEF contour, would be considered if adequate justification is provided. Municipal authorities advise Transport Canada (TC) Aviation, Air Navigation System (ANS) of the request;
- (b) the proponent undertakes to provide evidence that NEF contours, as they apply to his/her property, do not take into account factors that would affect aircraft noise attenuation or propagation. It is recommended that the proponent consult with TC Aviation, ANS to determine what evidence would be required to verify his/her contention;
- (c) the proponent obtains and submits the evidence to municipal authorities;
- (d) municipal authorities ask TC Aviation, ANS for its recommendations concerning the validity of evidence and claimed adjustment to noise impact relative to the official NEF contour;

- (e) TC Aviation, ANS makes recommendations to the municipality, and provides any pertinent additional information or advice that could bear on the municipality's decision; and
- (f) the municipality determines whether to allow variance from established zoning, taking into account TC Aviation, ANS's recommendations, and advises the proponent, provincial Ministries concerned and Transport Canada.

It is intended that this process will not affect the status of the applicable NEF map. The NEF map will not be changed to reflect the local variance, nor will future forecast show the local variance. The process just described is intended to accommodate small-scale characteristics of the property which can locally affect aircraft noise impact such as terrain features, ground condition, reflective or shielding surfaces, etc. The NEF model does not include such small scale characteristics, and it is not intended to incorporate a capability to do so in the future.

In summary, Transport Canada will not include local small-scale effects in the calculation of NEF contours, nor will official NEF contour sets be revised if and when it is demonstrated that localized small-scale effects modify predicted aircraft noise levels in specified areas. The municipality or province may request Transport Canada's technical advice and recommendations concerning such small-scale effects on aircraft noise levels, in order to consider the technical validity of claims to variances from official land zoning plans. The onus is on the proponent of such zoning variances to provide evidence of the noise impact adjustment; Transport Canada will not undertake any studies into the matter, and will only advise the municipality on the basis of evidence provided by the proponent.

4.2.2 Noise Exposure Projection (NEP)

It is recognized that much land use planning involves projections beyond five years into the future, when aircraft fleet mixes and runway configurations are most likely to be different from the known conditions of today. To provide provincial and municipal authorities with long range guidance in land use planning, Transport Canada introduced the Noise Exposure Projection (NEP). The NEP is based on a projection (not a forecast) of aircraft movements for up to 20 years into the future, and includes aircraft types and runway configurations that may materialize within this period. NEPs are approved (official) contours and Transport Canada will support them to the level of accuracy of the input data. The information required to produce an NEP must, at least, be contained in an Aviation System or Airport Master Plan.

NEPs are available to interested parties in the same manner as NEFs.

4.2.3 Planning Contour

The third type of noise contour is the Planning Contour which is produced to investigate planning alternatives and must be labelled as such. This may be released to the public by a regional TC Aviation office without Headquarters' (Ottawa) approval. Any agency may produce these contours as they do not have any official status.

4.3 PRODUCTION OF NOISE CONTOURS - AIRPORTS THAT ARE NEITHER OWNED NOR OPERATED BY TRANSPORT CANADA

The preparation and approval of noise contours for airports that are neither owned, nor operated by the Federal Government is not a responsibility of TC. However, TC will assist the owner or operator of such airports to produce noise contours for the airports, provided that:

- (a) the owner or operator initiates this action;
- (b) supplies or approves a projection of aircraft traffic, both as to type and numbers; and
- (c) uses the noise impact prediction methods, procedures and recommended practices relating to aircraft operations as established by TC.

4.4 PRODUCTION OF NOISE CONTOURS: DND AERODROMES

Production of noise contours for airports, used solely by the Department of National Defence (DND), is the responsibility of DND as to data input and production. When requested by DND, these contours will be published subject to TC's approval of the technical accuracy of the contours.

Noise contours for joint use DND/TC airports will normally be produced by regions in the same manner as for TC airports with the exception that DND Headquarters in Ottawa will provide the official military traffic forecasts. Requests for military forecasts will be submitted to TC Headquarters who will liaise with DND Headquarters for their procurement.

4.5 NOISE CONTOUR MAPS

All contour maps will be prepared at a 1:50 000 scale.

It may be necessary for computer produced contour lines to be mechanically smoothed to remove irregularities that arise in the plotting process. This will be done particularly in areas of sharp corners or tips.

NEF and NEP maps must depict the 40, 35 and 30 contours as a solid line. TC does not require any other contours to be depicted.

With respect to printing of maps with approved, superimposed NEF/NEP contours, TC Aviation Headquarters will produce a single master map with enough copies for internal TC Aviation use. Additional copies will be available from TC Aviation regional offices (see Appendix A) for a nominal fee.

4.6 COMMUNITY RESPONSE TO NOISE

During developmental work on preliminary noise rating systems, it was established that community response to aircraft noise correlated well with the noise contours then in use. Case histories of noise complaints at twenty-one airports were analyzed as to severity, frequency of complaint, and distribution around the airports to establish a relationship with known noise values. The results of this work, which may be found in Table 2, have been used for relating land uses to NEF contours.

The analysis of the effect of aircraft noise on various working and living environments is a complex matter. For each case where there is a note in the Land Use Tables (Table 3), it is desirable that a noise climate analysis or a noise reduction requirement analysis be undertaken, since each note indicates a particular specialized problem. Many of the factors that would be considered in such analyses are subject to changing technology. Also, the attitudes of those exposed to the noise environment are subjective and varied. Since these factors are under constant review, authorities undertaking analyses of noise climates and noise reduction requirements in buildings should maintain liaison with agencies conducting these reviews. At the present time, such agencies include: the National Research Council and TC Aviation.

4.7 RECOMMENDED NOISE CONTROL ACTION

For a specific noise problem, Table 4 may be used to select different actions.

4.8 RECOMMENDED PRACTICES

NEF/NEP contours approved by TC Aviation are to be used in conjunction with these guidelines to encourage compatible land use in the vicinity of airports. Therefore, it is imperative that these official contours be distributed by Airport Operators to the authorities responsible for land use and zoning of the affected land. This would normally include both provincial and municipal planners, and zoning boards. It should be noted that distribution of these official contours is not restricted.

TABLE 2
COMMUNITY RESPONSE PREDICTION

RESPONSE AREA	RESPONSE PREDICTION *
1 (over 40 NEF)	Repeated and vigorous individual complaints are likely. Concerted group and legal action might be expected.
2 (35-40 NEF)	Individual complaints may be vigorous. Possible group action and appeals to authorities.
3 (30-35 NEF)	Sporadic to repeated individual complaints. Group action is possible.
4 (below 30 NEF)	Sporadic complaints may occur. Noise may interfere occasionally with certain activities of the resident.
* It should be noted that the above community response predictions are generalizations based upon experience resulting from the evolutionary development of various noise exposure units used by other countries. For specific locations, the above response areas may vary somewhat in accordance with existing ambient or background noise levels and prevailing social, economic and political conditions.	

TABLE 3
LAND USE TABLES
AIRCRAFT NOISE CONSIDERATIONS ONLY

This land use tabulation should not be considered as an exhaustive listing, but merely as examples of how various land uses would be assessed in the Noise Exposure Forecast zones in terms of community response predictions.

No	- Indicates that new construction or development of this nature should not be undertaken.
A	- This particular land use may be acceptable in accordance with the appropriate note and subject to the limitations indicated therein.
Yes	- The indicated land use is not considered to be adversely affected by aircraft noise and no special noise insulation should be required for new construction or development of this nature.

(a)

NOISE EXPOSURE FORECAST VALUES	>40	40-35	35-30	<30
RESPONSE AREAS	1	2	3	4
RESIDENTIAL				
Detached, Semi-Detached	No	No	B	A
Town Houses, Garden Homes	No	No	B	A
Apartments	No	No	B	A

(b)

NOISE EXPOSURE FORECAST VALUES	>40	40-35	35-30	<30
RESPONSE AREAS	1	2	3	4
RECREATIONAL - OUTDOOR				
Athletic Fields	No	J	K	Yes
Stadiums	No	No	K	Yes
Theatres-Outdoor	No	No	No	H
Racetracks-Horses	No	K	K	Yes
Racetracks-Autos	Yes	Yes	Yes	Yes
Fairgrounds	K	K	Yes	Yes
Golf Courses	Yes	Yes	Yes	Yes
Beaches and Pools	Yes	Yes	Yes	Yes
Tennis Courts	No	K	Yes	Yes
Playgrounds	K	K	Yes	Yes
Marinas	Yes	Yes	Yes	Yes
Camping Grounds	No	No	No	H
Park and Picnic Areas	No	K	Yes	Yes

(c)

NOISE EXPOSURE FORECAST VALUES	>40	40-35	35-30	<30
RESPONSE AREAS	1	2	3	4
COMMERCIAL				
Offices	(F)	(E)	(D)	Yes
Retail Sales	(F)	(D)	Yes	Yes
Restaurants	(F)	(D)	(D)	Yes
Indoor Theatres	No	(G)	(D)	Yes
Hotels and Motels	No	(F)	(G)	Yes
Parking Lots	Yes	Yes	Yes	Yes
Gasoline Stations	Yes	Yes	Yes	Yes
Warehouses	Yes	Yes	Yes	Yes
Outdoor Sales	(E)	(K)	Yes	Yes

(d)

NOISE EXPOSURE FORECAST VALUES	>40	40-35	35-30	<30
RESPONSE AREAS	1	2	3	4
PUBLIC				
Schools	No	No	(D)	(C)
Churches	No	No	(D)	(C)
Hospitals	No	No	(D)	(C)
Nursing Homes	No	No	(D)	(C)
Auditoriums	No	No	(D)	(C)
Libraries	No	No	(D)	(C)
Community Centres	No	No	(D)	(C)
Cemeteries	(N)	(N)	(N)	(N)

(e)

NOISE EXPOSURE FORECAST VALUES	>40	40-35	35-30	<30
RESPONSE AREAS	1	2	3	4
MUNICIPAL UTILITIES				
Electric Generating Plants	Yes	Yes	Yes	Yes
Gas and Oil Storage	Yes	Yes	Yes	Yes
Garbage Disposal	Yes	Yes	Yes	Yes
Sewage Treatment	Yes	Yes	Yes	Yes
Water Treatment	Yes	Yes	Yes	Yes
Water Storage	Yes	Yes	Yes	Yes

(f)

NOISE EXPOSURE FORECAST VALUES	>40	40-35	35-30	<30
RESPONSE AREAS	1	2	3	4
INDUSTRIAL				
Factories	(I)	(I)	Yes	Yes
Machine Shops	(I)	(I)	Yes	Yes
Rail Yards	Yes	Yes	Yes	Yes
Ship Yards	Yes	Yes	Yes	Yes
Cement Plants	(I)	(I)	Yes	Yes
Quarries	Yes	Yes	Yes	Yes
Refineries	(I)	(I)	Yes	Yes
Laboratories	No	(D)	Yes	Yes
Lumber Yards	Yes	Yes	Yes	Yes
Saw Mills	(I)	(I)	Yes	Yes

4 - 10

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(g)

NOISE EXPOSURE FORECAST VALUES	>40	40-35	35-30	<30
RESPONSE AREAS	1	2	3	4
TRANSPORTATION				
Highways	Yes	Yes	Yes	Yes
Railroads	Yes	Yes	Yes	Yes
Shipping Terminals	Yes	Yes	Yes	Yes
Passenger Terminals	(D)	Yes	Yes	Yes

(h)

NOISE EXPOSURE FORECAST VALUES	>40	40-35	35-30	<30
RESPONSE AREAS	1	2	3	4
AGRICULTURAL				
Crop Farms	Yes	Yes	Yes	Yes
Market Gardens	Yes	Yes	Yes	Yes
Plant Nurseries	Yes	Yes	Yes	Yes
Tree Farms	Yes	Yes	Yes	Yes
Livestock Pastures	(M)	Yes	Yes	Yes
Poultry Farms	(L)	(L)	Yes	Yes
Stockyards	(M)	Yes	Yes	Yes
Dairy Farms	(M)	Yes	Yes	Yes
Feed Lots	(M)	Yes	Yes	Yes
Fur Farms	(K)	(K)	(K)	(K)

EXPLANATORY NOTES FOR TABLE 3

The location of the lines between noise zones cannot be fixed exactly. It will therefore be necessary for the responsible public authority to make an appropriate interpretation of what regulations are to apply at a specific location.

In cases where reference is made to a detailed on-site noise analysis, or to peak noise levels, it will be appreciated that the notes are intended to apply specifically at existing airports, where a field assessment is possible. For planning with respect to new airports, such zones should be considered cautionary. Before reaching a final decision with respect to permitting the particular land-use in question, the authority may wish to consider local topographic effects and ambient noise levels, in conjunction with generalized peak noise level "footprints" for the predominant aircraft types to be using the new airport.

- A. A marginal zone exists near the 30 NEF level where aircraft noise may begin to annoy some residents. It is recommended that developers be made aware of this fact and that they undertake to so inform prospective tenants or purchasers of residential units. In addition, it is suggested that development should not proceed until the responsible authority is satisfied that noise insulation features, if required, have been considered in the building design.¹
- B. The developer should be required to inform prospective tenants or purchasers of residential units that aircraft noise may interfere with certain activities. Construction should not be permitted to proceed until the responsible authority is satisfied that appropriate noise insulation features have been considered in the building design.¹
- C. These facilities should not be located close to the 30 NEF contour unless the restrictions outlined in Note D are applied.
- D. These uses should not be approved unless a detailed noise analysis is conducted and the required noise insulation features are considered by the architectural consultant responsible for the building design.
- E. When associated with a permitted land use, an office may be located in this zone provided that all relevant factors are considered and a detailed noise analysis is conducted to establish the noise reduction features required to provide an indoor environment suited to the specific office function.
- F. It is recommended that this specific land use should be permitted only if related directly to aviation-oriented activities or services. Conventional construction will generally be inadequate and special noise insulation features should be included in the building design.

1. National Research Council, working in conjunction with Canada Mortgage and Housing Corporation (CMHC) and Transport Canada Aviation, has developed a technique for selecting residential building components based on NEF values. This information is published in CMHC's *New Housing and Airport Noise Handbook*, NHA 5185 81/05. Authorities are referred to this document for assistance in determining appropriate noise insulation features for a particular residential development.

- G. Generally, these facilities should not be permitted in this zone. However, where it can be demonstrated that such a land use is highly desirable in a specific instance, construction may be permitted to proceed provided that a detailed noise analysis is conducted and the required noise insulation features are included in the building design.
- H. Facilities of this nature should not be located close to the NEF 30 contour unless a detailed noise analysis has been conducted.
- I. Many of these uses would be acceptable in all NEF zones. However, consideration should be given to internally generated noise levels, and acceptable noise levels in the working area.
- J. Undesirable if there is spectator involvement.
- K. It is recommended that serious consideration be given to an analysis of peak noise levels and the effects of these levels on the specific land use under consideration.
- L. The construction of covered enclosures should be undertaken if this use is to be newly introduced to the noise environment. (See Note M).
- M. Research has shown that animals condition themselves to high noise levels. However, it is recommended that peak noise levels be assessed before this use is allowed.
- N. This appears to be a compatible land use in all NEF zones.

TABLE 4
RECOMMENDED MATRIX OF NOISE CONTROL ACTIONS

CONSIDER THESE ACTIONS			IF YOU HAVE THIS PROBLEM		NOISE FROM TAKING DEPARTURE APPROACH LANDING ROLL TRAINING FLIGHTS MAINTENANCE GROUND EQUIPMENT									
↓			➡											
AIRPORT PLAN	Changes in Runway Location, Length or Strength	1	●	●	●	●	●							
	Displaced Thresholds	2				●		●						
	High-Speed Exit Taxways	3	●				●							
	Relocated Terminals	4	●							●	●			
	Isolating Maintenance Runups or Use of Test Stand Noise Suppressors and Barriers	5	●							●	●			
AIRPORT AND AIRSPACE USE	Preferential or Rotational Runway Use *	6	●	●	●	●	●							
	Preferential Flight Track Use or Modification to Approach and Departure Procedures *	7			●	●		●						
	Restrictions on Ground Movement of Aircraft *	8	●											
	Restrictions on Engine Runups or Use of Ground Equipment	9								●	●			
	Limitations on Number or Types of Operation or Types of Aircraft	10	●	●	●	●	●	●	●	●	●	●	●	
	Use Restrictions Rescheduling Move Flights to Another Airport	11	●	●	●	●	●	●	●	●	●	●	●	
	Raise Glide Slope Angle or Intercept *	12				●		●						
AIRCRAFT OPERATION	Power and Flap Management *	13			●	●		●						
	Limited Use of Reverse Thrust *	14						●						
LAND USE	Land or Easement Acquisition	15	●	●	●	●	●	●	●	●	●	●	●	
	Joint Development of Airport Property	16	●	●	●	●	●	●	●	●	●	●	●	
	Compatible Use Zoning	17	●	●	●	●	●	●	●	●	●	●	●	
	Building Code Provisions and Sound Insulation of Buildings	18	●	●	●	●	●	●	●	●	●	●	●	
	Real Property Noise Notices	19		●	●	●	●	●	●	●	●	●	●	
	Purchase Assurance	20		●	●	●	●	●	●	●	●	●	●	
NOISE PROGRAM MANAGEMENT	Noise Related Landing Fees	21	●	●	●	●	●							
	Noise Monitoring	22		●	●		●		●	●				
	Establish Citizen Complaint Mechanism Establish Community Participation Program	23	●	●	●	●	●	●	●	●	●	●	●	

* These are examples of "restrictions" that involve TC Aviation's responsibility for safe implementation.

Appendix D

EMME/2 Model

Base Network 1996 and Base Network 20020

Source: RMOC - Transportation Department

BASE NETWORK

emf2

1.1005
v.11.6.20

WINDOW:
4405 97 50116
4543 77 50219

96 09 05 13 54
MINUTE 2 13
PAGE

EMF2 PROJECT 851G3 851 tdm17_19.mxd tdm17_19.mxd
SCENARIO 8510 511 21_851g3 2021 demand Ditten Network North 14796

AUTO VOLUMES

Appendix E

Sao Paulo City - Brazil

Congonhas Airport Development 1936/1976

Source: dos Santos, Rubens R. "Aeroportos - Do Campo de Aviacao a Area Terminal". Sao Paulo: Editora Contar, 1985.

Appendix F

Public Archive Maps of the Ottawa-Carleton Region

Appendix G

Transport Canada - AMSAP Report

OMCIA Operation

Total Arrivals and Total Departures from 1990 to 1995

(Daytime/Nighttime, Aircraft Type and Runway Use)

R449N30.RPT

245

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Arrivals
Report Date(D/M/Y): 28:2:1996
Report Time(H/M/S): 2:26:19

January 1 to December 31 Year: 90

Power Type	Runway 25			Runway 32			Runway 7		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	10415	269	10684	7010	414	7424	5772	458	6230
%	97.5	2.5	42.4	94.4	5.6	29.5	92.6	7.4	24.7
Jet	9342	1314	10656	6732	914	7646	5681	1602	7283
%	87.7	12.3	40.6	88.0	12.0	29.1	78.0	22.0	27.7
Piston	1409	121	1530	1752	247	1999	775	161	936
%	92.1	7.9	10.3	87.6	12.4	13.4	82.8	17.2	6.3
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	2	0	2	0	1	1	1	1	2
%	100.0	0.0	7.7	0.0	100.0	3.8	50.0	50.0	7.7
Sub-Total	21168	1704	22872	15494	1576	17070	12229	2222	14451
%	92.5	7.5	33.4	90.8	9.2	24.9	84.6	15.4	21.1

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Arrivals
Report Date(D/M/Y): 28:2:1996
Report Time(H/M/S): 2:26:19

January 1 to December 31 Year: 90

Power Type	Runway 60			Runway 61			Runway 22		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	14	0	14	0	0	0	158	0	158
%	100.0	0.0	*	0.0	0.0	0.0	100.0	0.0	0.6
Jet	103	0	103	0	0	0	36	2	38
%	100.0	0.0	0.4	0.0	0.0	0.0	94.7	5.3	0.1
Piston	45	0	45	0	0	0	5718	4	5722
%	100.0	0.0	0.3	0.0	0.0	0.0	99.9	0.1	38.4

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Helicopter	0	0	0	2115	32	2147	0	0	0
%	0.0	0.0	0.0	98.5	1.5	100.0	0.0	0.0	0.0
Glider	2	0	2	0	0	0	8	0	8
%	100.0	0.0	7.7	0.0	0.0	0.0	100.0	0.0	30.8
Sub-Total	164	0	164	2115	32	2147	5920	6	5926
%	100.0	0.0	0.2	98.5	1.5	3.1	99.9	0.1	8.6

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Arrivals

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 2:26:19

January 1 to December 31 Year: 90

Power Type	Runway 14			Runway 99			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	438	24	462	130	3	133	37	3	40
%	94.8	5.2	1.8	97.7	2.3	0.5	92.5	7.5	0.2
Jet	301	41	342	156	16	172	14	1	15
%	88.0	12.0	1.3	90.7	9.3	0.7	93.3	6.7	*
Piston	337	52	389	584	47	631	1403	1	1404
%	86.6	13.4	2.6	92.6	7.4	4.2	99.9	0.1	9.4
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	0	0	0	1	0	1	5	0	5
%	0.0	0.0	0.0	100.0	0.0	3.8	100.0	0.0	19.2
Sub-Total	1076	117	1193	871	66	937	1459	5	1464
%	90.2	9.8	1.7	93.0	7.0	1.4	99.7	0.3	2.1

Airport: OTTAWA/MACDONALD-CARTIER INTL

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Itinerant Runway Utilization - Total Arrivals

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 2:26:19

January 1 to December 31 Year: 90

Power Type	Runway 4			Runway 17			Runway 70		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	41	0	41	2	0	2	0	0	0
%	100.0	0.0	0.2	100.0	0.0	*	0.0	0.0	0.0

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Jet	11	0	11	1	0	1	0	0	0
%	100.0	0.0	*	100.0	0.0	*	0.0	0.0	0.0
Piston	2177	2	2179	60	0	60	1	0	1
%	99.9	0.1	14.6	100.0	0.0	0.4	100.0	0.0	*
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	5	0	5	0	0	0	0	0	0
%	100.0	0.0	19.2	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	2234	2	2236	63	0	63	1	0	1
%	99.9	0.1	3.3	100.0	0.0	0.1	100.0	0.0	*

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Arrivals

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 2:26:19

January 1 to December 31

Power Type	Total Arrivals		
	Day	Night	Total
Turbo	24017	1171	25188
%	95.4	4.6	36.8
Jet	22377	3890	26267
%	85.2	14.8	38.3
Piston	14261	635	14896
%	95.7	4.3	21.7
Helicopter	2115	32	2147
%	98.5	1.5	3.1
Glider	24	2	26
%	92.3	7.7	*

Total Arrivals Day: 62794 %= 91.6

Total Arrivals Night: 5730 %= 8.4

Total Arrivals : 68524

Total Itinerant Movements in Interval: 136738

Notes: 1) (*) Denotes value was less than 0.1 percent

2) Percentages may not add up to 100 due to rounding

3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

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Airport: OTTAWA/MACDONALD-CARTIER INTL

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Itinerant Runway Utilization - Total Departures

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 2:26:19

January 1 to December 31 Year: 90

Power Type	Runway 25			Runway 32			Runway 7		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	11196	327	11523	5487	103	5590	5888	194	6082
%	97.2	2.8	46.1	98.2	1.8	22.4	96.8	3.2	24.3
Jet	10433	1224	11657	5864	288	6152	5605	931	6536
%	89.5	10.5	44.8	95.3	4.7	23.7	85.8	14.2	25.1
Piston	1310	78	1388	1093	36	1129	646	41	687
%	94.4	5.6	9.3	96.8	3.2	7.5	94.0	6.0	4.6
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	3	0	3	2	0	2	4	0	4
%	100.0	0.0	10.0	100.0	0.0	6.7	100.0	0.0	13.3
Sub-Total	22942	1629	24571	12446	427	12873	12143	1166	13309
%	93.4	6.6	36.0	96.7	3.3	18.9	91.2	8.8	19.5

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Departures

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 2:26:19

January 1 to December 31 Year: 90

Power Type	Runway 60			Runway 61			Runway 22		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	6	0	6	0	0	0	446	6	452
%	100.0	0.0	*	0.0	0.0	0.0	98.7	1.3	1.8
Jet	90	0	90	0	0	0	33	0	33
%	100.0	0.0	0.3	0.0	0.0	0.0	100.0	0.0	0.1
Piston	47	0	47	0	0	0	6508	27	6535
%	100.0	0.0	0.3	0.0	0.0	0.0	99.6	0.4	43.7

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Helicopter	0	0	0	2201	22	2223	0	0	0
%	0.0	0.0	0.0	99.0	1.0	100.0	0.0	0.0	0.0
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Glider	1	0	1	0	0	0	10	0	10
%	100.0	0.0	3.3	0.0	0.0	0.0	100.0	0.0	33.3
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Sub-Total	144	0	144	2201	22	2223	6997	33	7030
%	100.0	0.0	0.2	99.0	1.0	3.3	99.5	0.5	10.3

Airport: OTTAWA/MACDONALD-CARTIER INTL

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Itinerant Runway Utilization - Total Departures

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 2:26:19

January 1 to December 31 Year: 90

Power Type	Runway 14			Runway 99			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	848	172	1020	122	4	126	67	0	67
%	83.1	16.9	4.1	96.8	3.2	0.5	100.0	0.0	0.3
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Jet	1135	196	1331	139	18	157	21	0	21
%	85.3	14.7	5.1	88.5	11.5	0.6	100.0	0.0	*
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Piston	431	131	562	546	46	592	1578	0	1578
%	76.7	23.3	3.8	92.2	7.8	4.0	100.0	0.0	10.5
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Glider	2	0	2	2	0	2	3	0	3
%	100.0	0.0	6.7	100.0	0.0	6.7	100.0	0.0	10.0
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Sub-Total	2416	499	2915	809	68	877	1669	0	1669
%	82.9	17.1	4.3	92.2	7.8	1.3	100.0	0.0	2.4

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Departures

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 2:26:19

January 1 to December 31 Year: 90

Power Type	Runway 4			Runway 17			Runway 70		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	132	2	134	6	0	6	0	0	0
%	98.5	1.5	0.5	100.0	0.0	*	0.0	0.0	0.0

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Jet	16	0	16	2	0	2	0	1	1
%	100.0	0.0	*	100.0	0.0	*	0.0	100.0	*
Piston	2378	4	2382	59	0	59	0	0	0
%	99.8	0.2	15.9	100.0	0.0	0.4	0.0	0.0	0.0
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	3	0	3	0	0	0	0	0	0
%	100.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	2529	6	2535	67	0	67	0	1	1
%	99.8	0.2	3.7	100.0	0.0	0.1	0.0	100.0	*

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Departures
 Report Date(D/M/Y): 28:2:1996
 Report Time(H/M/S): 2:26:19

January 1 to December 31

Power Type	Total Departures /		
	Day	Night	Total
Turbo	24198	808	25006
%	96.8	3.2	36.7
Jet	23338	2658	25996
%	89.8	10.2	38.1
Piston	14596	363	14959
%	97.6	2.4	21.9
Helicopter	2201	22	2223
%	99.0	1.0	3.3
Glider	30	0	30
%	100.0	0.0	*

Total Departures Day: 64363 %= 94.4
 Total Departures Night: 3851 %= 5.6
 Total Departures : 68214

Total Itinerant Movements in Interval: 136738

Notes: 1) (*) Denotes value was less than 0.1 percent
 2) Percentages may not add up to 100 due to rounding
 3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

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Airport: OTTAWA/MACDONALD-CARTIER INTL

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Itinerant Runway Utilization - Total Arrivals

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:21:57

January 1 to December 31 Year: 91

Power Type	Runway 32			Runway 7			Runway 25		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	6876	550	7426	4522	375	4897	8552	188	8740
%	92.6	7.4	33.6	92.3	7.7	22.2	97.8	2.2	39.5
Jet	6600	820	7420	4986	1501	6487	8100	850	8950
%	88.9	11.1	31.9	76.9	23.1	27.8	90.5	9.5	38.4
Piston	1972	273	2245	670	236	906	1350	77	1427
%	87.8	12.2	15.2	74.0	26.0	6.1	94.6	5.4	9.6
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	1	0	1	2	0	2	3	0	3
%	100.0	0.0	5.3	100.0	0.0	10.5	100.0	0.0	15.8
Sub-Total	15449	1643	17092	10180	2112	12292	18005	1115	19120
%	90.4	9.6	27.1	82.8	17.2	19.5	94.2	5.8	30.3

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Arrivals

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:21:57

January 1 to December 31 Year: 91

Power Type	Runway 14			Runway 22			Runway 99		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	568	115	683	93	5	98	112	2	114
%	83.2	16.8	3.1	94.9	5.1	0.4	98.2	1.8	0.5
Jet	306	11	317	16	0	16	87	7	94
%	96.5	3.5	1.4	100.0	0.0	*	92.6	7.4	0.4
Piston	356	49	405	5961	13	5974	326	27	353
%	87.9	12.1	2.7	99.8	0.2	40.3	92.4	7.6	2.4

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Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	0	0	0	6	0	6	1	0	1
%	0.0	0.0	0.0	100.0	0.0	31.6	100.0	0.0	5.3
Sub-Total	1230	175	1405	6076	18	6094	526	36	562
%	87.5	12.5	2.2	99.7	0.3	9.7	93.6	6.4	0.9

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Arrivals

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:21:57

January 1 to December 31 Year: 91

Power Type	Runway 61			Runway 4			Runway 60		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	0	0	0	45	71	116	6	0	6
%	0.0	0.0	0.0	38.8	61.2	0.5	100.0	0.0	*
Jet	0	0	0	5	1	6	1	0	1
%	0.0	0.0	0.0	83.3	16.7	*	100.0	0.0	*
Piston	0	0	0	2622	3	2625	34	1	35
%	0.0	0.0	0.0	99.9	0.1	17.7	97.1	2.9	0.2
Helicopter	2678	201	2879	0	0	0	0	0	0
%	93.0	7.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	0	0	0	3	0	3	1	0	1
%	0.0	0.0	0.0	100.0	0.0	15.8	100.0	0.0	5.3
Sub-Total	2678	201	2879	2675	75	2750	42	1	43
%	93.0	7.0	4.6	97.3	2.7	4.4	97.7	2.3	*

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Arrivals

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:21:57

January 1 to December 31 Year: 91

Power Type	Runway 17			Runway 35			Total Arrivals		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	2	0	2	20	3	23	20796	1309	22105
%	100.0	0.0	*	87.0	13.0	0.1	94.1	5.9	35.0

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Jet	0	0	0	2	0	2	20103	3190	23293
%	0.0	0.0	0.0	100.0	0.0	*	86.3	13.7	36.9
Piston	43	0	43	798	1	799	14132	680	14812
%	100.0	0.0	0.3	99.9	0.1	5.4	95.4	4.6	23.5
Helicopter	0	0	0	0	0	0	2678	201	2879
%	0.0	0.0	0.0	0.0	0.0	0.0	93.0	7.0	4.6
Glider	0	0	0	2	0	2	19	0	19
%	0.0	0.0	0.0	100.0	0.0	10.5	100.0	0.0	*
Sub-Total	45	0	45	822	4	826			
%	100.0	0.0	*	99.5	0.5	1.3			

Total Arrivals Day: 57728 %= 91.5

Total Arrivals Night: 5380 %= 8.5

Total Arrivals : 63108

Total Itinerant Movements in Interval: 126286

Notes: 1) (*) Denotes value was less than 0.1 percent

2) Percentages may not add up to 100 due to rounding

3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

----- A.M.S.A.P. is a product of the ANS Long Range
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Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Departures
Report Date(D/M/Y): 11:4:1996
Report Time(H/M/S): 7:21:57

January 1 to December 31 Year: 91

Power Type	Runway 32			Runway 7			Runway 25		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	4285	69	4354	5038	166	5204	10518	332	10850
%	98.4	1.6	19.7	96.8	3.2	23.6	96.9	3.1	49.1
Jet	4790	258	5048	4908	1252	6160	9718	1238	10956
%	94.9	5.1	21.7	79.7	20.3	26.5	88.7	11.3	47.2
Piston	1043	44	1087	592	35	627	1628	112	1740
%	96.0	4.0	7.3	94.4	5.6	4.2	93.6	6.4	11.7
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	2	0	2	2	0	2	2	0	2
%	100.0	0.0	14.3	100.0	0.0	14.3	100.0	0.0	14.3
Sub-Total	10120	371	10491	10540	1453	11993	21866	1682	23548
%	96.5	3.5	16.6	87.9	12.1	19.0	92.9	7.1	37.3

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Departures
Report Date(D/M/Y): 11:4:1996
Report Time(H/M/S): 7:21:57

January 1 to December 31 Year: 91

Power Type	Runway 14			Runway 22			Runway 99		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	982	142	1124	248	75	323	106	3	109
%	87.4	12.6	5.1	76.8	23.2	1.5	97.2	2.8	0.5
Jet	848	114	962	10	0	10	78	8	86
%	88.1	11.9	4.1	100.0	0.0	*	90.7	9.3	0.4
Piston	391	77	468	6810	24	6834	302	30	332
%	83.5	16.5	3.1	99.6	0.4	45.9	91.0	9.0	2.2

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Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	1	0	1	4	0	4	0	0	0
%	100.0	0.0	7.1	100.0	0.0	28.6	0.0	0.0	0.0
Sub-Total	2222	333	2555	7072	99	7171	486	41	527
%	87.0	13.0	4.0	98.6	1.4	11.4	92.2	7.8	0.8

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Departures

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:21:57

January 1 to December 31 Year: 91

Power Type	Runway 61			Runway 4			Runway 60		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	0	0	0	81	8	89	5	1	6
%	0.0	0.0	0.0	91.0	9.0	0.4	83.3	16.7	*
Jet	0	0	0	5	0	5	6	0	6
%	0.0	0.0	0.0	100.0	0.0	*	100.0	0.0	*
Piston	0	0	0	2865	6	2871	24	0	24
%	0.0	0.0	0.0	99.8	0.2	19.3	100.0	0.0	0.2
Helicopter	2866	101	2967	0	0	0	0	0	0
%	96.6	3.4	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	0	0	0	2	0	2	1	0	1
%	0.0	0.0	0.0	100.0	0.0	14.3	100.0	0.0	7.1
Sub-Total	2866	101	2967	2953	14	2967	36	1	37
%	96.6	3.4	4.7	99.5	0.5	4.7	97.3	2.7	*

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Departures

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:21:57

January 1 to December 31 Year: 91

Power Type	Runway 17			Runway 35			Total Departures		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	2	0	2	17	0	17	21282	796	22078
%	100.0	0.0	*	100.0	0.0	*	96.4	3.6	34.9

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256

Jet	0	0	0	1	1	2	20364	2871	23235
%	0.0	0.0	0.0	50.0	50.0	*	87.6	12.4	36.8
Piston	48	0	48	852	0	852	14555	328	14883
%	100.0	0.0	0.3	100.0	0.0	5.7	97.8	2.2	23.6
Helicopter	0	0	0	0	0	0	2866	101	2967
%	0.0	0.0	0.0	0.0	0.0	0.0	96.6	3.4	4.7
Glider	0	0	0	0	0	0	14	0	14
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	*
Sub-Total	50	0	50	870	1	871			
%	100.0	0.0	*	99.9	0.1	1.4			

Total Departures Day: 59081 %= 93.5
Total Departures Night: 4096 %= 6.5
Total Departures : 63177

Total Itinerant Movements in Interval: 126286

Notes: 1) (*) Denotes value was less than 0.1 percent
2) Percentages may not add up to 100 due to rounding
3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

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Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

257

Itinerant Runway Utilization - Total Arrivals

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 0:10:14

January 1 to December 31 Year: 92

Power Type	Runway 7			Runway 61			Runway 25		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	5426	1518	6944	0	0	0	8025	979	9004
%	78.1	21.9	28.5	0.0	0.0	0.0	89.1	10.9	37.0
Helicopter	1	0	1	2820	231	3051	1	0	1
%	100.0	0.0	*	92.4	7.6	99.8	100.0	0.0	*
Turbo	4547	316	4863	0	0	0	7210	128	7338
%	93.5	6.5	24.1	0.0	0.0	0.0	98.3	1.7	36.4
Piston	702	265	967	0	0	0	1402	129	1531
%	72.6	27.4	7.1	0.0	0.0	0.0	91.6	8.4	11.3
Glider	2	0	2	0	0	0	1	0	1
%	100.0	0.0	28.6	0.0	0.0	0.0	100.0	0.0	14.3
Sub-Total	10678	2099	12777	2820	231	3051	16639	1236	17875
%	83.6	16.4	20.9	92.4	7.6	5.0	93.1	6.9	29.2

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Arrivals

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 0:10:14

January 1 to December 31 Year: 92

Power Type	Runway 14			Runway 32			Runway 22		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	166	18	184	7221	830	8051	21	0	21
%	90.2	9.8	0.8	89.7	10.3	33.1	100.0	0.0	*
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turbo	459	39	498	6655	445	7100	94	4	98
%	92.2	7.8	2.5	93.7	6.3	35.3	95.9	4.1	0.5
Piston	288	53	341	1723	210	1933	5431	11	5442
%	84.5	15.5	2.5	89.1	10.9	14.2	99.8	0.2	40.0
Glider	0	0	0	1	0	1	0	0	0
%	0.0	0.0	0.0	100.0	0.0	14.3	0.0	0.0	0.0
Sub-Total	913	110	1023	15600	1485	17085	5546	15	5561

| % | 89.2 10.8 1.7 | 91.4 29.3 8.3 | 99.7 0.3 9.1 |

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

258

Itinerant Runway Utilization - Total Arrivals

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 0:10:14

January 1 to December 31 Year: 92

Power Type	Runway 4			Runway 99			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	1	0	1	118	3	121	10	0	10
%	100.0	0.0	*	97.5	2.5	0.5	100.0	0.0	*
Helicopter	1	0	1	0	0	0	0	0	0
%	100.0	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0
Turbo	42	83	125	89	3	92	19	0	19
%	33.6	66.4	0.6	96.7	3.3	0.5	100.0	0.0	*
Piston	1961	6	1967	232	21	253	1111	5	1116
%	99.7	0.3	14.5	91.7	8.3	1.9	99.6	0.4	8.2
Glider	1	0	1	1	0	1	1	0	1
%	100.0	0.0	14.3	100.0	0.0	14.3	100.0	0.0	14.3
Sub-Total	2006	89	2095	440	27	467	1141	5	1146
%	95.8	4.2	3.4	94.2	5.8	0.8	99.6	0.4	1.9

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Arrivals

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 0:10:14

January 1 to December 31 Year: 92

Power Type	Runway 60			Runway 17			Total Arrivals		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	5	0	5	1	0	1	20994	3348	24342
%	100.0	0.0	*	100.0	0.0	*	85.2	13.8	39.8
Helicopter	3	0	3	0	0	0	2826	231	3057
%	100.0	0.0	*	0.0	0.0	0.0	92.4	7.6	5.0
Turbo	3	0	3	1	0	1	19119	1018	20137
%	100.0	0.0	*	100.0	0.0	*	94.9	5.1	32.9
Piston	19	1	20	34	0	34	12903	701	13604
%	95.0	5.0	0.1	100.0	0.0	0.2	94.8	5.2	22.2
Glider	0	0	0	0	0	0	7	0	7
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	*
Sub-Total	30	1	31	36	0	36			

| % | 96.8 3.2 * | 10049N38:RPT * |

Total Arrivals Day: 55849 %= 91.3
Total Arrivals Night: 5298 %= 8.7
Total Arrivals : 61147

259

Total Itinerant Movements in Interval: 122839

Notes: 1) (*) Denotes value was less than 0.1 percent
2) Percentages may not add up to 100 due to rounding
3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

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Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

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Itinerant Runway Utilization - Total Departures
Report Date(D/M/Y): 28:2:1996
Report Time(H/M/S): 0:10:14

January 1 to December 31 Year: 92

Power Type	Runway 7			Runway 61			Runway 25		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	5673	1224	6897	0	0	0	10153	1048	11201
%	82.3	17.7	28.4	0.0	0.0	0.0	90.6	9.4	46.1
Helicopter	0	0	0	3281	162	3443	0	0	0
%	0.0	0.0	0.0	95.3	4.7	99.8	0.0	0.0	0.0
Turbo	5172	159	5331	0	0	0	9512	252	9764
%	97.0	3.0	25.5	0.0	0.0	0.0	97.4	2.6	48.5
Piston	577	63	640	0	0	0	1841	178	2019
%	90.2	9.8	4.6	0.0	0.0	0.0	91.2	8.8	14.6
Glider	0	0	0	0	0	0	3	0	3
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	50.0
Sub-Total	11422	1446	12868	3281	162	3443	21509	1478	22987
%	88.8	11.2	20.9	95.3	4.7	5.6	93.6	6.4	37.3

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Departures
Report Date(D/M/Y): 28:2:1996
Report Time(H/M/S): 0:10:14

January 1 to December 31 Year: 92

Power Type	Runway 14			Runway 32			Runway 22		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	956	156	1112	4691	252	4943	8	0	8
%	86.0	14.0	4.6	94.9	5.1	20.4	100.0	0.0	*
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turbo	889	89	978	3511	80	3591	223	64	287
%	90.9	9.1	4.9	97.8	2.2	17.8	77.7	22.3	1.4
Piston	330	54	384	928	28	956	6142	16	6158
%	85.9	14.1	2.8	97.1	2.9	6.9	99.7	0.3	44.6
Glider	0	0	0	0	0	0	2	0	2
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	33.3
Sub-Total	2175	299	2474	9130	360	9490	6375	80	6455

| % | 87.9 12.1 4.0 | 94.4 9.3 15.4 | 98.8 1.2 10.5 |

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

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Itinerant Runway Utilization - Total Departures

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 0:10:14

January 1 to December 31 Year: 92

Power Type	Runway 4			Runway 99			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	3	0	3	95	2	97	6	0	6
%	100.0	0.0	*	97.9	2.1	0.4	100.0	0.0	*
Helicopter	1	0	1	0	0	0	0	0	0
%	100.0	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0
Turbo	77	3	80	84	3	87	22	0	22
%	96.2	3.8	0.4	96.6	3.4	0.4	100.0	0.0	0.1
Piston	2131	4	2135	232	24	256	1190	2	1192
%	99.8	0.2	15.5	90.6	9.4	1.9	99.8	0.2	8.6
Glider	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	2212	7	2219	411	29	440	1218	2	1220
%	99.7	0.3	3.6	93.4	6.6	0.7	99.8	0.2	2.0

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Departures

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 0:10:14

January 1 to December 31 Year: 92

Power Type	Runway 60			Runway 17			Total Departures		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	4	0	4	2	0	2	21591	2682	24273
%	100.0	0.0	*	100.0	0.0	*	89.0	11.0	39.3
Helicopter	6	0	6	0	0	0	3288	162	3450
%	100.0	0.0	0.2	0.0	0.0	0.0	95.3	4.7	5.6
Turbo	3	0	3	1	1	2	19494	651	20145
%	100.0	0.0	*	50.0	50.0	*	96.8	3.2	32.7
Piston	32	0	32	44	2	46	13447	371	13818
%	100.0	0.0	0.2	95.7	4.3	0.3	97.3	2.7	22.4
Glider	1	0	1	0	0	0	6	0	6
%	100.0	0.0	16.7	0.0	0.0	0.0	100.0	0.0	*
Sub-Total	46	0	46	47	3	50			

| % |100.0 0.0 * | 9449N35:RPT * |

Total Departures Day: 57826 %= 93.7
Total Departures Night: 3866 %= 6.3
Total Departures : 61692

262

Total Itinerant Movements in Interval: 122839

Notes: 1) (*) Denotes value was less than 0.1 percent
2) Percentages may not add up to 100 due to rounding
3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

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R449N30.RPT

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Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Arrivals
Report Date(D/M/Y): 14:4:1996
Report Time(H/M/S): 4:17:26

January 1 to December 31 Year: 93

Power Type	Runway 32			Runway 25			Runway 7		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	7055	419	7474	5980	100	6080	3624	223	3847
%	94.4	5.6	41.4	98.4	1.6	33.7	94.2	5.8	21.3
Jet	7547	581	8128	8040	961	9001	4623	1337	5960
%	92.9	7.1	34.6	89.3	10.7	38.3	77.6	22.4	25.4
Piston	1391	191	1582	1373	87	1460	531	230	761
%	87.9	12.1	12.7	94.0	6.0	11.7	69.8	30.2	6.1
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	1	0	1	1	0	1	0	0	0
%	100.0	0.0	16.7	100.0	0.0	16.7	0.0	0.0	0.0
Sub-Total	15994	1191	17185	15394	1148	16542	8778	1790	10568
%	93.1	6.9	30.0	93.1	6.9	28.9	83.1	16.9	18.4

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Arrivals
Report Date(D/M/Y): 14:4:1996
Report Time(H/M/S): 4:17:26

January 1 to December 31 Year: 93

Power Type	Runway 14			Runway 22			Runway 61		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	419	22	441	66	0	66	0	0	0
%	95.0	5.0	2.4	100.0	0.0	0.4	0.0	0.0	0.0
Jet	211	16	227	15	0	15	0	0	0
%	93.0	7.0	1.0	100.0	0.0	*	0.0	0.0	0.0
Piston	209	47	256	5401	5	5406	0	0	0
%	81.6	18.4	2.1	99.9	0.1	43.4	0.0	0.0	0.0

R449N30.RPT

Helicopter	0	0	0	0	0	0	3072	229	3301	264
%	0.0	0.0	0.0	0.0	0.0	0.0	93.1	6.9	100.0	
Glider	0	0	0	2	0	2	0	0	0	
%	0.0	0.0	0.0	100.0	0.0	33.3	0.0	0.0	0.0	
Sub-Total	839	85	924	5484	5	5489	3072	229	3301	
%	90.8	9.2	1.6	99.9	0.1	9.6	93.1	6.9	5.8	

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Arrivals
 Report Date(D/M/Y): 14:4:1996
 Report Time(H/M/S): 4:17:26

January 1 to December 31 Year: 93

Power Type	Runway 99			Runway 4			Runway 60		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	91	1	92	24	0	24	1	0	1
%	98.9	1.1	0.5	100.0	0.0	0.1	100.0	0.0	*
Jet	146	3	149	12	0	12	2	0	2
%	98.0	2.0	0.6	100.0	0.0	*	100.0	0.0	*
Piston	284	16	300	1530	3	1533	17	1	18
%	94.7	5.3	2.4	99.8	0.2	12.3	94.4	5.6	0.1
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	0	0	0	1	0	1	1	0	1
%	0.0	0.0	0.0	100.0	0.0	16.7	100.0	0.0	16.7
Sub-Total	521	20	541	1567	3	1570	21	1	22
%	96.3	3.7	0.9	99.8	0.2	2.7	95.5	4.5	*

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Arrivals
 Report Date(D/M/Y): 14:4:1996
 Report Time(H/M/S): 4:17:26

January 1 to December 31 Year: 93

Power Type	Runway 17			Runway 35			Total Arrivals		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	1	0	1	9	0	9	17270	765	18035
%	100.0	0.0	*	100.0	0.0	*	95.8	4.2	31.5

R449N30.RPT

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Jet	1	0	1	6	0	6	20603	2898	23501
%	100.0	0.0	*	100.0	0.0	*	87.7	12.3	41.0
Piston	60	0	60	1090	0	1090	11886	580	12466
%	100.0	0.0	0.5	100.0	0.0	8.7	95.3	4.7	21.8
Helicopter	0	0	0	0	0	0	3072	229	3301
%	0.0	0.0	0.0	0.0	0.0	0.0	93.1	6.9	5.8
Glider	0	0	0	0	0	0	6	0	6
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	*
Sub-Total	62	0	62	1105	0	1105			
%	100.0	0.0	0.1	100.0	0.0	1.9			

Total Arrivals Day: 52837 %= 92.2
 Total Arrivals Night: 4472 %= 7.8
 Total Arrivals : 57309

Total Itinerant Movements in Interval: 114901

Notes: 1) (*) Denotes value was less than 0.1 percent
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 3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

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R449N31.RPT

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Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Departures
Report Date(D/M/Y): 14:4:1996
Report Time(H/M/S): 4:17:26

January 1 to December 31 Year: 93

Power Type	Runway 32			Runway 25			Runway 7		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	3433	181	3614	8876	288	9164	4108	114	4222
%	95.0	5.0	20.1	96.9	3.1	50.9	97.3	2.7	23.4
Jet	4166	245	4413	10320	1182	11502	4899	1339	6238
%	94.4	5.6	18.8	89.7	10.3	49.1	78.5	21.5	26.6
Piston	724	31	755	1645	112	1757	481	41	522
%	95.9	4.1	6.0	93.6	6.4	13.9	92.1	7.9	4.1
Helicopter	1	0	1	0	0	0	0	0	0
%	100.0	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0
Glider	0	0	0	2	0	2	1	0	1
%	0.0	0.0	0.0	100.0	0.0	33.3	100.0	0.0	16.7
Sub-Total	8326	457	8783	20843	1582	22425	9489	1494	10983
%	94.8	5.2	15.3	92.9	7.1	38.9	86.4	13.6	19.1

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Departures
Report Date(D/M/Y): 14:4:1996
Report Time(H/M/S): 4:17:26

January 1 to December 31 Year: 93

Power Type	Runway 14			Runway 22			Runway 61		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	737	30	767	116	3	119	0	0	0
%	96.1	3.9	4.3	97.5	2.5	0.7	0.0	0.0	0.0
Jet	912	175	1087	16	0	16	0	0	0
%	83.9	16.1	4.6	100.0	0.0	*	0.0	0.0	0.0
Piston	312	53	365	6057	11	6068	0	0	0
%	85.5	14.5	2.9	99.8	0.2	48.1	0.0	0.0	0.0

R449N31.RPT

Helicopter	0	0	0	0	0	0	3414	130	3544	267
%	0.0	0.0	0.0	0.0	0.0	0.0	96.3	3.7	100.0	
Glider	1	0	1	1	0	1	0	0	0	
%	100.0	0.0	16.7	100.0	0.0	16.7	0.0	0.0	0.0	
Sub-Total	1962	258	2220	6190	14	6204	3414	130	3544	
%	88.4	11.6	3.9	99.8	0.2	10.8	96.3	3.7	6.2	

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Departures

Report Date(D/M/Y): 14:4:1996

Report Time(H/M/S): 4:17:26

January 1 to December 31 Year: 93

Power Type	Runway 99			Runway 4			Runway 60		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	88	1	89	20	0	20	2	0	2
%	98.9	1.1	0.5	100.0	0.0	0.1	100.0	0.0	*
Jet	142	2	144	12	1	13	3	0	3
%	98.6	1.4	0.6	92.3	7.7	*	100.0	0.0	*
Piston	276	16	292	1630	1	1631	13	0	13
%	94.5	5.5	2.3	99.9	0.1	12.9	100.0	0.0	0.1
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	0	0	0	0	0	0	1	0	1
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	16.7
Sub-Total	506	19	525	1662	2	1664	19	0	19
%	96.4	3.6	0.9	99.9	0.1	2.9	100.0	0.0	*

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Departures

Report Date(D/M/Y): 14:4:1996

Report Time(H/M/S): 4:17:26

January 1 to December 31 Year: 93

Power Type	Runway 17			Runway 35			Total Departures		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Turbo	3	0	3	20	0	20	17403	617	18020
%	100.0	0.0	*	100.0	0.0	0.1	96.6	3.4	31.3

R449N31.RPT

Jet	0	0	0	2	0	2	20474	2944	23418	268
%	0.0	0.0	0.0	100.0	0.0	*	87.4	12.6	40.7	
Piston	101	0	101	1098	1	1099	12337	266	12603	
%	100.0	0.0	0.8	99.9	0.1	8.7	97.9	2.1	21.9	
Helicopter	0	0	0	0	0	0	3415	130	3545	
%	0.0	0.0	0.0	0.0	0.0	0.0	96.3	3.7	6.2	
Glider	0	0	0	0	0	0	6	0	6	
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	*	
Sub-Total	104	0	104	1120	1	1121				
%	100.0	0.0	0.2	99.9	0.1	1.9				

Total Departures Day: 53635 %= 93.1
 Total Departures Night: 3957 %= 6.9
 Total Departures : 57592

Total Itinerant Movements in Interval: 114901

Notes: 1) (*) Denotes value was less than 0.1 percent
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 3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

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R449N30.RPT

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Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Arrivals
Report Date (D/M/Y): 14:4:1996
Report Time (H/M/S): 8:24:23

January 1 to December 31 Year: 94

Power Type	Runway 7			Runway 25			Runway 14		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	3904	1200	5104	7598	1010	8608	327	21	348
%	76.5	23.5	20.5	88.3	11.7	34.5	94.0	6.0	1.4
Turbo	3019	213	3232	5081	154	5235	488	22	510
%	93.4	6.6	18.0	97.1	2.9	29.2	95.7	4.3	2.8
Piston	511	201	712	1365	67	1432	194	29	223
%	71.8	28.2	5.6	95.3	4.7	11.4	87.0	13.0	1.8
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	7434	1614	9048	14044	1231	15275	1009	72	1081
%	82.2	17.8	15.5	91.9	8.1	26.2	93.3	6.7	1.9

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Arrivals
Report Date (D/M/Y): 14:4:1996
Report Time (H/M/S): 8:24:23

January 1 to December 31 Year: 94

Power Type	Runway 32			Runway 22			Runway 99		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	9354	1359	10713	14	0	14	147	7	154
%	87.3	12.7	42.9	100.0	0.0	*	95.5	4.5	0.6
Turbo	8252	478	8730	59	0	59	82	4	86
%	94.5	5.5	48.7	100.0	0.0	0.3	95.3	4.7	0.5
Piston	1843	236	2079	4874	8	4882	397	24	421
%	88.6	11.4	16.5	99.8	0.2	38.7	94.3	5.7	3.3

R449N30.RPT

Helicopter	0	0	0	0	0	0	0	0	0	270
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Glider	2	0	2	0	0	0	1	0	1	
%	100.0	0.0	50.0	0.0	0.0	0.0	100.0	0.0	25.0	
Sub-Total	19451	2073	21524	4947	8	4955	627	35	662	
%	90.4	9.6	37.0	99.8	0.2	8.5	94.7	5.3	1.1	

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Arrivals

Report Date(D/M/Y): 14:4:1996

Report Time(H/M/S): 8:24:23

January 1 to December 31 Year: 94

Power Type	Runway 4			Runway 61			Runway 60		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	7	1	8	0	0	0	4	0	4
%	87.5	12.5	*	0.0	0.0	0.0	100.0	0.0	*
Turbo	21	0	21	0	0	0	3	0	3
%	100.0	0.0	0.1	0.0	0.0	0.0	100.0	0.0	*
Piston	1382	2	1384	0	0	0	33	1	34
%	99.9	0.1	11.0	0.0	0.0	0.0	97.1	2.9	0.3
Helicopter	0	0	0	2567	185	2752	0	0	0
%	0.0	0.0	0.0	93.3	6.7	100.0	0.0	0.0	0.0
Glider	0	0	0	0	0	0	1	0	1
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	25.0
Sub-Total	1410	3	1413	2567	185	2752	41	1	42
%	99.8	0.2	2.4	93.3	6.7	4.7	97.6	2.4	*

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Arrivals

Report Date(D/M/Y): 14:4:1996

Report Time(H/M/S): 8:24:23

January 1 to December 31 Year: 94

Power Type	Runway 35			Runway 17			Total Arrivals		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	5	0	5	0	0	0	21360	3598	24958
%	100.0	0.0	*	0.0	0.0	0.0	85.6	14.4	42.9

R449N30.RPT

Turbo	35	0	35	1	0	1	17041	871	17912
%	100.0	0.0	0.2	100.0	0.0	*	95.1	4.9	30.8
Piston	1394	0	1394	45	0	45	12038	568	12606
%	100.0	0.0	11.1	100.0	0.0	0.4	95.5	4.5	21.6
Helicopter	0	0	0	0	0	0	2567	185	2752
%	0.0	0.0	0.0	0.0	0.0	0.0	93.3	6.7	4.7
Glider	0	0	0	0	0	0	4	0	4
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	*
Sub-Total	1434	0	1434	46	0	46			
%	100.0	0.0	2.5	100.0	0.0	*			

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Total Arrivals Day: 53010 %= 91.0
 Total Arrivals Night: 5222 %= 9.0
 Total Arrivals : 58232

Total Itinerant Movements in Interval: 116578

Notes: 1) (*) Denotes value was less than 0.1 percent
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----- End Of A.M.S.A.P. V1.0 Report -----

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Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Departures
Report Date(D/M/Y): 14:4:1996
Report Time(H/M/S): 8:24:23

January 1 to December 31 Year: 94

Power Type	Runway 7			Runway 25			Runway 14		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	4160	1053	5213	9689	1267	10956	1035	213	1248
%	79.8	20.2	21.0	88.4	11.6	44.2	82.9	17.1	5.0
Turbo	3148	163	3311	7643	410	8053	722	100	822
%	95.1	4.9	18.5	94.9	5.1	45.1	87.8	12.2	4.6
Piston	485	33	518	1608	141	1749	249	43	292
%	93.6	6.4	4.0	91.9	8.1	13.6	85.3	14.7	2.3
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	7793	1249	9042	18940	1818	20758	2006	356	2362
%	86.2	13.8	15.5	91.2	8.8	35.6	84.9	15.1	4.0

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Departures
Report Date(D/M/Y): 14:4:1996
Report Time(H/M/S): 8:24:23

January 1 to December 31 Year: 94

Power Type	Runway 32			Runway 22			Runway 99		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	6727	461	7188	7	0	7	132	8	140
%	93.6	6.4	29.0	100.0	0.0	*	94.3	5.7	0.6
Turbo	5047	441	5488	51	2	53	79	2	81
%	92.0	8.0	30.7	96.2	3.8	0.3	97.5	2.5	0.5
Piston	1251	59	1310	5691	14	5705	382	23	405
%	95.5	4.5	10.2	99.8	0.2	44.4	94.3	5.7	3.2

R449N31.RPT

Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glider	3	0	3	0	0	0	1	0	1
%	100.0	0.0	75.0	0.0	0.0	0.0	100.0	0.0	25.0
Sub-Total	13028	961	13989	5749	16	5765	594	33	627
%	93.1	6.9	24.0	99.7	0.3	9.9	94.7	5.3	1.1

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Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Departures
 Report Date (D/M/Y): 14:4:1996
 Report Time (H/M/S): 8:24:23

January 1 to December 31 Year: 94

Power Type	Runway 4			Runway 61			Runway 60		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	3	0	3	0	0	0	7	0	7
%	100.0	0.0	*	0.0	0.0	0.0	100.0	0.0	*
Turbo	7	0	7	0	0	0	3	0	3
%	100.0	0.0	*	0.0	0.0	0.0	100.0	0.0	*
Piston	1423	1	1424	0	0	0	33	2	35
%	99.9	0.1	11.1	0.0	0.0	0.0	94.3	5.7	0.3
Helicopter	0	0	0	2737	150	2887	0	0	0
%	0.0	0.0	0.0	94.8	5.2	100.0	0.0	0.0	0.0
Glider	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	1433	1	1434	2737	150	2887	43	2	45
%	99.9	0.1	2.5	94.8	5.2	4.9	95.6	4.4	*

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Departures
 Report Date (D/M/Y): 14:4:1996
 Report Time (H/M/S): 8:24:23

January 1 to December 31 Year: 94

Power Type	Runway 35			Runway 17			Total Departures		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	4	0	4	1	0	1	21765	3002	24767
%	100.0	0.0	*	100.0	0.0	*	87.9	12.1	42.4

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Turbo	33	0	33	1	0	1	16734	1118	17852
%	100.0	0.0	0.2	100.0	0.0	*	93.7	6.3	30.6
Piston	1309	2	1311	75	12	87	12506	330	12836
%	99.8	0.2	10.2	86.2	13.8	0.7	97.4	2.6	22.0
Helicopter	0	0	0	0	0	0	2737	150	2887
%	0.0	0.0	0.0	0.0	0.0	0.0	94.8	5.2	4.9
Glider	0	0	0	0	0	0	4	0	4
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	*
Sub-Total	1346	2	1348	77	12	89			
%	99.9	0.1	2.3	86.5	13.5	0.2			

Total Departures Day: 53746 %= 92.1
 Total Departures Night: 4600 %= 7.9
 Total Departures : 58346

Total Itinerant Movements in Interval: 116578

Notes: 1) (*) Denotes value was less than 0.1 percent
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----- End Of A.M.S.A.P. V1.0 Report -----

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R449N30.RPT

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Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Arrivals
Report Date(D/M/Y): 7:5:1996
Report Time(H/M/S): 22:57:8

January 1 to December 31 Year: 95

Power Type	Runway 7			Runway 14			Runway 32		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	5404	1756	7160	252	20	272	9903	1576	11479
%	75.5	24.5	25.1	92.6	7.4	1.0	86.3	13.7	40.3
Turbo	3031	258	3289	488	26	514	6660	487	7147
%	92.2	7.8	20.3	94.9	5.1	3.2	93.2	6.8	44.2
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Piston	561	252	813	332	57	389	1552	201	1753
%	69.0	31.0	5.7	85.3	14.7	2.7	88.5	11.5	12.3
Glider	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	8996	2266	11262	1072	103	1175	18115	2264	20379
%	79.9	20.1	18.4	91.2	8.8	1.9	88.9	11.1	33.4

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Arrivals
Report Date(D/M/Y): 7:5:1996
Report Time(H/M/S): 22:57:8

January 1 to December 31 Year: 95

Power Type	Runway 61			Runway 25			Runway 22		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	0	0	0	8074	1287	9361	17	0	17
%	0.0	0.0	0.0	86.3	13.7	32.9	100.0	0.0	*
Turbo	0	0	0	4962	150	5112	18	0	18
%	0.0	0.0	0.0	97.1	2.9	31.6	100.0	0.0	0.1
Helicopter	2088	119	2207	1	0	1	0	0	0
%	94.6	5.4	99.9	100.0	0.0	*	0.0	0.0	0.0

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Piston	0	0	0	1554	115	1669	6104	6	6110	276
%	0.0	0.0	0.0	93.1	6.9	11.7	99.9	0.1	42.9	
Glider	0	0	0	1	0	1	0	0	0	
%	0.0	0.0	0.0	100.0	0.0	100.0	0.0	0.0	0.0	
Sub-Total	2088	119	2207	14592	1552	16144	6139	6	6145	
%	94.6	5.4	3.6	90.4	9.6	26.4	99.9	0.1	10.1	

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Arrivals
Report Date(D/M/Y): 7:5:1996
Report Time(H/M/S): 22:57:8

January 1 to December 31 Year: 95

Power Type	Runway 99			Runway 4			Runway 60		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	145	12	157	10	0	10	20	2	22
%	92.4	7.6	0.6	100.0	0.0	*	90.9	9.1	*
Turbo	89	3	92	4	0	4	3	0	3
%	96.7	3.3	0.6	100.0	0.0	*	100.0	0.0	*
Helicopter	0	0	0	0	0	0	2	0	2
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	*
Piston	284	18	302	1941	3	1944	28	0	28
%	94.0	6.0	2.1	99.8	0.2	13.7	100.0	0.0	0.2
Glider	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	518	33	551	1955	3	1958	53	2	55
%	94.0	6.0	0.9	99.8	0.2	3.2	96.4	3.6	0.1

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Arrivals
Report Date(D/M/Y): 7:5:1996
Report Time(H/M/S): 22:57:8

January 1 to December 31 Year: 95

Power Type	Runway 35			Runway 17			Total Arrivals		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	5	0	5	1	0	1	23831	4653	28484
%	100.0	0.0	*	100.0	0.0	*	83.7	16.3	46.6

R449N30.RPT

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Turbo	1	0	1	0	0	0	15256	924	16180
%	100.0	0.0	*	0.0	0.0	0.0	94.3	5.7	26.5
Helicopter	0	0	0	0	0	0	2091	119	2210
%	0.0	0.0	0.0	0.0	0.0	0.0	94.6	5.4	3.6
Piston	1132	0	1132	90	0	90	13578	652	14230
%	100.0	0.0	8.0	100.0	0.0	0.6	95.4	4.6	23.3
Glider	0	0	0	0	0	0	1	0	1
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	*
Sub-Total	1138	0	1138	91	0	91			
%	100.0	0.0	1.9	100.0	0.0	0.1			

Total Arrivals Day: 54757 %= 89.6
 Total Arrivals Night: 6348 %= 10.4
 Total Arrivals : 61105

Total Itinerant Movements in Interval: 122338

Notes: 1) (*) Denotes value was less than 0.1 percent
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----- End Of A.M.S.A.P. V1.0 Report -----

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R449N31.RPT

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Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Departures
Report Date(D/M/Y): 7:5:1996
Report Time(H/M/S): 22:57:8

January 1 to December 31 Year: 95

Power Type	Runway 7			Runway 14			Runway 32		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	6114	1217	7331	1092	113	1205	4632	299	4931
%	83.4	16.6	25.8	90.6	9.4	4.2	93.9	6.1	17.4
Turbo	3655	247	3902	1063	68	1131	2594	252	2846
%	93.7	6.3	24.2	94.0	6.0	7.0	91.1	8.9	17.6
Helicopter	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Piston	518	58	576	457	56	513	860	35	895
%	89.9	10.1	4.0	89.1	10.9	3.6	96.1	3.9	6.2
Glider	0	1	1	0	0	0	1	0	1
%	0.0	100.0	14.3	0.0	0.0	0.0	100.0	0.0	14.3
Sub-Total	10287	1523	11810	2612	237	2849	8087	586	8673
%	87.1	12.9	19.3	91.7	8.3	4.7	93.2	6.8	14.2

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization - Total Departures
Report Date(D/M/Y): 7:5:1996
Report Time(H/M/S): 22:57:8

January 1 to December 31 Year: 95

Power Type	Runway 61			Runway 25			Runway 22		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	0	0	0	13166	1541	14707	18	0	18
%	0.0	0.0	0.0	89.5	10.5	51.8	100.0	0.0	*
Turbo	0	0	0	7804	360	8164	9	0	9
%	0.0	0.0	0.0	95.6	4.4	50.5	100.0	0.0	*
Helicopter	2196	105	2301	0	0	0	0	0	0
%	95.4	4.6	99.9	0.0	0.0	0.0	0.0	0.0	0.0

R449N31.RPT

Piston	0	0	0	1919	165	2084	6631	47	6678	279
%	0.0	0.0	0.0	92.1	7.9	14.5	99.3	0.7	46.4	
Glider	0	0	0	1	0	1	2	0	2	
%	0.0	0.0	0.0	100.0	0.0	14.3	100.0	0.0	28.6	
Sub-Total	2196	105	2301	22890	2066	24956	6660	47	6707	
%	95.4	4.6	3.8	91.7	8.3	40.8	99.3	0.7	11.0	

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Departures

Report Date(D/M/Y): 7:5:1996

Report Time(H/M/S): 22:57:8

January 1 to December 31 Year: 95

Power Type	Runway 99			Runway 4			Runway 60		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	140	11	151	11	0	11	19	1	20
%	92.7	7.3	0.5	100.0	0.0	*	95.0	5.0	*
Turbo	90	3	93	4	0	4	2	1	3
%	96.8	3.2	0.6	100.0	0.0	*	66.7	33.3	*
Helicopter	0	0	0	0	0	0	2	0	2
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	*
Piston	279	18	297	2093	10	2103	25	0	25
%	93.9	6.1	2.1	99.5	0.5	14.6	100.0	0.0	0.2
Glider	0	0	0	0	0	0	2	0	2
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	28.6
Sub-Total	509	32	541	2108	10	2118	50	2	52
%	94.1	5.9	0.9	99.5	0.5	3.5	96.2	3.8	*

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization - Total Departures

Report Date(D/M/Y): 7:5:1996

Report Time(H/M/S): 22:57:9

January 1 to December 31 Year: 95

Power Type	Runway 35			Runway 17			Total Departures		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Jet	3	0	3	1	0	1	25196	3182	28378
%	100.0	0.0	*	100.0	0.0	*	88.8	11.2	46.3

R449N31.RPT

Turbo	0	0	0	0	0	0	15221	931	16152
%	0.0	0.0	0.0	0.0	0.0	0.0	94.2	5.8	26.4
Helicopter	0	0	0	0	0	0	2198	105	2303
%	0.0	0.0	0.0	0.0	0.0	0.0	95.4	4.6	3.8
Piston	1103	4	1107	112	3	115	13997	396	14393
%	99.6	0.4	7.7	97.4	2.6	0.8	97.2	2.8	23.5
Glider	0	0	0	0	0	0	6	1	7
%	0.0	0.0	0.0	0.0	0.0	0.0	85.7	14.3	*
Sub-Total	1106	4	1110	113	3	116			
%	99.6	0.4	1.8	97.4	2.6	0.2			

280

Total Departures Day: 56618 %= 92.5
 Total Departures Night: 4615 %= 7.5
 Total Departures : 61233

Total Itinerant Movements in Interval: 122338

Notes: 1) (*) Denotes value was less than 0.1 percent
 2) Percentages may not add up to 100 due to rounding
 3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

----- A.M.S.A.P. is a product of the ANS Long Range
 Planning Group (AANDFA Ottawa) -----

Appendix H

Transport Canada - AMSAP Report

OMCIA Aircraft Fleet Data

Jets, Turbos and Pistons by Number of Engines from 1990 to 1995

(Daytime/Nighttime and Runway Use)

R449N53.RPT

282

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 2:27:23

January 1 to December 31 Data Year: 90

# Engines	Runway 32			Runway 25			Runway 7		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	255	0	255	371	6	377	181	3	184
%	100.0	0.0	28.9	98.4	1.6	42.7	98.4	1.6	20.9
Two	8226	790	9016	13583	1567	15150	7856	1533	9389
%	91.2	8.8	25.7	89.7	10.3	43.3	83.7	16.3	26.8
Three	3368	340	3708	4620	801	5421	2600	942	3542
%	90.8	9.2	28.0	85.2	14.8	40.9	73.4	26.6	26.7
Four	747	72	819	1201	164	1365	649	55	704
%	91.2	8.8	26.3	88.0	12.0	43.8	92.2	7.8	22.6
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	12596	1202	13798	19775	2538	22313	11286	2533	13819
%	91.3	8.7	26.4	88.6	11.4	42.7	81.7	18.3	26.4

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 2:27:23

January 1 to December 31 Data Year: 90

# Engines	Runway 14			Runway 99			Runway 60		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	16	1	17	46	0	46	1	0	1
%	94.1	5.9	1.9	100.0	0.0	5.2	100.0	0.0	0.1

R449N53.RPT

Two %	831 86.6	129 13.4	960 2.7	196 87.9	27 12.1	223 0.6	191 100.0	0 0.0	191 0.5
Three %	462 90.6	48 9.4	510 3.8	29 80.6	7 19.4	36 0.3	1 100.0	0 0.0	1 *
Four %	127 68.3	59 31.7	186 6.0	24 100.0	0 0.0	24 0.8	0 0.0	0 0.0	0 0.0
Five %	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
Six %	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
Sub-Total %	1436 85.8	237 14.2	1673 3.2	295 89.7	34 10.3	329 0.6	193 100.0	0 0.0	193 0.4

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Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets
 Report Date(D/M/Y): 28:2:1996
 Report Time(H/M/S): 2:27:23

January 1 to December 31 Data Year: 90

# Engines	Runway 4			Runway 22			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None %	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
One %	0 0.0	0 0.0	0 0.0	2 100.0	0 0.0	2 0.2	0 0.0	0 0.0	0 0.0
Two %	15 100.0	0 0.0	15 *	44 97.8	1 2.2	45 0.1	24 96.0	1 4.0	25 *
Three %	7 100.0	0 0.0	7 *	14 93.3	1 6.7	15 0.1	8 100.0	0 0.0	8 *
Four %	5 100.0	0 0.0	5 0.2	9 100.0	0 0.0	9 0.3	3 100.0	0 0.0	3 *
Five %	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
Six %	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
Sub-Total %	27 100.0	0 0.0	27 *	69 97.2	2 2.8	71 0.1	35 97.2	1 2.8	36 *

R449N53.RPT

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

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Itinerant Runway Utilization By Number of Engines for - Jets
Report Date(D/M/Y): 28:2:1996
Report Time(H/M/S): 2:27:23

January 1 to December 31 Data Year: 90

# Engines	Runway 17			Runway 70			Sub-Totals		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	0	0	0	0	0	0	872	10	882
%	0.0	0.0	0.0	0.0	0.0	0.0	98.9	1.1	1.7
Two	1	0	1	0	1	1	30967	4049	35016
%	100.0	0.0	*	0.0	100.0	*	88.4	11.6	67.0
Three	1	0	1	0	0	0	11110	2139	13249
%	100.0	0.0	*	0.0	0.0	0.0	83.9	16.1	25.4
Four	1	0	1	0	0	0	2766	350	3116
%	100.0	0.0	*	0.0	0.0	0.0	88.8	11.2	6.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	3	0	3	0	1	1			
%	100.0	0.0	*	0.0	100.0	*			

Total Jets Day: 45715 = % 87.5
Total Jets Night: 6548 = % 12.5
Jets: 52263

Total Itinerant Movements in Interval: 136738

Notes: 1) (*) Denotes value was less than 0.1 percent
2) Percentages may not add up to 100 due to rounding
3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

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R449NS1.RPT

285

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos
Report Date(D/M/Y): 28:2:1996
Report Time(H/M/S): 2:26:55

January 1 to December 31 Data Year: 90

# Engines	Runway 25			Runway 32			Runway 7		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	412	47	459	431	60	491	310	50	360
%	89.8	10.2	25.0	87.8	12.2	26.8	86.1	13.9	19.6
Two	19840	496	20336	11120	410	11530	10460	502	10962
%	97.6	2.4	45.4	96.4	3.6	25.7	95.4	4.6	24.5
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	1359	53	1412	946	47	993	890	100	990
%	96.2	3.8	39.6	95.3	4.7	27.9	89.9	10.1	27.8
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	21611	596	22207	12497	517	13014	11660	652	12312
%	97.3	2.7	44.2	96.0	4.0	25.9	94.7	5.3	24.5

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos
Report Date(D/M/Y): 28:2:1996
Report Time(H/M/S): 2:26:55

January 1 to December 31 Data Year: 90

# Engines	Runway 14			Runway 22			Runway 99		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	128	14	142	249	1	250	2	2	4
%	90.1	9.9	7.7	99.6	0.4	13.6	50.0	50.0	0.2

R449N51.RPT

Two	1075	161	1236	343	5	348	205	3	208
%	87.0	13.0	2.8	98.6	1.4	0.8	98.6	1.4	0.5
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	83	21	104	12	0	12	45	2	47
%	79.8	20.2	2.9	100.0	0.0	0.3	95.7	4.3	1.3
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	1286	196	1482	604	6	610	252	7	259
%	86.8	13.2	3.0	99.0	1.0	1.2	97.3	2.7	0.5

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Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 2:26:56

January 1 to December 31 Data Year: 90

# Engines	Runway 35			Runway 4			Runway 60		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	41	0	41	87	0	87	0	0	0
%	100.0	0.0	2.2	100.0	0.0	4.7	0.0	0.0	0.0
Two	63	2	65	85	2	87	16	0	16
%	96.9	3.1	0.1	97.7	2.3	0.2	100.0	0.0	*
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	1	1	1	0	1	4	0	4
%	0.0	100.0	*	100.0	0.0	*	100.0	0.0	0.1
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	104	3	107	173	2	175	20	0	20
%	97.2	2.8	0.2	98.9	1.1	0.3	100.0	0.0	*

R449N51.RPT

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

287

Itinerant Runway Utilization By Number of Engines for - Turbos
 Report Date(D/M/Y): 28:2:1996
 Report Time(H/M/S): 2:26:56

January 1 to December 31 Data Year: 90

# Engines	Runway 17			Sub-Totals		
	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
One	0	0	0	1660	174	1834
%	0.0	0.0	0.0	90.5	9.5	3.7
Two	8	0	8	43215	1581	44796
%	100.0	0.0	*	96.5	3.5	89.2
Three	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	3340	224	3564
%	0.0	0.0	0.0	93.7	6.3	7.1
Five	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	8	0	8			
%	100.0	0.0	*			

Total Turbos Day: 48215 = % 96.1
 Total Turbos Night: 1979 = % 3.9
 Turbos: 50194

Total Itinerant Movements in Interval: 136738

Notes: 1)(*) Denotes value was less than 0.1 percent
 2)Percentages may not add up to 100 due to rounding
 3)Night is defined as (22:00 - 06:59)

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R449N50.RPT

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Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 2:26:42

January 1 to December 31 Data Year: 90

# Engines	Runway 32			Runway 25			Runway 60		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	1733	182	1915	1315	102	1417	84	0	84
%	90.5	9.5	8.1	92.8	7.2	6.0	100.0	0.0	0.4
Two	1108	101	1209	1397	97	1494	8	0	8
%	91.6	8.4	19.3	93.5	6.5	23.8	100.0	0.0	0.1
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	4	0	4	7	0	7	0	0	0
%	100.0	0.0	25.0	100.0	0.0	43.8	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	2845	283	3128	2719	199	2918	92	0	92
%	91.0	9.0	10.5	93.2	6.8	9.8	100.0	0.0	0.3

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 2:26:42

January 1 to December 31 Data Year: 90

# Engines	Runway 22			Runway 7			Runway 14		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	11043	25	11068	594	61	655	609	137	746
%	99.8	0.2	47.0	90.7	9.3	2.8	81.6	18.4	3.2

R449N50.RPT

Two	1181	6	1187	826	139	965	159	46	205
%	99.5	0.5	18.9	85.6	14.4	15.4	77.6	22.4	3.3
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	2	0	2	1	2	3	0	0	0
%	100.0	0.0	12.5	33.3	66.7	18.8	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	12226	31	12257	1421	202	1623	768	183	951
%	99.7	0.3	41.1	87.6	12.4	5.4	80.8	19.2	3.2

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Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons
 Report Date(D/M/Y): 28:2:1996
 Report Time(H/M/S): 2:26:42

January 1 to December 31 Data Year: 90

# Engines	Runway 99			Runway 4			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	733	76	809	4095	6	4101	2649	1	2650
%	90.6	9.4	3.4	99.9	0.1	17.4	100.0	0.0	11.2
Two	397	17	414	460	0	460	332	0	332
%	95.9	4.1	6.6	100.0	0.0	7.3	100.0	0.0	5.3
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	1130	93	1223	4555	6	4561	2981	1	2982
%	92.4	7.6	4.1	99.9	0.1	15.3	100.0	0.0	10.0

R449N50.RPT

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

290

Itinerant Runway Utilization By Number of Engines for - Pistons
Report Date(D/M/Y): 28:2:1996
Report Time(H/M/S): 2:26:42

January 1 to December 31 Data Year: 90

# Engines	Runway 17			Runway 70			Sub-Totals		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	115	0	115	1	0	1	22971	590	23561
%	100.0	0.0	0.5	100.0	0.0	*	97.5	2.5	78.9
Two	4	0	4	0	0	0	5872	406	6278
%	100.0	0.0	*	0.0	0.0	0.0	93.5	6.5	21.0
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	0	0	0	14	2	16
%	0.0	0.0	0.0	0.0	0.0	0.0	87.5	12.5	*
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	119	0	119	1	0	1			
%	100.0	0.0	0.4	100.0	0.0	*			

Total Pistons Day: 28857 = % 96.7
Total Pistons Night: 998 = % 3.3
Pistons: 29855

Total Itinerant Movements in Interval: 136738

Notes: 1) (*) Denotes value was less than 0.1 percent
2) Percentages may not add up to 100 due to rounding
3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

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R449N53.RPT

291

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:22:54

January 1 to December 31 Data Year: 91

# Engines	Runway 7			Runway 25			Runway 32		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	143	3	146	310	9	319	199	2	201
%	97.9	2.1	19.4	97.2	2.8	42.4	99.0	1.0	26.7
Two	7621	2165	9786	13226	1432	14658	8548	825	9373
%	77.9	22.1	28.2	90.2	9.8	42.2	91.2	8.8	27.0
Three	1373	532	1905	2629	431	3060	1928	162	2090
%	72.1	27.9	25.9	85.9	14.1	41.6	92.2	7.8	28.4
Four	757	53	810	1653	216	1869	715	89	804
%	93.5	6.5	22.1	88.4	11.6	51.0	88.9	11.1	21.9
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	9894	2753	12647	17818	2088	19906	11390	1078	12468
%	78.2	21.8	27.2	89.5	10.5	42.8	91.4	8.6	26.8

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:22:54

January 1 to December 31 Data Year: 91

# Engines	Runway 14			Runway 4			Runway 60		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	41	0	41	0	0	0	1	0	1
%	100.0	0.0	5.4	0.0	0.0	0.0	100.0	0.0	0.1

R449N53.RPT

Two	705	86	791	5	0	5	5	0	5
%	89.1	10.9	2.3	100.0	0.0	*	100.0	0.0	*
Three	260	16	276	5	1	6	0	0	0
%	94.2	5.8	3.8	83.3	16.7	*	0.0	0.0	0.0
Four	148	23	171	0	0	0	1	0	1
%	86.5	13.5	4.7	0.0	0.0	0.0	100.0	0.0	*
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	1154	125	1279	10	1	11	7	0	7
%	90.2	9.8	2.7	90.9	9.1	*	100.0	0.0	*

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Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:22:54

January 1 to December 31 Data Year: 91

# Engines	Runway 99			Runway 22			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	43	0	43	1	0	1	0	1	1
%	100.0	0.0	5.7	100.0	0.0	0.1	0.0	100.0	0.1
Two	100	6	106	20	0	20	3	0	3
%	94.3	5.7	0.3	100.0	0.0	*	100.0	0.0	*
Three	13	7	20	3	0	3	0	0	0
%	65.0	35.0	0.3	100.0	0.0	*	0.0	0.0	0.0
Four	9	2	11	2	0	2	0	0	0
%	81.8	18.2	0.3	100.0	0.0	*	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	165	15	180	26	0	26	3	1	4
%	91.7	8.3	0.4	100.0	0.0	*	75.0	25.0	*

R449N53.RPT

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

293

Itinerant Runway Utilization By Number of Engines for - Jets
 Report Date (D/M/Y): 11:4:1996
 Report Time (H/M/S): 7:22:54

January 1 to December 31 Data Year: 91

# Engines	Sub-Totals		
	Day	Night	Total
None	0	0	0
%	0.0	0.0	0.0
One	738	15	753
%	98.0	2.0	1.6
Two	30233	4514	34747
%	87.0	13.0	74.7
Three	6211	1149	7360
%	84.4	15.6	15.8
Four	3285	383	3668
%	89.6	10.4	7.9
Five	0	0	0
%	0.0	0.0	0.0
Six	0	0	0
%	0.0	0.0	0.0

Total Jets Day: 40467 = % 87.0
 Total Jets Night: 6061 = % 13.0
 Jets: 46528

Total Itinerant Movements in Interval: 126286

Notes: 1) (*) Denotes value was less than 0.1 percent
 2) Percentages may not add up to 100 due to rounding
 3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

----- A.M.S.A.P. is a product of the ANS Long Range
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R449NS1.RPT

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Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:22:28

January 1 to December 31 Data Year: 91

# Engines	Runway 7			Runway 25			Runway 14		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	162	82	244	386	19	405	138	99	237
%	66.4	33.6	13.0	95.3	4.7	21.6	58.2	41.8	12.6
Two	9263	444	9707	18406	479	18885	1386	153	1539
%	95.4	4.6	23.3	97.5	2.5	45.4	90.1	9.9	3.7
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	135	15	150	278	22	300	26	5	31
%	90.0	10.0	20.8	92.7	7.3	41.6	83.9	16.1	4.3
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	9560	541	10101	19070	520	19590	1550	257	1807
%	94.6	5.4	22.9	97.3	2.7	44.3	85.8	14.2	4.1

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:22:28

January 1 to December 31 Data Year: 91

# Engines	Runway 32			Runway 22			Runway 4		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	350	135	485	243	80	323	76	79	155
%	72.2	27.8	25.8	75.2	24.8	17.2	49.0	51.0	8.2

R449N51.RPT

Two	10629	475	11104	98	0	98	50	0	50	295
%	95.7	4.3	26.7	100.0	0.0	0.2	100.0	0.0	0.1	
Three	0	0	0	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Four	182	9	191	0	0	0	0	0	0	
%	95.3	4.7	26.5	0.0	0.0	0.0	0.0	0.0	0.0	
Five	0	0	0	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Six	0	0	0	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Sub-Total	11161	619	11780	341	80	421	126	79	205	
%	94.7	5.3	26.7	81.0	19.0	1.0	61.5	38.5	0.5	

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos
 Report Date(D/M/Y): 11:4:1996
 Report Time(H/M/S): 7:22:28

January 1 to December 31 Data Year: 91

# Engines	Runway 60			Runway 99			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	0	0	0	12	0	12	14	3	17
%	0.0	0.0	0.0	100.0	0.0	0.6	82.4	17.6	0.9
Two	10	0	10	158	5	163	23	0	23
%	100.0	0.0	*	96.9	3.1	0.4	100.0	0.0	*
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	1	1	2	48	0	48	0	0	0
%	50.0	50.0	0.3	100.0	0.0	6.6	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	11	1	12	218	5	223	37	3	40
%	91.7	8.3	*	97.8	2.2	0.5	92.5	7.5	0.1

R449N51.RPT

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Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos
 Report Date(D/M/Y): 11:4:1996
 Report Time(H/M/S): 7:22:28

January 1 to December 31 Data Year: 91

# Engines	Runway 17			Sub-Totals		
	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
One	1	0	1	1382	497	1879
%	100.0	0.0	*	73.5	26.5	4.3
Two	3	0	3	40026	1556	41582
%	100.0	0.0	*	96.3	3.7	94.1
Three	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	670	52	722
%	0.0	0.0	0.0	92.8	7.2	1.6
Five	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	4	0	4			
%	100.0	0.0	*			

Total Turbos Day: 42078 = % 95.2
 Total Turbos Night: 2105 = % 4.8
 Turbos: 44183

Total Itinerant Movements in Interval: 126286

Notes: 1) (*) Denotes value was less than 0.1 percent
 2) Percentages may not add up to 100 due to rounding
 3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

----- A.M.S.A.P. is a product of the ANS Long Range
 Planning Group (AANDFA Ottawa) -----

R449NS0.RPT

297

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:22:15

January 1 to December 31 Data Year: 91

# Engines	Runway 32			Runway 25			Runway 22		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	1968	206	2174	1399	97	1496	11989	31	12020
%	90.5	9.5	8.9	93.5	6.5	6.1	99.7	0.3	49.4
Two	1043	110	1153	1557	92	1649	780	6	786
%	90.5	9.5	21.6	94.4	5.6	30.9	99.2	0.8	14.7
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	4	2	6	22	0	22	2	0	2
%	66.7	33.3	15.0	100.0	0.0	55.0	100.0	0.0	5.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	3015	318	3333	2978	189	3167	12771	37	12808
%	90.5	9.5	11.2	94.0	6.0	10.7	99.7	0.3	43.1

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:22:15

January 1 to December 31 Data Year: 91

# Engines	Runway 99			Runway 14			Runway 4		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	408	47	455	612	89	701	5189	6	5195
%	89.7	10.3	1.9	87.3	12.7	2.9	99.9	0.1	21.4

R449N50.RPT

Two	218	10	228	134	37	171	298	3	301
%	95.6	4.4	4.3	78.4	21.6	3.2	99.0	1.0	5.6
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	2	0	2	1	0	1	0	0	0
%	100.0	0.0	5.0	100.0	0.0	2.5	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	628	57	685	747	126	873	5487	9	5496
%	91.7	8.3	2.3	85.6	14.4	2.9	99.8	0.2	18.5

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Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:22:15

January 1 to December 31 Data Year: 91

# Engines	Runway 7			Runway 60			Runway 17		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	527	56	583	52	1	53	83	0	83
%	90.4	9.6	2.4	98.1	1.9	0.2	100.0	0.0	0.3
Two	729	214	943	6	0	6	8	0	8
%	77.3	22.7	17.7	100.0	0.0	0.1	100.0	0.0	0.2
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	6	1	7	0	0	0	0	0	0
%	85.7	14.3	17.5	0.0	0.0	0.0	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	1262	271	1533	58	1	59	91	0	91
%	82.3	17.7	5.2	98.3	1.7	0.2	100.0	0.0	0.3

R449N50.RPT

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

299

Itinerant Runway Utilization By Number of Engines for - Pistons
Report Date(D/M/Y): 11:4:1996
Report Time(H/M/S): 7:22:15

January 1 to December 31				Data Year: 91			
Runway 35				Sub-Totals			
# Engines	Day	Night	Total	Day	Night	Total	
None	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	
One	1565	1	1566	23792	534	24326	
%	99.9	0.1	6.4	97.8	2.2	81.9	
Two	85	0	85	4858	472	5330	
%	100.0	0.0	1.6	91.1	8.9	17.9	
Three	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	
Four	0	0	0	37	3	40	
%	0.0	0.0	0.0	92.5	7.5	0.1	
Five	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	
Six	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	
Sub-Total	1650	1	1651				
%	99.9	0.1	5.6				

Total Pistons Day: 28687 = % 96.6
Total Pistons Night: 1009 = % 3.4
Pistons: 29696

Total Itinerant Movements in Interval: 126286

Notes: 1) (*) Denotes value was less than 0.1 percent
2) Percentages may not add up to 100 due to rounding
3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

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R449N53.RPT

300

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 0:11:9

January 1 to December 31 Data Year: 92

# Engines	Runway 7			Runway 25			Runway 14		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	100	13	113	337	6	343	17	1	18
%	88.5	11.5	18.0	98.3	1.7	54.6	94.4	5.6	2.9
Two	9171	2259	11430	14569	1511	16080	689	127	816
%	80.2	19.8	29.1	90.6	9.4	40.9	84.4	15.6	2.1
Three	1041	378	1419	1735	254	1989	197	18	215
%	73.4	26.6	28.7	87.2	12.8	40.2	91.6	8.4	4.3
Four	787	92	879	1537	256	1793	218	28	246
%	89.5	10.5	23.6	85.7	14.3	48.2	88.6	11.4	6.6
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	11099	2742	13841	18178	2027	20205	1121	174	1295
%	80.2	19.8	28.5	90.0	10.0	41.6	86.6	13.4	2.7

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 0:11:9

January 1 to December 31 Data Year: 92

# Engines	Runway 32			Runway 99			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	129	3	132	20	0	20	2	0	2
%	97.7	2.3	21.0	100.0	0.0	3.2	100.0	0.0	0.3
Two	9837	934	10771	160	3	163	13	0	13
%	91.3	8.7	27.4	98.2	1.8	0.4	100.0	0.0	*
Three	1263	52	1315	7	2	9	1	0	1
%	96.0	4.0	26.6	77.8	22.2	0.2	100.0	0.0	*

R449N53.RPT

Four	683	93	776	26	0	26	0	0	0
%	88.0	12.0	20.9	100.0	0.0	0.7	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	11912	1082	12994	213	5	218	16	0	16
%	91.7	8.3	26.7	97.7	2.3	0.4	100.0	0.0	*

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Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets
 Report Date(D/M/Y): 28:2:1996
 Report Time(H/M/S): 0:11:9

January 1 to December 31 Data Year: 92

# Engines	Runway 60			Runway 22			Runway 4		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Two	9	0	9	26	0	26	3	0	3
%	100.0	0.0	*	100.0	0.0	*	100.0	0.0	*
Three	0	0	0	2	0	2	1	0	1
%	0.0	0.0	0.0	100.0	0.0	*	100.0	0.0	*
Four	0	0	0	1	0	1	0	0	0
%	0.0	0.0	0.0	100.0	0.0	*	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	9	0	9	29	0	29	4	0	4
%	100.0	0.0	*	100.0	0.0	*	100.0	0.0	*

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets
 Report Date(D/M/Y): 28:2:1996
 Report Time(H/M/S): 0:11:9

January 1 to December 31 Data Year: 92

# Engines	Runway 17			Sub-Totals		
	Day	Night	Total	Day	Night	Total
=====	=====	=====	=====	=====	=====	=====

302

				R449N53.RPT		
None	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
One	0	0	0	605	23	628
%	0.0	0.0	0.0	96.3	3.7	1.3
Two	3	0	3	34480	4834	39314
%	100.0	0.0	*	87.7	12.3	80.9
Three	0	0	0	4247	704	4951
%	0.0	0.0	0.0	85.8	14.2	10.2
Four	0	0	0	3252	469	3721
%	0.0	0.0	0.0	87.4	12.6	7.7
Five	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	3	0	3			
%	100.0	0.0	*			

Total Jets Day: 42584 = % 87.6

Total Jets Night: 6030 = % 12.4

Jets: 48614

Total Itinerant Movements in Interval: 122839

Notes: 1) (*) Denotes value was less than 0.1 percent

2) Percentages may not add up to 100 due to rounding

3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

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R449NS1.RPT

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

303

Itinerant Runway Utilization By Number of Engines for - Turbos
Report Date(D/M/Y): 28:2:1996
Report Time(H/M/S): 0:10:43

January 1 to December 31 Data Year: 92

# Engines	Runway 14			Runway 32			Runway 25		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	71	61	132	288	77	365	375	5	380
%	53.8	46.2	8.9	78.9	21.1	24.5	98.7	1.3	25.5
Two	1238	61	1299	9783	443	10226	16112	365	16477
%	95.3	4.7	3.4	95.7	4.3	26.8	97.8	2.2	43.1
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	39	6	45	95	5	100	235	10	245
%	86.7	13.3	8.0	95.0	5.0	17.7	95.9	4.1	43.4
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	1348	128	1476	10166	525	10691	16722	380	17102
%	91.3	8.7	3.7	95.1	4.9	26.5	97.8	2.2	42.5

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos
Report Date(D/M/Y): 28:2:1996
Report Time(H/M/S): 0:10:43

January 1 to December 31 Data Year: 92

# Engines	Runway 7			Runway 4			Runway 99		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	217	36	253	60	85	145	4	0	4
%	85.8	14.2	17.0	41.4	58.6	9.7	100.0	0.0	0.3
Two	9373	435	9808	59	1	60	132	2	134
%	95.6	4.4	25.7	98.3	1.7	0.2	98.5	1.5	0.4
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

R449N51.RPT

Four	129	4	133	0	0	0	37	4	41
%	97.0	3.0	23.6	0.0	0.0	0.0	90.2	9.8	7.3
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	9719	475	10194	119	86	205	173	6	179
%	95.3	4.7	25.3	58.0	42.0	0.5	96.6	3.4	0.4

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Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 0:10:43

January 1 to December 31 Data Year: 92

# Engines	Runway 22			Runway 60			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	141	66	207	0	0	0	3	0	3
%	68.1	31.9	13.9	0.0	0.0	0.0	100.0	0.0	0.2
Two	176	2	178	6	0	6	38	0	38
%	98.9	1.1	0.5	100.0	0.0	*	100.0	0.0	*
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	317	68	385	6	0	6	41	0	41
%	82.3	17.7	1.0	100.0	0.0	*	100.0	0.0	0.1

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 0:10:43

January 1 to December 31 Data Year: 92

# Engines	Runway 17			Sub-Totals		
	Day	Night	Total	Day	Night	Total
=====	=====	=====	=====	=====	=====	=====

				R449NS1.RPT		
None	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0

One	1	1	2	1160	331	1491
%	50.0	50.0	0.1	77.8	22.2	3.7

Two	1	0	1	36918	1309	38227
%	100.0	0.0	*	96.6	3.4	94.9

Three	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0

Four	0	0	0	535	29	564
%	0.0	0.0	0.0	94.9	5.1	1.4

Five	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0

Six	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0

Sub-Total	2	1	3			
%	66.7	33.3	*			

Total Turbos Day: 38613 = % 95.9
 Total Turbos Night: 1669 = % 4.1
 Turbos: 40282

Total Itinerant Movements in Interval: 122839

Notes: 1) (*) Denotes value was less than 0.1 percent
 2) Percentages may not add up to 100 due to rounding
 3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

----- A.M.S.A.P. is a product of the ANS Long Range
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R449N50.RPT

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Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 0:10:30

January 1 to December 31 Data Year: 92

# Engines	Runway 14			Runway 22			Runway 32		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	539	91	630	11021	20	11041	1853	158	2011
%	85.6	14.4	2.7	99.8	0.2	48.1	92.1	7.9	8.8
Two	79	16	95	552	7	559	797	80	877
%	83.2	16.8	2.1	98.7	1.3	12.6	90.9	9.1	19.8
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	0	0	0	1	0	1
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	2.5
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	618	107	725	11573	27	11600	2651	238	2889
%	85.2	14.8	2.6	99.8	0.2	42.3	91.8	8.2	10.5

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons

Report Date(D/M/Y): 28:2:1996

Report Time(H/M/S): 0:10:30

January 1 to December 31 Data Year: 92

# Engines	Runway 25			Runway 7			Runway 4		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	1790	199	1989	591	108	699	3932	8	3940
%	90.0	10.0	8.7	84.5	15.5	3.0	99.8	0.2	17.2
Two	1426	108	1534	678	220	898	160	2	162
%	93.0	7.0	34.5	75.5	24.5	20.2	98.8	1.2	3.6
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

R449N50.RPT

Four	27	0	27	10	0	10	0	0	0
%	100.0	0.0	67.5	100.0	0.0	25.0	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	3243	307	3550	1279	328	1607	4092	10	4102
%	91.4	8.6	12.9	79.6	20.4	5.9	99.8	0.2	15.0

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Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons
 Report Date(D/M/Y): 28:2:1996
 Report Time(H/M/S): 0:10:30

January 1 to December 31 Data Year: 92

# Engines	Runway 99			Runway 60			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	282	31	313	49	1	50	2187	7	2194
%	90.1	9.9	1.4	98.0	2.0	0.2	99.7	0.3	9.6
Two	180	14	194	2	0	2	114	0	114
%	92.8	7.2	4.4	100.0	0.0	*	100.0	0.0	2.6
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	2	0	2	0	0	0	0	0	0
%	100.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	464	45	509	51	1	52	2301	7	2308
%	91.2	8.8	1.9	98.1	1.9	0.2	99.7	0.3	8.4

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons
 Report Date(D/M/Y): 28:2:1996
 Report Time(H/M/S): 0:10:30

January 1 to December 31 Data Year: 92

# Engines	Runway 17			Sub-Totals		
	Day	Night	Total	Day	Night	Total
=====	=====	=====	=====	=====	=====	=====

R449N50.RPT

None	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
One	74	1	75	22318	624	22942
%	98.7	1.3	0.3	97.3	2.7	83.7
Two	4	1	5	3992	448	4440
%	80.0	20.0	0.1	89.9	10.1	16.2
Three	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	40	0	40
%	0.0	0.0	0.0	100.0	0.0	0.1
Five	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	78	2	80			
%	97.5	2.5	0.3			

308

Total Pistons Day: 26350 = % 96.1
 Total Pistons Night: 1072 = % 3.9
 Pistons: 27422

Total Itinerant Movements in Interval: 122839

Notes: 1) (*) Denotes value was less than 0.1 percent
 2) Percentages may not add up to 100 due to rounding
 3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

----- A.M.S.A.P. is a product of the ANS Long Range
 Planning Group (AANDFA Ottawa) -----

R449N53.RPT

309

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets
Report Date(D/M/Y): 11:4:1996
Report Time(H/M/S): 7:43:2

January 1 to December 31				Data Year: 93					
# Engines	Runway 32			Runway 25			Runway 14		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	88	3	91	312	5	317	28	2	30
%	96.7	3.3	16.6	98.4	1.6	58.0	93.3	6.7	5.5
Two	10487	642	11129	15708	1545	17253	691	94	785
%	94.2	5.8	27.9	91.0	9.0	43.2	88.0	12.0	2.0
Three	519	40	559	818	150	968	162	2	164
%	92.8	7.2	24.2	84.5	15.5	42.0	98.8	1.2	7.1
Four	620	141	761	1522	443	1965	240	93	333
%	81.5	18.5	18.3	77.5	22.5	47.2	72.1	27.9	8.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	11714	826	12540	18360	2143	20503	1121	191	1312
%	93.4	6.6	26.7	89.5	10.5	43.7	85.4	14.6	2.8

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets
Report Date(D/M/Y): 11:4:1996
Report Time(H/M/S): 7:43:2

January 1 to December 31				Data Year: 93					
# Engines	Runway 7			Runway 99			Runway 22		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	85	4	89	17	0	17	2	0	2
%	95.5	4.5	16.3	100.0	0.0	3.1	100.0	0.0	0.4

R449N53.RPT

Two	8281	2129	10410	250	5	255	29	0	29	310
%	79.5	20.5	26.1	98.0	2.0	0.6	100.0	0.0	*	
Three	353	257	610	5	0	5	0	0	0	
%	57.9	42.1	26.4	100.0	0.0	0.2	0.0	0.0	0.0	
Four	803	286	1089	16	0	16	0	0	0	
%	73.7	26.3	26.1	100.0	0.0	0.4	0.0	0.0	0.0	
Five	0	0	0	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Six	0	0	0	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Sub-Total	9522	2676	12198	288	5	293	31	0	31	
%	78.1	21.9	26.0	98.3	1.7	0.6	100.0	0.0	*	

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:43:2

January 1 to December 31 Data Year: 93

# Engines	Runway 4			Runway 60			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	0	0	0	0	0	0	1	0	1
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.2
Two	24	0	24	4	0	4	7	0	7
%	100.0	0.0	*	100.0	0.0	*	100.0	0.0	*
Three	0	0	0	1	0	1	0	0	0
%	0.0	0.0	0.0	100.0	0.0	*	0.0	0.0	0.0
Four	0	1	1	0	0	0	0	0	0
%	0.0	100.0	*	0.0	0.0	0.0	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	24	1	25	5	0	5	8	0	8
%	96.0	4.0	*	100.0	0.0	*	100.0	0.0	*

R449NS3.RPT

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

311

Itinerant Runway Utilization By Number of Engines for - Jets
 Report Date(D/M/Y): 11:4:1996
 Report Time(H/M/S): 7:43:2

January 1 to December 31 Data Year: 93

# Engines	Runway 17			Sub-Totals		
	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
One	0	0	0	533	14	547
%	0.0	0.0	0.0	97.4	2.6	1.2
Two	1	0	1	35482	4415	39897
%	100.0	0.0	*	88.9	11.1	85.0
Three	0	0	0	1858	449	2307
%	0.0	0.0	0.0	80.5	19.5	4.9
Four	0	0	0	3201	964	4165
%	0.0	0.0	0.0	76.9	23.1	8.9
Five	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	1	0	1			
%	100.0	0.0	*			

Total Jets Day: 41074 = % 87.5
 Total Jets Night: 5842 = % 12.5
 Jets: 46916

Total Itinerant Movements in Interval: 114901

Notes: 1) (*) Denotes value was less than 0.1 percent
 2) Percentages may not add up to 100 due to rounding
 3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

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R449N51.RPT

312

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos

Report Date (D/M/Y): 11:4:1996

Report Time (H/M/S): 7:42:40

January 1 to December 31 Data Year: 93

# Engines	Runway 32			Runway 25			Runway 14		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	186	1	187	231	0	231	12	0	12
%	99.5	0.5	31.1	100.0	0.0	38.4	100.0	0.0	2.0
Two	10171	596	10767	14452	377	14829	1116	47	1163
%	94.5	5.5	30.8	97.5	2.5	42.4	96.0	4.0	3.3
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	131	3	134	173	11	184	28	5	33
%	97.8	2.2	26.5	94.0	6.0	36.4	84.8	15.2	6.5
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	10488	600	11088	14856	388	15244	1156	52	1208
%	94.6	5.4	30.8	97.5	2.5	42.3	95.7	4.3	3.4

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos

Report Date (D/M/Y): 11:4:1996

Report Time (H/M/S): 7:42:40

January 1 to December 31 Data Year: 93

# Engines	Runway 7			Runway 22			Runway 99		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	152	1	153	8	0	8	2	0	2
%	99.3	0.7	25.5	100.0	0.0	1.3	100.0	0.0	0.3

R449N51.RPT

313

Two	7468	332	7800	174	3	177	138	2	140
%	95.7	4.3	22.3	98.3	1.7	0.5	98.6	1.4	0.4
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	112	4	116	0	0	0	39	0	39
%	96.6	3.4	22.9	0.0	0.0	0.0	100.0	0.0	7.7
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	7732	337	8069	182	3	185	179	2	181
%	95.8	4.2	22.4	98.4	1.6	0.5	98.9	1.1	0.5

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:42:40

January 1 to December 31 Data Year: 93

# Engines	Runway 4			Runway 60			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	6	0	6	0	0	0	1	0	1
%	100.0	0.0	1.0	0.0	0.0	0.0	100.0	0.0	0.2
Two	38	0	38	3	0	3	28	0	28
%	100.0	0.0	0.1	100.0	0.0	*	100.0	0.0	*
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	44	0	44	3	0	3	29	0	29
%	100.0	0.0	0.1	100.0	0.0	*	100.0	0.0	*

R449N51.RPT

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

314

Itinerant Runway Utilization By Number of Engines for - Turbos
Report Date(D/M/Y): 11:4:1996
Report Time(H/M/S): 7:42:40

January 1 to December 31 Data Year: 93

# Engines	Runway 17			Sub-Totals		
	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
One	1	0	1	599	2	601
%	100.0	0.0	0.2	99.7	0.3	1.7
Two	3	0	3	33591	1357	34948
%	100.0	0.0	*	96.1	3.9	96.9
Three	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	483	23	506
%	0.0	0.0	0.0	95.5	4.5	1.4
Five	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	4	0	4			
%	100.0	0.0	*			

Total Turbos Day: 34673 = % 96.2
Total Turbos Night: 1382 = % 3.8
Turbos: 36055

Total Itinerant Movements in Interval: 114901

Notes: 1)(*) Denotes value was less than 0.1 percent
2) Percentages may not add up to 100 due to rounding
3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

----- A.M.S.A.P. is a product of the ANS Long Range
Planning Group (AANDFA Ottawa) -----

R449N50.RPT

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

315

Itinerant Runway Utilization By Number of Engines for - Pistons
Report Date(D/M/Y): 11:4:1996
Report Time(H/M/S): 7:42:29

January 1 to December 31 Data Year: 93

# Engines	Runway 32			Runway 7			Runway 14		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	1361	150	1511	484	58	542	422	84	506
%	90.1	9.9	7.3	89.3	10.7	2.6	83.4	16.6	2.5
Two	753	72	825	518	213	731	98	16	114
%	91.3	8.7	18.8	70.9	29.1	16.6	86.0	14.0	2.6
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	1	0	1	10	0	10	1	0	1
%	100.0	0.0	2.7	100.0	0.0	27.0	100.0	0.0	2.7
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	2115	222	2337	1012	271	1283	521	100	621
%	90.5	9.5	9.3	78.9	21.1	5.1	83.9	16.1	2.5

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons
Report Date(D/M/Y): 11:4:1996
Report Time(H/M/S): 7:42:29

January 1 to December 31 Data Year: 93

# Engines	Runway 22			Runway 25			Runway 99		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	10766	15	10781	1574	120	1694	359	28	387
%	99.9	0.1	52.2	92.9	7.1	8.2	92.8	7.2	1.9

R449N50.RPT

Two	692	1	693	1423	79	1502	197	4	201	316
%	99.9	0.1	15.8	94.7	5.3	34.2	98.0	2.0	4.6	
Three	0	0	0	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Four	0	0	0	21	0	21	4	0	4	
%	0.0	0.0	0.0	100.0	0.0	56.8	100.0	0.0	10.8	
Five	0	0	0	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Six	0	0	0	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Sub-Total	11458	16	11474	3018	199	3217	560	32	592	
%	99.9	0.1	45.8	93.8	6.2	12.8	94.6	5.4	2.4	

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons

Report Date(D/M/Y): 11:4:1996

Report Time(H/M/S): 7:42:29

January 1 to December 31 Data Year: 93

# Engines	Runway 4			Runway 60			Runway 17		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	2962	3	2965	26	0	26	153	0	153
%	99.9	0.1	14.4	100.0	0.0	0.1	100.0	0.0	0.7
Two	198	1	199	4	1	5	8	0	8
%	99.5	0.5	4.5	80.0	20.0	0.1	100.0	0.0	0.2
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	3160	4	3164	30	1	31	161	0	161
%	99.9	0.1	12.6	96.8	3.2	0.1	100.0	0.0	0.6

R449N50.RPT

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

317

Itinerant Runway Utilization By Number of Engines for - Pistons
Report Date(D/M/Y): 11:4:1996
Report Time(H/M/S): 7:42:29

January 1 to December 31 Data Year: 93

# Engines	Runway 35			Sub-Totals		
	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
One	2071	1	2072	20178	459	20637
%	100.0	0.0	10.0	97.8	2.2	82.3
Two	117	0	117	4008	387	4395
%	100.0	0.0	2.7	91.2	8.8	17.5
Three	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	37	0	37
%	0.0	0.0	0.0	100.0	0.0	0.1
Five	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	2188	1	2189			
%	100.0	0.0	8.7			

Total Pistons Day: 24223 = % 96.6
Total Pistons Night: 846 = % 3.4
Pistons: 25069

Total Itinerant Movements in Interval: 114901

Notes: 1) (*) Denotes value was less than 0.1 percent
2) Percentages may not add up to 100 due to rounding
3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

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R449N53.RPT

318

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets

Report Date(D/M/Y): 14:4:1996

Report Time(H/M/S): 8:25:14

January 1 to December 31 Data Year: 94

# Engines	Runway 7			Runway 25			Runway 14		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	57	5	62	233	6	239	17	0	17
%	91.9	8.1	14.6	97.5	2.5	56.2	100.0	0.0	4.0
Two	6868	1759	8627	14778	1734	16512	876	143	1019
%	79.6	20.4	20.5	89.5	10.5	39.2	86.0	14.0	2.4
Three	470	255	725	898	277	1175	131	20	151
%	64.8	35.2	23.4	76.4	23.6	38.0	86.8	13.2	4.9
Four	669	234	903	1378	260	1638	336	71	407
%	74.1	25.9	22.3	84.1	15.9	40.5	82.6	17.4	10.1
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	8064	2253	10317	17287	2277	19564	1360	234	1594
%	78.2	21.8	20.8	88.4	11.6	39.4	85.3	14.7	3.2

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets

Report Date(D/M/Y): 14:4:1996

Report Time(H/M/S): 8:25:14

January 1 to December 31 Data Year: 94

# Engines	Runway 32			Runway 99			Runway 22		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	90	3	93	12	0	12	0	0	0
%	96.8	3.2	21.9	100.0	0.0	2.8	0.0	0.0	0.0

R449NS3.RPT

Two	14217	1468	15685	255	4	259	20	0	20	319
%	90.6	9.4	37.2	98.5	1.5	0.6	100.0	0.0	*	
Three	855	176	1031	4	6	10	0	0	0	
%	82.9	17.1	33.3	40.0	60.0	0.3	0.0	0.0	0.0	
Four	915	173	1088	6	5	11	1	0	1	
%	84.1	15.9	26.9	54.5	45.5	0.3	100.0	0.0	*	
Five	0	0	0	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Six	0	0	0	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Sub-Total	16077	1820	17897	277	15	292	21	0	21	
%	89.8	10.2	36.0	94.9	5.1	0.6	100.0	0.0	*	

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets
 Report Date(D/M/Y): 14:4:1996
 Report Time(H/M/S): 8:25:14

January 1 to December 31 Data Year: 94

# Engines	Runway 60			Runway 4			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	2	0	2	0	0	0	0	0	0
%	100.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Two	9	0	9	10	1	11	8	0	8
%	100.0	0.0	*	90.9	9.1	*	100.0	0.0	*
Three	0	0	0	0	0	0	1	0	1
%	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	*
Four	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	11	0	11	10	1	11	9	0	9
%	100.0	0.0	*	90.9	9.1	*	100.0	0.0	*

R449N53.RPT

320

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets
Report Date (D/M/Y): 14:4:1996
Report Time (H/M/S): 8:25:14

January 1 to December 31 Data Year: 94

# Engines	Runway 17			Sub-Totals		
	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
One	0	0	0	411	14	425
%	0.0	0.0	0.0	96.7	3.3	0.9
Two	0	0	0	37041	5109	42150
%	0.0	0.0	0.0	87.9	12.1	84.8
Three	1	0	1	2360	734	3094
%	100.0	0.0	*	76.3	23.7	6.2
Four	0	0	0	3305	743	4048
%	0.0	0.0	0.0	81.6	18.4	8.1
Five	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	1	0	1			
%	100.0	0.0	*			

Total Jets Day: 43117 = % 86.7
Total Jets Night: 6600 = % 13.3
Jets: 49717

Total Itinerant Movements in Interval: 116578

Notes: 1) (*) Denotes value was less than 0.1 percent
2) Percentages may not add up to 100 due to rounding
3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

----- A.M.S.A.P. is a product of the ANS Long Range
Planning Group (AANDFA Ottawa) -----

R449N51.RPT

321

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos

Report Date(D/M/Y): 14:4:1996

Report Time(H/M/S): 8:24:51

January 1 to December 31 Data Year: 94

# Engines	Runway 7			Runway 25			Runway 32		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	60	5	65	140	1	141	76	2	78
%	92.3	7.7	21.7	99.3	0.7	47.2	97.4	2.6	26.1
Two	6027	366	6393	12400	557	12957	13104	909	14013
%	94.3	5.7	18.3	95.7	4.3	37.0	93.5	6.5	40.0
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	80	5	85	184	6	190	119	8	127
%	94.1	5.9	18.5	96.8	3.2	41.3	93.7	6.3	27.6
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	6167	376	6543	12724	564	13288	13299	919	14218
%	94.3	5.7	18.3	95.8	4.2	37.2	93.5	6.5	39.8

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos

Report Date(D/M/Y): 14:4:1996

Report Time(H/M/S): 8:24:51

January 1 to December 31 Data Year: 94

# Engines	Runway 14			Runway 22			Runway 99		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	7	1	8	6	0	6	0	0	0
%	87.5	12.5	2.7	100.0	0.0	2.0	0.0	0.0	0.0

R449N51.RPT

Two	1175	115	1290	104	2	106	138	5	143
%	91.1	8.9	3.7	98.1	1.9	0.3	96.5	3.5	0.4
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	28	6	34	0	0	0	23	1	24
%	82.4	17.6	7.4	0.0	0.0	0.0	95.8	4.2	5.2
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	1210	122	1332	110	2	112	161	6	167
%	90.8	9.2	3.7	98.2	1.8	0.3	96.4	3.6	0.5

322

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos
 Report Date(D/M/Y): 14:4:1996
 Report Time(H/M/S): 8:24:51

January 1 to December 31 Data Year: 94

# Engines	Runway 4			Runway 60			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	1	0	1	0	0	0	0	0	0
%	100.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Two	27	0	27	6	0	6	68	0	68
%	100.0	0.0	*	100.0	0.0	*	100.0	0.0	0.2
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	28	0	28	6	0	6	68	0	68
%	100.0	0.0	*	100.0	0.0	*	100.0	0.0	0.2

R449N51.RPT

323

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos
Report Date(D/M/Y): 14:4:1996
Report Time(H/M/S): 8:24:51

January 1 to December 31				Data Year: 94			
# Engines	Runway 17			Sub-Totals			
	Day	Night	Total	Day	Night	Total	
None	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	
One	0	0	0	290	9	299	
%	0.0	0.0	0.0	97.0	3.0	0.8	
Two	2	0	2	33051	1954	35005	
%	100.0	0.0	*	94.4	5.6	97.9	
Three	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	
Four	0	0	0	434	26	460	
%	0.0	0.0	0.0	94.3	5.7	1.3	
Five	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	
Six	0	0	0	0	0	0	
%	0.0	0.0	0.0	0.0	0.0	0.0	
Sub-Total	2	0	2				
%	100.0	0.0	*				

Total Turbos Day: 33775 = % 94.4
Total Turbos Night: 1989 = % 5.6
Turbos: 35764

Total Itinerant Movements in Interval: 116578

Notes: 1) (*) Denotes value was less than 0.1 percent
2) Percentages may not add up to 100 due to rounding
3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

----- A.M.S.A.P. is a product of the ANS Long Range
Planning Group (AANDFA Ottawa) -----

R449N50.RPT

324

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons
Report Date(D/M/Y): 14:4:1996
Report Time(H/M/S): 8:24:39

January 1 to December 31 Data Year: 94

# Engines	Runway 14			Runway 25			Runway 22		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	364	61	425	1902	143	2045	9953	21	9974
%	85.6	14.4	2.0	93.0	7.0	9.6	99.8	0.2	46.9
Two	79	11	90	1050	65	1115	612	1	613
%	87.8	12.2	2.2	94.2	5.8	27.4	99.8	0.2	15.1
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	21	0	21	0	0	0
%	0.0	0.0	0.0	100.0	0.0	18.3	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	443	72	515	2973	208	3181	10565	22	10587
%	86.0	14.0	2.0	93.5	6.5	12.5	99.8	0.2	41.6

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons
Report Date(D/M/Y): 14:4:1996
Report Time(H/M/S): 8:24:39

January 1 to December 31 Data Year: 94

# Engines	Runway 32			Runway 99			Runway 4		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	2117	182	2299	551	41	592	2623	3	2626
%	92.1	7.9	10.8	93.1	6.9	2.8	99.9	0.1	12.4

R449N50.RPT

325

Two	942	113	1055	204	6	210	182	0	182
%	89.3	10.7	25.9	97.1	2.9	5.2	100.0	0.0	4.5
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	35	0	35	24	0	24	0	0	0
%	100.0	0.0	30.4	100.0	0.0	20.9	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	3094	295	3389	779	47	826	2805	3	2808
%	91.3	8.7	13.3	94.3	5.7	3.2	99.9	0.1	11.0

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons
 Report Date(D/M/Y): 14:4:1996
 Report Time(H/M/S): 8:24:39

January 1 to December 31 Data Year: 94

# Engines	Runway 7			Runway 60			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	545	43	588	65	3	68	2542	1	2543
%	92.7	7.3	2.8	95.6	4.4	0.3	100.0	0.0	12.0
Two	416	191	607	1	0	1	161	1	162
%	68.5	31.5	14.9	100.0	0.0	*	99.4	0.6	4.0
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	35	0	35	0	0	0	0	0	0
%	100.0	0.0	30.4	0.0	0.0	0.0	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	996	234	1230	66	3	69	2703	2	2705
%	81.0	19.0	4.8	95.7	4.3	0.3	99.9	0.1	10.6

R449N50.RPT

326

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons
 Report Date(D/M/Y): 14:4:1996
 Report Time(H/M/S): 8:24:39

January 1 to December 31				Data Year: 94		
# Engines	Runway 17			Sub-Totals		
	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
One	96	1	97	20758	499	21257
%	99.0	1.0	0.5	97.7	2.3	83.6
Two	24	11	35	3671	399	4070
%	68.6	31.4	0.9	90.2	9.8	16.0
Three	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	115	0	115
%	0.0	0.0	0.0	100.0	0.0	0.5
Five	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	120	12	132			
%	90.9	9.1	0.5			

Total Pistons Day: 24544 = % 96.5
 Total Pistons Night: 898 = % 3.5
 Pistons: 25442

Total Itinerant Movements in Interval: 116578

Notes: 1) (*) Denotes value was less than 0.1 percent
 2) Percentages may not add up to 100 due to rounding
 3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

----- A.M.S.A.P. is a product of the ANS Long Range
 Planning Group (AANDFA Ottawa) -----

R449N53.RPT

327

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets
Report Date(D/M/Y): 7:5:1996
Report Time(H/M/S): 22:58:9

January 1 to December 31 Data Year: 95

# Engines	Runway 7			Runway 14			Runway 32		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	52	1	53	11	1	12	105	1	106
%	98.1	1.9	15.2	91.7	8.3	3.4	99.1	0.9	30.4
Two	10265	2354	12619	811	68	879	13256	1676	14932
%	81.3	18.7	25.2	92.3	7.7	1.8	88.8	11.2	29.8
Three	557	324	881	169	22	191	616	117	733
%	63.2	36.8	27.8	88.5	11.5	6.0	84.0	16.0	23.1
Four	644	294	938	352	42	394	557	81	638
%	68.7	31.3	29.2	89.3	10.7	12.3	87.3	12.7	19.9
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	11518	2973	14491	1343	133	1476	14534	1875	16409
%	79.5	20.5	25.5	91.0	9.0	2.6	88.6	11.4	28.9

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets
Report Date(D/M/Y): 7:5:1996
Report Time(H/M/S): 22:58:9

January 1 to December 31 Data Year: 95

# Engines	Runway 25			Runway 99			Runway 22		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	152	1	153	18	0	18	0	0	0
%	99.3	0.7	43.8	100.0	0.0	5.2	0.0	0.0	0.0

R449N53.RPT

328

Two	19119	2227	21346	242	15	257	34	0	34
%	89.6	10.4	42.6	94.2	5.8	0.5	100.0	0.0	*
Three	884	462	1346	9	8	17	0	0	0
%	65.7	34.3	42.5	52.9	47.1	0.5	0.0	0.0	0.0
Four	1085	138	1223	16	0	16	1	0	1
%	88.7	11.3	38.1	100.0	0.0	0.5	100.0	0.0	*
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	21240	2828	24068	285	23	308	35	0	35
%	88.2	11.8	42.3	92.5	7.5	0.5	100.0	0.0	*

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Jets
 Report Date(D/M/Y): 7:5:1996
 Report Time(H/M/S): 22:58:9

January 1 to December 31 Data Year: 95

# Engines	Runway 60			Runway 4			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	7	0	7	0	0	0	0	0	0
%	100.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
Two	32	3	35	19	0	19	7	0	7
%	91.4	8.6	*	100.0	0.0	*	100.0	0.0	*
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	2	0	2	1	0	1
%	0.0	0.0	0.0	100.0	0.0	*	100.0	0.0	*
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	39	3	42	21	0	21	8	0	8
%	92.9	7.1	*	100.0	0.0	*	100.0	0.0	*

R449N53.RPT

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

329

Itinerant Runway Utilization By Number of Engines for - Jets
 Report Date(D/M/Y): 7:5:1996
 Report Time(H/M/S): 22:58:9

January 1 to December 31 Data Year: 95

# Engines	Runway 17			Sub-Totals		
	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
One	0	0	0	345	4	349
%	0.0	0.0	0.0	98.9	1.1	0.6
Two	2	0	2	43787	6343	50130
%	100.0	0.0	*	87.3	12.7	88.2
Three	0	0	0	2235	933	3168
%	0.0	0.0	0.0	70.5	29.5	5.6
Four	0	0	0	2658	555	3213
%	0.0	0.0	0.0	82.7	17.3	5.7
Five	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	2	0	2			
%	100.0	0.0	*			

Total Jets Day: 49025 = % 86.2
 Total Jets Night: 7835 = % 13.8
 Jets: 56860

Total Itinerant Movements in Interval: 122338

Notes: 1) (*) Denotes value was less than 0.1 percent
 2) Percentages may not add up to 100 due to rounding
 3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

----- A.M.S.A.P. is a product of the ANS Long Range
 Planning Group (AANDFA Ottawa) -----

R449N50.RPT

330

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons
Report Date(D/M/Y): 7:5:1996
Report Time(H/M/S): 22:57:28

January 1 to December 31 Data Year: 95

# Engines	Runway 7			Runway 25			Runway 14		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	611	81	692	2135	200	2335	686	103	789
%	88.3	11.7	2.8	91.4	8.6	9.5	86.9	13.1	3.2
Two	468	229	697	1329	80	1409	103	10	113
%	67.1	32.9	17.7	94.3	5.7	35.9	91.2	8.8	2.9
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	9	0	9	0	0	0
%	0.0	0.0	0.0	100.0	0.0	52.9	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	1079	310	1389	3473	280	3753	789	113	902
%	77.7	22.3	4.9	92.5	7.5	13.1	87.5	12.5	3.2

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons
Report Date(D/M/Y): 7:5:1996
Report Time(H/M/S): 22:57:28

January 1 to December 31 Data Year: 95

# Engines	Runway 32			Runway 22			Runway 99		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	1777	177	1954	12206	52	12258	372	32	404
%	90.9	9.1	7.9	99.6	0.4	49.7	92.1	7.9	1.6

R449N50.RPT

Two	627	59	686	529	1	530	191	4	195
%	91.4	8.6	17.5	99.8	0.2	13.5	97.9	2.1	5.0
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	8	0	8	0	0	0	0	0	0
%	100.0	0.0	47.1	0.0	0.0	0.0	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	2412	236	2648	12735	53	12788	563	36	599
%	91.1	8.9	9.3	99.6	0.4	44.7	94.0	6.0	2.1

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Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons
Report Date(D/M/Y): 7:5:1996
Report Time(H/M/S): 22:57:28

January 1 to December 31 Data Year: 95

# Engines	Runway 60			Runway 4			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	50	0	50	3882	13	3895	2111	3	2114
%	100.0	0.0	0.2	99.7	0.3	15.8	99.9	0.1	8.6
Two	3	0	3	152	0	152	124	1	125
%	100.0	0.0	*	100.0	0.0	3.9	99.2	0.8	3.2
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	53	0	53	4034	13	4047	2235	4	2239
%	100.0	0.0	0.2	99.7	0.3	14.1	99.8	0.2	7.8

R449N50.RPT

332

Airport: OTTAWA/MACDONALD-CARTIER INTL Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Pistons
 Report Date(D/M/Y): 7:5:1996
 Report Time(H/M/S): 22:57:28

January 1 to December 31 Data Year: 95

# Engines	Runway 17			Sub-Totals		
	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
One	184	1	185	24014	662	24676
%	99.5	0.5	0.7	97.3	2.7	86.2
Two	18	2	20	3544	386	3930
%	90.0	10.0	0.5	90.2	9.8	13.7
Three	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	17	0	17
%	0.0	0.0	0.0	100.0	0.0	*
Five	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	202	3	205			
%	98.5	1.5	0.7			

Total Pistons Day: 27575 = % 96.3
 Total Pistons Night: 1048 = % 3.7
 Pistons: 28623

Total Itinerant Movements in Interval: 122338

Notes: 1) (*) Denotes value was less than 0.1 percent
 2) Percentages may not add up to 100 due to rounding
 3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

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Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

333

Itinerant Runway Utilization By Number of Engines for - Turbos
Report Date(D/M/Y): 7:5:1996
Report Time(H/M/S): 22:57:41

January 1 to December 31 Data Year: 95

# Engines	Runway 7			Runway 32			Runway 14		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	65	3	68	83	2	85	17	1	18
%	95.6	4.4	17.9	97.6	2.4	22.4	94.4	5.6	4.7
Two	6556	494	7050	9096	732	9828	1522	92	1614
%	93.0	7.0	22.3	92.6	7.4	31.1	94.3	5.7	5.1
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	65	8	73	75	5	80	12	1	13
%	89.0	11.0	20.5	93.8	6.2	22.5	92.3	7.7	3.7
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	6686	505	7191	9254	739	9993	1551	94	1645
%	93.0	7.0	22.2	92.6	7.4	30.9	94.3	5.7	5.1

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos
Report Date(D/M/Y): 7:5:1996
Report Time(H/M/S): 22:57:41

January 1 to December 31 Data Year: 95

# Engines	Runway 25			Runway 22			Runway 99		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	193	7	200	6	0	6	2	0	2
%	96.5	3.5	52.6	100.0	0.0	1.6	100.0	0.0	0.5

R449N51.RPT

334

Two	12437	479	12916	21	0	21	150	4	154
%	96.3	3.7	40.9	100.0	0.0	*	97.4	2.6	0.5
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	136	24	160	0	0	0	27	2	29
%	85.0	15.0	44.9	0.0	0.0	0.0	93.1	6.9	8.1
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	12766	510	13276	27	0	27	179	6	185
%	96.2	3.8	41.1	100.0	0.0	*	96.8	3.2	0.6

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

Itinerant Runway Utilization By Number of Engines for - Turbos

Report Date(D/M/Y): 7:5:1996

Report Time(H/M/S): 22:57:42

January 1 to December 31 Data Year: 95

# Engines	Runway 4			Runway 60			Runway 35		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
None	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
One	1	0	1	0	0	0	0	0	0
%	100.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Two	7	0	7	4	1	5	1	0	1
%	100.0	0.0	*	80.0	20.0	*	100.0	0.0	*
Three	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Four	0	0	0	1	0	1	0	0	0
%	0.0	0.0	0.0	100.0	0.0	0.3	0.0	0.0	0.0
Five	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Six	0	0	0	0	0	0	0	0	0
%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-Total	8	0	8	5	1	6	1	0	1
%	100.0	0.0	*	83.3	16.7	*	100.0	0.0	*

R449N51.RPT

Airport: OTTAWA/MACDONALD-CARTIER INTL

Prov. ONT

335

Itinerant Runway Utilization By Number of Engines for - Turbos
 Report Date(D/M/Y): 7:5:1996
 Report Time(H/M/S): 22:57:42

January 1 to December 31 Data Year: 95

# Engines	Sub-Totals		
	Day	Night	Total
None	0	0	0
%	0.0	0.0	0.0
One	367	13	380
%	96.6	3.4	1.2
Two	29794	1802	31596
%	94.3	5.7	97.7
Three	0	0	0
%	0.0	0.0	0.0
Four	316	40	356
%	88.8	11.2	1.1
Five	0	0	0
%	0.0	0.0	0.0
Six	0	0	0
%	0.0	0.0	0.0

Total Turbos Day: 30477 = % 94.3
 Total Turbos Night: 1855 = % 5.7
 Turbos: 32332

Total Itinerant Movements in Interval: 122338

Notes: 1)(*) Denotes value was less than 0.1 percent
 2) Percentages may not add up to 100 due to rounding
 3) Night is defined as (22:00 - 06:59)

----- End Of A.M.S.A.P. V1.0 Report -----

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Appendix I

Transport Canada - OMCIA

Annual Aircraft Movement - Historical and Forecasting

(from 1978 to 2012)

Appendix J

Transport Canada - OMCLA Aircraft Daily Movement

(From 1980 to 1995)

Yr	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2443	2444	2445	2446	2447	2448	2449	2450	2451	2452	2453	2454	2455	2456	2457	2458	2459	2460	2461	2462	2463	2464	2465	2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479	2480	2481	2482	2483	2484	2485	2486	2487	2488	2489	2490	2491	2492	2493	2494	2495	2496	2497	2498	2499	2500	2501	2502	2503	2504	2505	2506	2507	2508	2509	2510	2511	2512	2513	2514	2515	2516	2517	2518	2519	2520	2521	2522	2523	2524	2525	2526	2527	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541	2542	2543	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554	2555	2556	2557	2558	2559	2560	2561	2562	2563	2564	2565	2566	2567	2568	2569	2570	2571	2572	2573	2574	2575	2576	2577	2578	2579	2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591	2592	2593	2594	2595	2596	2597	2598	2599	2600	2601	2602	2603	2604	2605	2606	2607	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617	2618	2619	2620	2621	2622	2623	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636	2637	2638	2639	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655	2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671	2672	2673	2674	2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687	2688	2689	2690	2691	2692	2693	2694	2695	2696	2697	2698	2699	2700	2701	2702	2703	2704	2705	2706	2707	2708	2709	2710	2711	2712	2713	2714	2715	2716	2717	2718	2719	2720	2721	2722	2723	2724	2725	2726	2727	2728	2729	2730	2731	2732	2733	2734	2735	2736	2737	2738	2739	2740	2741	2742	2743	2744	2745	2746	2747	2748	2749	2750	2751	2752	2753	2754	2755	2756	2757	2758	2759	2760	2761	2762	2763	2764	2765	2766	2767	2768	2769	2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783	2784	2785	2786	2787	2788	2789	2790	2791	2792	2793	2794	2795	2796	2797	2798	2799	2800	2801	2802	2803	2804	2805	2806	2807	2808	2809	2810	2811	2812	2813	2814	2815	2816	2817	2818	2819	2820	2821	2822	2823	2824	2825	2826	2827	2828	2829	2830	2831	2832	2833	2834	2835	2836	2837	2838	2839	2840	2841	2842	2843	2844	2845	2846	2847	2848	2849	2850	2851	2852	2853	2854	2855	2856	2857	2858	2859	2860	2861	2862	2863	2864	2865	2866	2867	2868	2869	2870	2871	2872	2873	2874	2875	2876	2877	2878	2879	2880	2881	2882	2883	2884	2885	2886	2887	2888	2889	2890	2891	2892	2893	2894	2895	2896	2897	2898	28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Appendix K

Transport Canada - OMCL

Annual Percentage Average By Aircraft Type and Daytime/Nighttime

(From 1990 to 1995 and Projection to 2004)

OMCIA - Dvtime Jet Aircraft - Departure Movements - 1990/1995 and 2004*								
AC Type	1990	1991	1992	1993	1994	1995	2004	2004(A)
A10	0.00%	0.00%	0.02%	0.02%	0.02%	0.02%	0.01%	0.01%
B707	1.05%	0.45%	0.51%	0.18%	0.10%	0.04%	0.34%	
B727	24.96%	14.83%	9.42%	3.85%	5.05%	4.40%	10.44%	
B737	28.86%	32.58%	29.17%	26.38%	24.42%	24.72%	27.77%	
B738	0.56%	0.28%	0.00%	0.19%	0.23%	0.44%	0.28%	28.05%
B747	0.46%	0.53%	0.45%	0.01%	0.04%	0.03%	0.23%	0.64%
B757	0.11%	0.05%	0.56%	0.99%	0.24%	0.27%	0.37%	0.37%
B767	2.64%	3.06%	1.73%	3.61%	4.99%	3.72%	3.29%	13.73%
BA11	0.05%	0.01%	0.00%	0.01%	0.02%	0.00%	0.02%	
BA46	4.22%	6.81%	6.53%	7.07%	7.41%	5.28%	6.22%	6.24%
C135	0.03%	0.03%	0.04%	0.02%	0.03%	0.00%	0.03%	0.05%
C141	0.01%	0.02%	0.03%	0.09%	0.12%	0.04%	0.05%	0.05%
C21	0.10%	0.03%	0.07%	0.09%	0.03%	0.05%	0.06%	0.06%
C500	2.47%	2.79%	2.00%	1.00%	0.36%	0.21%	1.47%	1.47%
C550	1.18%	1.86%	3.76%	5.32%	4.11%	4.19%	3.40%	3.40%
C690	0.11%	0.14%	0.15%	0.18%	0.19%	0.15%	0.15%	0.15%
CL60	4.44%	4.21%	4.50%	3.90%	3.76%	3.67%	4.05%	4.05%
DA10	0.21%	0.21%	0.27%	0.17%	0.21%	0.15%	0.20%	0.20%
DA50	0.16%	0.42%	0.34%	0.25%	0.15%	0.20%	0.25%	0.25%
DA90	0.04%	0.02%	0.05%	0.06%	0.05%	0.07%	0.05%	0.05%
DC8	0.16%	0.36%	0.61%	0.71%	0.18%	0.02%	0.42%	0.44%
DC9	13.96%	14.33%	18.64%	16.75%	16.03%	21.17%	16.81%	
DC93	1.99%	0.05%	0.01%	0.02%	0.07%	0.01%	0.36%	
EA31	0.30%	0.22%	0.28%	0.76%	0.42%	0.31%	0.38%	0.38%
EA32	2.00%	8.06%	15.87%	22.50%	21.22%	20.06%	14.95%	32.13%
F16	0.02%	0.04%	0.00%	0.03%	0.03%	0.00%	0.02%	0.02%
F18	0.53%	0.48%	0.37%	0.32%	0.26%	0.26%	0.37%	0.37%
F5	0.22%	0.09%	0.04%	0.07%	0.07%	0.01%	0.08%	0.08%
FF7	0.71%	0.52%	0.28%	0.36%	0.08%	0.08%	0.34%	0.34%
FK10	2.16%	1.61%	0.15%	0.01%	0.00%	3.00%	1.15%	2.87%
FKC8	0.05%	0.00%	0.00%	0.25%	6.14%	3.85%	1.72%	
G2	0.10%	0.10%	0.05%	0.11%	0.03%	0.03%	0.07%	0.07%
G3	0.08%	0.12%	0.06%	0.01%	0.09%	0.05%	0.07%	0.07%
G4	0.06%	0.12%	0.08%	0.05%	0.10%	0.08%	0.08%	0.08%
H125	1.70%	1.27%	0.99%	0.87%	0.92%	1.02%	1.13%	1.13%
HS21	0.31%	0.09%	0.02%	0.03%	0.02%	0.03%	0.08%	0.08%
L329	0.02%	0.01%	0.01%	0.01%	0.01%	0.02%	0.01%	
LR24	0.03%	0.06%	0.03%	0.07%	0.06%	0.17%	0.07%	
LR25	0.14%	0.20%	0.17%	0.24%	0.19%	0.16%	0.18%	
LR35	0.28%	0.38%	0.27%	0.33%	0.39%	0.42%	0.34%	0.60%
LR36	0.04%	0.02%	0.02%	0.01%	0.02%	0.00%	0.02%	0.02%
LR35	0.04%	0.03%	0.06%	0.05%	0.06%	0.09%	0.06%	0.06%
N265	0.09%	0.06%	0.05%	0.02%	0.07%	0.03%	0.05%	0.05%
T114	0.64%	0.92%	0.77%	0.74%	0.67%	0.48%	0.70%	0.70%
T33	1.26%	0.91%	0.74%	0.52%	0.33%	0.28%	0.67%	0.67%
T38	0.01%	0.00%	0.01%	0.03%	0.01%	0.00%	0.01%	0.01%
VC10	0.04%	0.01%	0.01%	0.03%	0.00%	0.02%	0.02%	
WW24	1.38%	1.05%	1.00%	1.29%	0.98%	0.59%	1.05%	1.07%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	99.98%

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OMCIA - Daytime Piston Aircraft - Departure Movements - 1990/1995 and 2004*							
AC TYPE	1990	1991	1992	1993	1994	1995	2004
AA1	0.01%	0.02%	0.27%	0.04%	0.04%	0.07%	0.08%
AA5	0.83%	0.76%	0.48%	0.56%	0.56%	0.36%	0.56%
AC2A	0.41%	0.59%	0.42%	0.45%	0.60%	0.26%	0.46%
AC30	0.08%	0.14%	0.10%	0.06%	0.03%	0.03%	0.07%
AC68	0.04%	0.02%	0.03%	0.15%	0.05%	0.02%	0.05%
AR11	0.01%	0.04%	0.04%	0.01%	0.02%	0.01%	0.02%
B75	0.01%	0.02%	0.01%	0.39%	0.02%	0.11%	0.09%
BE33	0.51%	0.67%	0.69%	0.54%	2.54%	2.49%	1.24%
BE33	0.04%	0.03%	0.06%	0.10%	0.12%	0.13%	0.08%
BE35	0.29%	0.24%	0.16%	0.29%	0.47%	0.34%	0.30%
BE36	0.47%	0.47%	0.29%	0.13%	0.27%	0.20%	0.30%
BE55	0.50%	0.43%	0.50%	0.30%	0.24%	0.19%	0.36%
BE56	0.34%	0.16%	0.25%	0.23%	0.11%	0.08%	0.20%
BE58	0.06%	0.06%	0.18%	0.30%	0.23%	0.29%	0.19%
BE60	0.07%	0.10%	0.02%	0.19%	0.20%	0.32%	0.15%
BE76	2.49%	2.51%	1.69%	2.81%	3.57%	3.24%	2.72%
BE95	0.23%	0.28%	0.19%	0.29%	0.35%	0.17%	0.25%
C14	0.15%	0.03%	0.05%	0.02%	0.03%	0.07%	0.06%
C150	37.35%	37.69%	40.11%	36.28%	29.15%	28.60%	34.86%
C152	0.27%	0.30%	0.21%	0.49%	0.25%	0.38%	0.55%
C170	0.17%	0.09%	0.05%	0.06%	0.08%	0.15%	0.10%
C172	19.49%	20.46%	20.14%	22.18%	24.99%	20.70%	21.33%
C177	2.08%	2.63%	2.21%	1.50%	1.36%	1.29%	1.84%
C180	0.32%	0.24%	0.30%	0.18%	0.13%	0.07%	0.21%
C182	2.62%	2.54%	2.28%	2.73%	2.70%	2.17%	2.51%
C185	0.38%	0.43%	0.16%	0.26%	0.16%	0.23%	0.27%
C188	0.10%	0.03%	0.07%	0.08%	0.02%	0.01%	0.05%
C206	0.46%	0.30%	0.68%	0.89%	1.21%	0.71%	0.71%
C210	1.90%	1.86%	1.84%	0.42%	0.77%	0.37%	1.19%
C303	0.02%	0.01%	0.01%	0.02%	0.09%	0.01%	0.03%
C310	1.04%	0.61%	0.76%	0.87%	0.95%	0.85%	0.85%
C335	0.01%	0.02%	0.01%	0.02%	0.04%	0.02%	0.02%
C336	0.01%	0.01%	0.03%	0.03%	0.03%	0.07%	0.03%
C337	0.09%	0.09%	0.23%	0.47%	0.47%	0.54%	0.32%
C340	0.10%	0.91%	0.57%	0.42%	0.03%	0.23%	0.1%
C401	0.07%	0.10%	0.04%	0.01%	0.04%	0.01%	0.02%
C402	0.27%	0.59%	0.70%	0.29%	0.07%	0.04%	0.33%
C404	0.40%	0.17%	0.14%	0.17%	0.36%	0.16%	0.23%
C414	0.62%	0.60%	0.56%	0.44%	0.51%	0.36%	0.52%
C421	0.19%	0.25%	0.56%	0.44%	0.58%	0.46%	0.41%
C72R	2.36%	2.44%	3.02%	3.53%	2.47%	2.84%	2.78%
C82R	0.08%	0.33%	0.85%	0.51%	0.61%	0.58%	0.49%
CH7	0.30%	0.27%	0.32%	0.36%	0.33%	0.22%	0.28%
DC3	1.36%	0.66%	0.66%	0.72%	0.61%	0.26%	0.71%
DH82	0.02%	0.03%	0.01%	0.05%	0.04%	0.02%	0.03%
DHC2	0.19%	0.11%	0.06%	0.22%	0.22%	0.39%	0.20%

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OMCIA - Daytime Piston Aircraft - Arrival Movements - 1990/1995 and 2004*							
AC TYPE	1990	1991	1992	1993	1994	1995	2004
AA1	0.04%	0.03%	0.20%	0.05%	0.04%	0.08%	0.07%
AA5	0.87%	0.70%	0.45%	0.59%	0.36%	0.36%	0.55%
AC2A	0.39%	0.58%	0.39%	0.44%	0.50%	0.20%	0.42%
AC50	0.11%	0.14%	0.13%	0.05%	0.04%	0.03%	0.08%
AC68	0.02%	0.03%	0.07%	0.17%	0.05%	0.02%	0.06%
AR11	0.01%	0.03%	0.03%	0.02%	0.03%	0.02%	0.02%
B75	0.01%	0.04%	0.01%	0.39%	0.02%	0.08%	0.09%
BE23	0.50%	0.63%	0.70%	0.55%	2.41%	2.40%	1.20%
BE33	0.05%	0.05%	0.07%	0.12%	0.09%	0.14%	0.09%
BE35	0.28%	0.24%	0.14%	0.29%	0.53%	0.33%	0.30%
BE36	0.51%	0.48%	0.29%	0.13%	0.27%	0.26%	0.32%
BE55	0.48%	0.46%	0.46%	0.27%	0.25%	0.23%	0.36%
BE56	0.37%	0.18%	0.27%	0.26%	0.14%	0.10%	0.22%
BE58	0.08%	0.08%	0.17%	0.34%	0.24%	0.32%	0.20%
BE60	0.07%	0.10%	0.02%	0.20%	0.19%	0.32%	0.15%
BE76	2.50%	2.48%	1.66%	2.75%	3.55%	3.26%	2.70%
BE95	0.23%	0.26%	0.15%	0.26%	0.35%	0.18%	0.24%
C14	0.15%	0.05%	0.05%	0.02%	0.03%	0.08%	0.06%
C150	37.78%	38.64%	41.31%	37.21%	29.51%	29.33%	35.63%
C152	0.26%	0.52%	0.50%	0.53%	0.37%	0.49%	0.40%
C170	0.18%	0.08%	0.05%	0.12%	0.08%	0.14%	0.11%
C172	19.47%	20.49%	20.06%	22.25%	25.58%	20.86%	21.45%
C177	2.04%	2.56%	2.07%	1.48%	1.43%	1.27%	1.81%
C180	0.37%	0.28%	0.33%	0.20%	0.14%	0.05%	0.23%
C182	2.68%	2.56%	2.41%	2.76%	2.77%	2.29%	2.58%
C185	0.40%	0.45%	0.20%	0.32%	0.20%	0.26%	0.30%
C188	0.11%	0.06%	0.07%	0.12%	0.05%	0.01%	0.07%
C206	0.55%	0.35%	0.71%	0.87%	1.21%	0.65%	0.72%
C210	1.85%	1.87%	1.85%	0.47%	0.78%	0.41%	1.21%
C305	0.02%	0.01%	0.02%	0.02%	0.08%	0.02%	0.03%
C310	1.01%	0.64%	0.80%	0.92%	1.00%	0.85%	0.87%
C335	0.01%	0.03%	0.01%	0.02%	0.04%	0.02%	0.02%
C337	0.08%	0.11%	0.22%	0.55%	0.59%	0.60%	0.36%
C340	0.11%	0.93%	0.57%	0.43%	0.03%	0.23%	0.39%
C401	0.07%	0.11%	0.05%	0.02%	0.05%	0.02%	0.05%
C402	0.32%	0.57%	0.67%	0.32%	0.06%	0.04%	0.33%
C404	0.24%	0.17%	0.13%	0.20%	0.38%	0.14%	0.21%
C414	0.61%	0.62%	0.66%	0.41%	0.51%	0.38%	0.53%
C421	0.20%	0.27%	0.56%	0.42%	0.62%	0.48%	0.43%
C72R	2.27%	2.44%	3.01%	3.51%	2.39%	2.85%	2.74%
CH2R	0.07%	0.35%	0.85%	0.48%	0.63%	0.58%	0.49%
CH7	0.35%	0.28%	0.41%	0.39%	0.20%	0.24%	0.31%
DC3	1.33%	0.67%	0.69%	0.72%	0.64%	0.26%	0.72%
DH82	0.02%	0.03%	0.02%	0.09%	0.05%	0.01%	0.04%
DHC2	0.25%	0.19%	0.12%	0.36%	0.26%	0.42%	0.27%
DHC3	0.09%	0.05%	0.06%	0.08%	0.20%	0.08%	0.09%

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Appendix L

Aerial Photos - OMCLIA Region - 1952

Appendix M

Aerial Photos - OMCIA Region - 1977

Appendix N

Aerial Photos - OMCIA Region - 1988

Appendix O

Aerial Photos - OMCI A Region - 1994

Appendix P

Statistical Analysis - SPSS Printout

- Accessibility vs. Density -

Dependent variable.. DISTANCE Method.. LINEAR

Listwise Deletion of Missing Data

Multiple R .83515
 R Square .69748
 Adjusted R Square .62185
 Standard Error .05628

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.02921286	.02921286
Residuals	4	.01267048	.00316762

F = 9.22234 Signif F = .0385

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
DENSITY	4.08571429E-05	1.3454E-05	.835154	3.037	.0385
(Constant)	.175762	.046443		3.784	.0194

Dependent variable.. DISTANCE Method.. LOGARITH

382

Listwise Deletion of Missing Data

Multiple R .80662
R Square .65064
Adjusted R Square .56330
Standard Error .06048

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.02725111	.02725111
Residuals	4	.01463222	.00365806

F = 7.44962 Signif F = .0525

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
DENSITY	.083549	.030611	.806625	2.729	.0525
(Constant)	-.349683	.238702		-1.465	.2168

Dependent Variable.. DISTANCE Method.. QUADRATIC

383

Listwise Deletion of Missing Data

Multiple R .83950
 R Square .70476
 Adjusted R Square .50793
 Standard Error .06420

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	.02951762	.01475881
Residuals	3	.01236571	.00412190

F = 3.58058 Signif F = .1604

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
DENSITY	2.37142857E-05	6.4886E-05	.484740	.365	.7390
DENSITY**2	2.85714286E-09	1.0508E-08	.360647	.272	.8033
(Constant)	.193143	.083022		2.326	.1025

Dependent variable.. DISTANCE Method.. CUBIC

384

Listwise Deletion of Missing Data

Multiple R .96025
 R Square .92208
 Adjusted R Square .90520
 Standard Error .04039

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	.03861984	.01287328
Residuals	2	.00326349	.00163175

F = 7.88927 Signif F = .1146

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
DENSITY	.000284	.000117	5.802382	2.416	.1369
DENSITY**2	-1.03809524E-07	4.5644E-08	-13.103520	-2.274	.1508
DENSITY**3	1.18518519E-11	5.0181E-12	8.405135	.	.
(Constant)	.052698	.079149		.666	.5740

Dependent variable.. DISTANCE Method.. POWER

385

Listwise Deletion of Missing Data

Multiple R .86897
 R Square .75512
 Adjusted R Square .69390
 Standard Error .17024

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.35746661	.35746661
Residuals	4	.11592606	.02898151

F = 12.33430 Signif F = .0246

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
DENSITY	.302599	.086161	.868974	3.512	.0246
(Constant)	.027444	.018439		1.488	.2109

Dependent variable.. DISTANCE Method.. EXPONENT

386

Listwise Deletion of Missing Data

Multiple R .85084
 R Square .72393
 Adjusted R Square .65492
 Standard Error .18075

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.34270532	.34270532
Residuals	4	.13068736	.03267184

F = 10.48932 Signif F = .0317

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
DENSITY	.000140	4.3208E-05	.850843	3.239	.0317
(Constant)	.188541	.028122		6.704	.0026

Newdata

387

	density	distance
1	500.00	.18
2	1500.00	.25
3	2500.00	.34
4	3500.00	.27
5	4500.00	.30
6	5500.00	.45
7	.	.
8	.	.
9	.	.
10	.	.

Independent: DENSITY

388

Dependent	Mth	Rsq	d.f.	F	Sig ²	b0	b1	b2	b3
DISTANCE LIN	.688	4	8.80	.041	.1754	4.1E-05			
DISTANCE LOG	.638	4	7.05	.057	-.3465	.0830			
DISTANCE QUA	.697	3	3.45	.167	.1949	2.1E-05	3.2E-09		
DISTANCE CUB	.919	2	7.60	.119	.0523	.0003	-1.E-07	1.2E-11	
DISTANCE POW	.741	4	11.47	.028	.0278	.3007			
DISTANCE EXP	.715	4	10.01	.034	.1883	.0001			

H1-Res Chart # 6:Curvefit for distance

Appendix Q

Statistical Analysis - SPSS Printout

- Complaint vs NEF vs Density -

a:\nefdata1.sav

390

	nef	dens500	dens1500	dens2500	dens3500	dens4500	dens5500
1	20.00	1.07	.06	.05	.05	.04	.02
2	20.50	2.55	.18	.25	.34	.17	.04
3	21.50	.54	.16	.15	.24	.14	.
4	22.50	.	.17	.60	.17	.09	.13
5	23.50	.	.	.25	.18	.17	.04
6	24.50	3.49	.16	.24	.30	.	.07
7	25.50	18.62	.18	.31	.39	.21	.10
8	26.50	48.09	.23	.33	.34	.34	.06
9	27.50	1.05	.27	.45	.20	.	.07
10	28.50	1.57	.	.68	.42	.	.
11	29.50	2.66	.	.86	.70	.	.26
12	30.50	63.83	.	.91	.	.	.
13	31.50	87.89	.	.	.	.	.
14	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.

People's Complaint vs Noise Level
Population Density < 999 People/km2
OMCIA Region

391

Dependent variable.. DENS500 Method.. LINEAR

Listwise Deletion of Missing Data

Multiple R .62097
 R Square .38560
 Adjusted R Square .31734
 Standard Error 26.62911

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	3709.0828	3709.0828
Residuals	9	5909.8163	656.6463

F = 5.64852 Signif F = .0415

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	4.807239	2.022685	.620970	2.377	.0415
(Constant)	-103.945604	53.154330		-1.956	.0822

Dependent Variable.. DENSS00 Method.. LOGARITH

393

Listwise Deletion of Missing Data

Multiple R .59752
R Square .35703
Adjusted R Square .28559
Standard Error 26.21428

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	3434.2036	3434.2036
Residuals	9	6184.6955	687.1884

F = 4.99747 Signif F = .0522

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	116.246125	52.000003	.597517	2.236	.0522
(Constant)	-356.386368	169.018996		-2.109	.0642

Dependent variable.. DENS500 Method.. QUADRATIC

394

Listwise Deletion of Missing Data

Multiple R .73008
 R Square .53301
 Adjusted R Square .41626
 Standard Error 23.69576

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	5126.9885	2563.4942
Residuals	8	4491.9106	561.4888

F = 4.56553 Signif F = .0476

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	-42.498370	29.827378	-5.489681	-1.425	.1920
NEF**2	.927221	.583486	6.122701	1.589	.1507
(Constant)	485.669747	374.277189		1.298	.2306

Dependent variable.. DENS500 Method.. CUBIC

395

Listwise Deletion of Missing Data

Multiple R .74217
 R Square .55082
 Adjusted R Square .43852
 Standard Error 23.23962

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	5298.2606	2649.1303
Residuals	8	4320.6384	540.0798

F = 4.90507 Signif F = .0407

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF**2	-.797162	.575320	-5.263884	-1.386	.2033
NEF**3	.022994	.014758	5.919233	1.558	.1578
(Constant)	141.573475	123.291848		1.148	.2840

----- Variables not in the Equation -----

Variable	Beta In	Partial	Min Toler	T	Sig T
NEF	86.612763	.540224	4.367E-06	1.698	.1332

Notes:

9 Tolerance limits reached; some dependent variables were not entered.

Dependent variable.. DENSS00 Method.. POWER

Listwise Deletion of Missing Data

396

Multiple R .58419
R Square .34127
Adjusted R Square .26808
Standard Error 1.54939

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	11.193371	11.193371
Residuals	9	21.605456	2.400606

F = 4.66273 Signif F = .0591

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	6.636604	3.073448	.584186	2.159	.0591
(Constant)	2.4047860122E-09	2.4023E-08		.100	.9225

Dependent variable.. DENS500 Method.. EXPONENT

Listwise Deletion of Missing Data

397

Multiple R .59198
 R Square .35044
 Adjusted R Square .27827
 Standard Error 1.53857

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	11.494015	11.494015
Residuals	9	21.304812	2.367201

F = 4.85553 Signif F = .0550

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	.267608	.121445	.591980	2.204	.0550
(Constant)	.005217	.016650		.313	.7612

Notes:

9 Tolerance limits reached; some dependent variables were not entered.

Hi-Res Chart # 1:Curvefit for dens500

People's Complaint vs Noise Levels

398

1000people/km2<Population Density<1999people/km2

OMCIA Region

Dependent variable.. DENS1500 Method.. LINEAR

399

Listwise Deletion of Missing Data

Multiple R .80849
R Square .65366
Adjusted R Square .59594
Standard Error .01908

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.01729708	.01729708
Residuals	6	.00916476	.00152746

F = 11.32408 Signif F = .0151

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	.017541	.005212	.808493	3.365	.0151
(Constant)	-.237128	.123594		-1.919	.1035

Dependent variable.. DENS1500 Method.. LOGARITH

400

Listwise Deletion of Missing Data

Multiple R .80568
 R Square .64912
 Adjusted R Square .59064
 Standard Error .03934

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.01717688	.01717688
Residuals	6	.00928497	.00154749

F = 11.09980 Signif F = .0158

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	.410561	.123231	.805679	3.332	.0158
(Constant)	-1.118449	.388834		-2.876	.0292

Dependent variable.. DENS1500 Method.. QUADRATIC

Listwise Deletion of Missing Data

401

Multiple R .81250
 R Square .66019
 Adjusted R Square .52421
 Standard Error .04241

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	.01746880	.00873440
Residuals	5	.00899304	.00179861

F = 4.85620 Signif F = .0673

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	-.026186	.141631	-1.206989	-.185	.8606
NEF**2	.000924	.002991	2.017092	.309	.7698
(Constant)	.273584	1.658302		.165	.8754

Dependent variable.. DENS1500 Method.. CUBIC

Listwise Deletion of Missing Data

402

Multiple R .81435
 R Square .66317
 Adjusted R Square .52843
 Standard Error .04222

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	.01754862	.00877431
Residuals	5	.00891323	.00178265

F = 4.92207 Signif F = .0658

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF**2	-.000470	.002991	-1.025548	-.157	.8813
NEF**3	2.35281415E-05	8.3569E-05	1.938066	.282	.7896
(Constant)	.120848	.549868		.220	.8347

----- Variables not in the Equation -----

Variable	Beta In	Partial	Min Toler	T	Sig T
NEF	172.550906	.711438	1.429E-06	2.025	.1129

Notes:

9 Tolerance limits reached; some dependent variables were not entered.

Dependent variable.. DENSI500 Method.. PCWER

403

Listwise Deletion of Missing Data

Multiple R .73515
R Square .54044
Adjusted R Square .46385
Standard Error .33714

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.80202495	.80202495
Residuals	6	.68198814	.11366469

F = 7.05606 Signif F = .0377

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	2.805433	1.056133	.735148	2.656	.0377
(Constant)	2.3515801971E-05	7.8365E-05		.300	.7742

Dependent variable.. DENS1500 Method.. EXPONENT

Listwise Deletion of Missing Data

404

Multiple R .72862
 R Square .53089
 Adjusted R Square .45270
 Standard Error .34063

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.78784386	.78784386
Residuals	6	.69616924	.11602821

F = 6.79011 Signif F = .0403

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	.118380	.045430	.728620	2.606	.0403
(Constant)	.010044	.010819		.928	.3891

Notes:

9 Tolerance limits reached; some dependent variables were not entered.

Hi-Res Chart # 2:Curvefit for dens1500

People's Complaint vs Noise Levels

405

2000people/km2<Population Density<2999people/km2

OMCIA Region

Dependent Variable.. DENS2500 Method.. LINEAR

Listwise Deletion of Missing Data

406

Multiple R .81953
R Square .67164
Adjusted R Square .63980
Standard Error .16743

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.57335541	.57335541
Residuals	10	.29031561	.02903156

F = 20.45392 Signif F = .0011

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	.064521	.014266	.819533	4.523	.0011
(Constant)	-1.192186	.360506		-3.307	.0079

Dependent Variable.. DENS2500 Method.. LOGARITH

407

Listwise Deletion of Missing Data

Multiple R .80289
R Square .64464
Adjusted R Square .60910
Standard Error .17417

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.55030949	.55030949
Residuals	10	.30336154	.03033615

F = 18.14038 Signif F = .0017

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	1.568989	.368381	.802894	4.259	.0017
(Constant)	-4.614953	1.184043		-3.898	.0030

Dependent variable.. DENS2500 Method.. QUADRATIC

Listwise Deletion of Missing Data

408

Multiple R .96678
 R Square .75132
 Adjusted R Square .69605
 Standard Error .15358

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	.64137627	.32068813
Residuals	9	.21229476	.02358831

F = 13.59522 Signif F = .0019

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	-.320637	.227189	-4.072689	-1.411	.1918
NEF**2	.007663	.004513	4.900360	1.698	.1237
(Constant)	3.559182	2.817465		1.263	.2382

Dependent variable.. DENS2500 Method.. CUBIC

Listwise Deletion of Missing Data

409

Multiple R .87144
 R Square .75941
 Adjusted R Square .70595
 Standard Error .15106

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	.64829035	.32414518
Residuals	9	.20538068	.02282008

F = 14.20439 Signif F = .0016

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF**2	-.005633	.004522	-3.602271	-1.246	.2443
NEF**3	.000182	.000118	4.443814	1.537	.1587
(Constant)	1.012758	.940920		1.076	.3098

----- Variables not in the Equation -----

Variable	Beta In	Partial	Min Toler	T	Sig T
NEF	52.070927	.446609	4.363E-06	1.412	.1957

Notes:

9 Tolerance limits reached; some dependent variables were not entered.

Dependent variable.. DENS2500 Method.. POWER

410

Listwise Deletion of Missing Data

Multiple R .79938
 R Square .63901
 Adjusted R Square .60292
 Standard Error .52763

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	4.9281555	4.9281555
Residuals	10	2.7839717	.2783972

F = 17.70189 Signif F = .0018

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	4.695249	1.115960	.799383	4.207	.0018
(Constant)	9.2863758247E-08	3.3309E-07		.279	.7861

Dependent variable.. DENS2500 Method.. EXPONENT

Listwise Deletion of Missing Data

411

Multiple R .79570
 R Square .63314
 Adjusted R Square .59645
 Standard Error .53191

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	4.8828431	4.8828431
Residuals	10	2.8292842	.2829284

F = 17.25823 Signif F = .0020

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	.188288	.045324	.795700	4.154	.0020
(Constant)	.002940	.003367		.873	.4031

Notes:

9 Tolerance limits reached; some dependent variables were not entered.

Hi-Res Chart # 6:Curvefit for dens2500

People's Complaint vs Noise Levels

412

3000people/km2<Population Density<3999people/km2

OMCIA Region

Dependent variable.. DENS3500 Method.. LINEAR

Listwise Deletion of Missing Data

413

Multiple R .69981
R Square .48974
Adjusted R Square .43304
Standard Error .12877

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.14323644	.14323644
Residuals	9	.14923971	.01658219

F = 8.63797 Signif F = .0165

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	.036895	.012553	.699812	2.939	.0165
(Constant)	-.603844	.310562		-1.944	.0837

Dependent variable.. DENS3500 Method.. LOGARITH

Listwise Deletion of Missing Data

414

Multiple R .68429
 R Square .46825
 Adjusted R Square .40917
 Standard Error .13145

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.13695280	.13695280
Residuals	9	.15552335	.01728037

F = 7.92534 Signif F = .0202

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	.879494	.312409	.684290	2.815	.0202
(Constant)	-2.506050	.998159		-2.511	.0333

Dependent variable.. DENS3500 Method.. QUADRATI

Listwise Deletion of Missing Data

415

Multiple R .75855
 R Square .57540
 Adjusted R Square .46924
 Standard Error .12459

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	.16828949	.08414474
Residuals	8	.12418666	.01552333

F = 5.42053 Signif F = .0325

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	-.252182	.227873	-4.783364	-1.107	.3006
NEF**2	.005866	.004618	5.490982	1.270	.2396
(Constant)	2.901157	2.775307		1.045	.3264

Dependent variable.. DENS3500 Method.. CUBIC

416

Listwise Deletion of Missing Data

Multiple R .76596
 R Square .58670
 Adjusted R Square .48337
 Standard Error .12292

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	.17159482	.08579741
Residuals	8	.12088133	.01511017

F = 5.67812 Signif F = .0292

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF**2	-.004850	.004625	-.539255	-1.049	.3250
NEF**3	.000150	.000123	5.260930	1.215	.2589
(Constant)	.944395	.925941		1.020	.3376

----- Variables not in the Equation -----

Variable	Beta In	Partial	Min Toler	T	Sig T
NEF	85.805919	.478036	3.171E-06	1.440	.1931

Notes:

9 Tolerance limits reached; some dependent variables were not entered.

Dependent variable.. DENS3500 Method.. POWER

417

Listwise Deletion of Missing Data

Multiple R .67231
R Square .45200
Adjusted R Square .39111
Standard Error .54143

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	2.1760703	2.1760703
Residuals	9	2.6382759	.2931418

F = 7.42327 Signif F = .0234

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	3.505772	1.286726	.672307	2.725	.0234
(Constant)	3.4855733261E-06	1.4330E-05		.243	.8133

Dependent variable.. DENS3500 Method.. EXPONENT

418

Listwise Deletion of Missing Data

Multiple R .66926
 R Square .44791
 Adjusted R Square .38657
 Standard Error .54344

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	2.1564109	2.1564109
Residuals	9	2.6579352	.2953261

F = 7.30180 Signif F = .0243

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	.143153	.052977	.669263	2.702	.0243
(Constant)	.007533	.009874		.763	.4650

Notes:

9 Tolerance limits reached; some dependent variables were not entered.

Hi-Res Chart # 13:Curvefit for dens3500

Dependent variable.. DENS4500 Method.. LINEAR

Listwise Deletion of Missing Data

Multiple R .81900
R Square .67076
Adjusted R Square .60491
Standard Error .05593

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.03658180	.03658180
Residuals	5	.01795595	.00359119

F = 10.18654 Signif F = .0242

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	.031720	.009939	.819000	3.192	.0242
(Constant)	-.560017	.228294		-2.453	.0577

Dependent variable.. DENS4500 Method.. LOGARITH

Listwise Deletion of Missing Data

421

Multiple R .80886
R Square .65425
Adjusted R Square .58511
Standard Error .06141

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.03568159	.03568159
Residuals	5	.01885617	.00377123

F = 9.46152 Signif F = .0276

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	.723781	.235303	.808860	3.076	.0276
(Constant)	-2.096336	.735537		-2.850	.0358

Dependent variable.. DENS1500 Method.. QUADRATIC

Listwise Deletion of Missing Data

422

Multiple R .95889
R Square .73786
Adjusted R Square .60679
Standard Error .05978

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	.04024122	.02012061
Residuals	4	.01429654	.00357413

F = 5.62951 Signif F = .0687

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	-.230034	.258876	-5.939344	-.889	.4244
NEF**2	.005631	.005565	6.763306	1.012	.3688
(Constant)	2.451957	2.985370		.821	.4576

Dependent variable.. DENS4500 Method.. CUSIC

Listwise Deletion of Missing Data

423

Multiple R .86248
 R Square .74387
 Adjusted R Square .61581
 Standard Error .05909

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	.04056903	.02028451
Residuals	4	.01396873	.00349218

F = 5.80855 Signif F = .0656

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF**2	-.004634	.005610	-5.566612	-.826	.4552
NEF**3	.000152	.000160	6.399446	.950	.3960
(Constant)	.744322	.999543		.745	.4978

----- Variables not in the Equation -----

Variable	Beta In	Partial	Min Toler	T	Sig T
NEF	167.768361	.562507	7.071E-07	1.178	.3236

Notes:

9 Tolerance limits reached; some dependent variables were not entered.

Dependent variable.. DENS4500 Method.. POWER

Listwise Deletion of Missing Data

424

Multiple R .74981
R Square .56222
Adjusted R Square .47465
Standard Error .51377

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	1.6949649	1.6949649
Residuals	5	1.3198192	.2639638

F = 6.42120 Signif F = .0523

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	4.988448	1.968599	.749812	2.534	.0523
(Constant)	2.3472596077E-08	1.4444E-07		.163	.8773

Dependent variable.. DENS4500 Method.. EXPONENT

Listwise Deletion of Missing Data

425

Multiple R .74858
 R Square .56038
 Adjusted R Square .47245
 Standard Error .51485

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	1.6894194	1.6894194
Residuals	5	1.3253647	.2650729

F = 6.37341 Signif F = .0529

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	.215563	.085386	.748584	2.525	.0529
(Constant)	.000999	.001959		.510	.6319

Notes:

9 Tolerance limits reached; some dependent variables were not entered.

Hi-Res Chart # 5:Curvefit for dens4500

People's Complaint vs Noise Levels

5000people/km2<Population Density

426

OMCIA Region

Dependent variable.. DENS5500 Method.. LINEAR

427

Listwise Deletion of Missing Data

Multiple R .68212
R Square .46529
Adjusted R Square .38891
Standard Error .05618

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.01922643	.01922643
Residuals	7	.02209462	.00315637

F = 6.09130 Signif F = .0430

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	.015481	.006273	.682125	2.468	.0430
(Constant)	-.290905	.154469		-1.883	.1017

Dependent variable.. DENS5500 Method.. LOGARITH

428

Listwise Deletion of Missing Data

Multiple R	.66069
R Square	.43651
Adjusted R Square	.35601
Standard Error	.05767

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	.01803713	.01803713
Residuals	7	.02328393	.00332628

F = 5.42262 Signif F = .0527

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	.363293	.156006	.660690	2.329	.0527
(Constant)	-1.070935	.497851		-2.151	.0685

Dependent variable.. DENSS500 Method.. QUADRATIC

429

Listwise Deletion of Missing Data

Multiple R .77839
 R Square .60589
 Adjusted R Square .47453
 Standard Error .05210

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	.02503619	.01251809
Residuals	6	.01628487	.00271414

F = 4.61217 Signif F = .0612

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	-.126702	.097355	-5.582701	-1.301	.2408
NEF**2	.002901	.001983	6.276037	1.463	.1938
(Constant)	1.425559	1.181913		1.206	.2732

Dependent variable.. DENSS500 Method.. CUSIC

430

Listwise Deletion of Missing Data

Multiple R .79292
 R Square .62873
 Adjusted R Square .50497
 Standard Error .05057

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	.02597970	.01298985
Residuals	6	.01534135	.00255689

F = 5.08033 Signif F = .0512

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF**2	-.002518	.001935	-5.447744	-1.301	.2408
NEF**3	7.63155554E-05	5.1843E-05	6.161943	1.472	.1914
(Constant)	.449817	.386745		1.163	.2890

----- Variables not in the Equation -----

Variable	Beta In	Partial	Min Toler	T	Sig T
NEF	130.924935	.819627	3.635E-06	3.199	.0240

Notes:

9 Tolerance limits reached; some dependent variables were not entered.

Dependent variable.. DEMS5500 Method.. POWER

431

Listwise Deletion of Missing Data

Multiple R .75589
 R Square .57136
 Adjusted R Square .51013
 Standard Error .50438

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	2.3737413	2.3737413
Residuals	7	1.7807871	.2543982

F = 9.33081 Signif F = .0185

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	4.167518	1.364325	.755885	3.055	.0185
(Constant)	1.1624530041E-07	5.0612E-07		.230	.8249

Dependent variable.. DENS5500 Method.. EXPONENT

432

Listwise Deletion of Missing Data

Multiple R .75788
 R Square .57439
 Adjusted R Square .51359
 Standard Error .50260

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	1	2.3863144	2.3863144
Residuals	7	1.7682140	.2526020

F = 9.44693 Signif F = .0180

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
NEF	.172471	.056114	.757884	3.074	.0180
(Constant)	.001014	.001401		.724	.4927

Notes:

9 Tolerance limits reached; some dependent variables were not entered.

Hi-Res Chart # 14:Curvefit for dens5500