AIRPORT VICINITIES:

THE DEVELOPMENT OF A LAND USE PLAN.

A Thesis

Presented to

The Faculty of Graduate Studies and Research

University of Manitoba.

In Partial Fulfillment

of the Requirements of the Degree

Master of City Planning

by

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February 1970.

ACKNOWLEDGMENTS

I wish to express my gratitude to those individuals, government offices and private organizations who have been enormous help during the preparation of this study. I am thankful to Professor B.M. Rotoff, Department of City Planning, University of Manitoba, for his guidance, co-operation and encouragement in investigating the problem. For the large part of the subject matter, I owe much to the Federal Aviation Administration, Port of New York Authority, and Air Canada officials who were liberal with their time and efforts to attend to my enquiries. In the end, a special word of thanks goes to J.P. Dunne, the First Deputy Commissioner of the Department of Aviation, Chicago O'Hare International Airport; W.J. McKay, Regional Supervisor, the Federal Department of Transport, Winnipeg, and S.T. Howe, Air Freight Manager, Air Canada, Winnipeg.

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> "We are very slow to learn. Our new airports are still planned with old attitudes and talents; the same interests that failed in the past are recalled for still more advice; and the results are the same static conception of airports as being merely bases for airplanes....What airports are really meant to be and how they should best serve continues to elude us...the opportunities have existed, but foresight has not, to take the Air Age for what it really is--a gigantic evolution in the habits of man--and to plan for it being just as practical as it is imaginative....Airports today are a result of location of our cities....The Air Harbour will be where Nature and enormity of things to come determine. Then around it--possibly under it-- a city will grow." [1]

The views held by W.L. Pereira (1957) about the attitudes towards airports are valid even these days. The present day practices of "City Planning"[2] clearly shows that an airport is considered just a transportation terminal and nothing more. In North America the general approach of a Development Plan[3] while dealing with airports, is simply to provide for the future air traffic volume, with some concern which is rather occasional, shown to the effects of the aircraft noise. In the field of physical planning, the role of a Development Plan to recognize the future air traffic volume and plan accordingly, is a step in the right direction. But such a plan deals with an airport in

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1. W.L. Pereira, "Airports, Planes, and People," Proceedings of the American Society of Civil Engineers, Vol. LXXXIII, No. AT2: <u>Journal of the Air Transport Division</u> (December, 1957), Procedure Paper 1476, p. 3.

2. In view of the subject of the thesis the term "City Planning" is meant to refer to only physical planning thus excluding any confusion with social or economic planning. Henceforth the term "Planning" wherever used shall mean physical planning unless otherwise stated.

3. Development Plan of a city is an official document that guides its future physical growth.

isolation and hence does not recognize the potential of urban growth it has. Therefore, the meaning and city-building potential of an airport are not yet fully understood and exploited by urban planners, civic leaders and the public at large.

Although the potential of urban growth created by an airport is not properly recognized and rationalized, a closer examination of the recent growth of some large cities clearly demonstrates that strong "magnetic" forces of a major airport are nevertheless in action. The result being that, within our fast-growing metropolitan areas, we are amazed to see the emergence of new kinds of cities which may be called "airport cities." To name a few large ones, there are Century City in Los Angeles, Clear Lake City in Houston, and Reston and Columbia near Washington, D.C.[4] It seems that we were caught unaware: the size, scale and the rate of their growth did not allow us any time to plan them within our largely unplanned metropolitan areas.

The urban growth potential of a large transportation facility as such is not a new phenomenon. The history of the City can show that docks and rail terminals have always been strong gravitational nodes for urban growth. In his article on the growth of communities around rail terminal, R. Bradbury explains the phenomenon as follows: "For, riding the train, you can build the roads,...chop the wood for fences, pile the rocks in walls...light the lamps in lonely cottages, and

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4. Gordon Edwards, "Jumbo Jets and the Emerging Airport City," Planning 1967, American Society of Planning Officials, Chicago, Illinois, p. 240. Edwards is Director, Co-operative Urban Extension Center, State University of New York at Buffalo.

suddenly bring together full towns and cities."[5] The basic principles of growth of viable communities focused on a terminal facility are quite similar when applied to airports. The community life around a rail terminal and the validity of their comparison with airports may be explained in the words of J.R.L. Anderson as it appeared in Manchester Guardian:

> "An airport has to serve at the same time and place the functions of a dock and of a railway station; soon it may have to be a bus stop as well....Railways...went automatically from town centre to town centre, and their main stations were built in the middle of towns. This has had profound effects, some good, some bad, on the development of urban life...one thing it did ensure was that railways became very much part of people's lives. Aeroplanes came late in the day when there was no room for airports in town centres....But although airports remain strange institutions, they are of integral importance in the community they serve."[6]

Docks and rail terminals are, however, of considerable historic significance and some lessons can be learnt from their development as well as the various problems they faced during the process. But it should be noted that an enormous amount of research work has already been done on the impact that docks and rail terminals have had on the growth of cities, therefore this example will not be elaborated on any further. Roads, under the contemporary name of 'highways', are relatively new means of transportation and have been chosen as the mode of intra-city movement of people and goods. Thus, any large public facility in a metropolitan

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5. Ray Bradbury, "Any Friend of Trains is a Friend of Mine," Life, Vol. 65, No. 5, August 2, 1968, p. 48.

6. J.R.L. Anderson, "Living with Airports," Manchester Guardian Weekly, October 25, 1962.

area, which has to be accessible to its population, cannot be considered separately, but would have to be planned with the system of metropolitan roads. A major airport is no exception.

II. AIRPORT AND COMMUNITY

The relationship between airport and community can be investigated with different sets of questions (such as social, economic, political, etc.) in mind depending upon the objective of the study. From the point of Planning, a comprehensive study of the relationship between a major airport and the inevitable urban growth in its vicinity seems to be a valuable and timely endeavour. For this it is suggested that the reader should be introduced to the broad outlines of the approach adopted in the study. The investigation begins by reviewing how the airport in all its potentials, serves the community and what its deleterious effects on the community life are. The desired end would then be to maximize the potentials of the airport and minimize its negative effects on the population concerned. The elementary principles of "planning" when applied to the problem at hand, suggest that, to begin with, it is important to understand clearly "what an airport is." Some efforts have been made towards this end and it would be relevant at this point to quote John Abiac on the London Airport:

> "...it is a town. It has faults, still suffers from growing pains, is noisily functional. It is still expanding, still a great experiment, its final shape still dependent upon future aircraft development. But though in many ways like other towns, it is yet like no other. It has its own shops, police force, transport and power services, town council, fire brigade, doctors, warehouses, restaurants, telephone exchange, its own slick language and brittle smell, its own radius of sky more

> crowded than any in the world. Yet nobody lives there. Its visitors are measured in millions, most of whom stay only a few minutes and then see it no more, they are of every type, nationality, and colour. It lives on them but is concerned only to see them go, and the sooner the better." 7

From the planning point of view, Abiac raises two important points. First, an airport is a living and growing organism. Second, airport operation is inherently noisy and spreads its negative effects on the surrounding area. The result of incomplete recognition of these two factors by urban planners is that the airports in the metropolitan areas of today have been excessively ill-planned. Incompatible urban growth around the airports and the ensuing nuisance have been, in most cases, important factors causing their removal or isolation from the urban environs. But, the banishment from the urban built-up area does not provide a tangible solution to the problem. The strong forces of modern urbanization and the airport magnetic-pull, constantly keep on narrowing down the deliberately created physical distance. Thus, a community and its airport tend to become inseparable. An airport, therefore, attracts urban growth irrespective of its location, and tends to createa city of its own, or else, it is functionally ineffective.

III. SCOPE OF THE STUDY

The body of this thesis deals with the considerations of physical planning around an airport so that it becomes an integral component of

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7. John D. Abiac, "London Airport," Journal of the Royal Aeronautical Society, Vol. 61, April, 1957, p. 225.

the community it serves. In doing so, the emphasis throughout is the study of the compatibility criteria of physical development in the vicinity of a modern, commercial jet airport handling mainly scheduled domestic as well as international air traffic. The term 'vicinity' wherever used in the thesis is intended to mean the surrounding area of the airport which is affected by its operation. Upon completion of the investigation, the physical boundaries of the vicinity as such, can be laid out accurately.

It should be noted that this study is about the major forces or constraints of the airport operation as they affect the urban growth in the vicinity. Since this study does not relate to any existing airport in Canada, nor does it specify the location of the airport (within the metropolitan area) being discussed, it is, therefore, assumed that the impact of location of the airport on the nature of urban growth in its vicinity is negligible. Thus, the discussion in this thesis relates to a hypothetical airport where its location in the metropolitan area exert little influence on the surrounding urban development.

The content of the thesis shall be dealt with in the following three parts:

Part one will deal with the historical perspective of the technological developments of aviation which led to the creation of modern jet aircraft, and their effects on the airports and cities. A brief discussion of the nature of urban growth which has occurred around the airports in the past is intended to be included in this part. In its objective this part will attempt to demonstrate the critical nature of the problem of physical growth around airports so that an effective investigative approach in the main body of the thesis could be adopted.

Part two will study the negative effects of the airport operation and their effects on the surrounding development. The areas thus affected will be delineated and their desirable and undesirable use shall be the recommendations of part two.

Part three will relate to the fact that an airport, like any other transportation terminal, is a growing and living organism, and provides a fast mode of inter-city transport of people and goods. For the operation of an airport as such, the location of certain necessary urban functions in its proximity will be studied in detail. The discussion will endeavour to isolate precisely those urban functions which are vital to serve the needs of air passengers and air freight business.

In the end, this study will present a list of compatible land uses which can serve as a land-use model for planning in the vicinity of an airport.

CHAPTER I

HISTORICAL PERSPECTIVE OF AVIATION AND EFFECTS ON CITIES

A. GROWTH OF AVIATION SINCE WORLD WAR II

Like other evolutionary and far-reaching achievements, aviation and its present day use also came about by a process of trial and error. A better grasp of the developments of aviation, and the several problems encountered on the way, is possible through a brief historical review. It is, however, implicit that the interest of this thesis is as much on the technically changing product of the airplane and airport, as on its use and sociological impact on community affairs. This chapter, therefore, will be completely devoted to describe the vivid historical advances in modern craft design, its role as civilian transportation, and the consequent problems created in our cities.

1. Development of Aircraft Design:

Until World War II, aircraft technology had remained relatively simple and modest. The challenge of necessary ground operational facilities, like airports, could be met with relative ease and through normal efforts. The piston-engined aircraft of those days needed shorter runways and smaller hangar buildings. The services provided for the air-passengers by the airlines and the airport owners[8] were akin to the basic

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8. "Airport owners" in those days could have been private persons or local municipal body or provincial or federal government.

requirements of transport and nothing more. Then, in the early 1940's, traditional craft design entered the era of aeronautical revolution.

It is true that some minor improvements in the basic design of airplane were achieved in the early part of the twentieth century, but these achievements, as such, have not made a significant contribution towards the creation of modern jets. The invention of the turbine engine[9] and jet propulsion[10] which was to have a far-reaching effect on the future of the postwar flights, came through in the early 1940's.[11] The advantages thus introduced are the availability of increased engine power (or greater load-carrying capacity) and higher cruising speed. In essence, the concern of aeronautical progress since the war has been focussed mainly on the development of jet propulsion either by the gas turbine or by rocket.[12] The benefits of this progress for the civilian air transport fleet are reflected in modern airliners which are bigger, faster and safer, and capable of undertaking longer-haul flights.

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9. It may be added that the invention of the turbine engine was rather timely. The load-carrying capacity of the piston-engined aircraft had reached its ultimate stage during the late 1940's and could not have been increased without serious economic consequences for the craft manufacturers and airlines.

10. The jet propulsion in the last decade is responsible for the vast revolution from DC-3 (piston-engined, 28 seats, 150 m.p.h., cruising speed) to large sub-sonic jets, carrying 150 passengers and flying at the speed of 600 m.p.h.
Source: Personal interview with Mr. McKay, Airport Maintenance Branch, Department of Transport of Canada, Winnipeg, February, 1969.

11. J.L. Nayler, Aviation: Its Technical Development, London: Peter Owen/Vision Press, 1965, Chapter XIV, Civil Aviation, p. 200.

12. Rockets have been extensively used only in space exploration programmes.

Although the role played by the technological advance of the post-war years deserves our admiration, it is equally important to realize that this great revolution had some less admirable side effects. The use of the modern jets, besides their definite advantages, has created quite serious problems at our airports as well as in our cities. Since little thought, if any, was given to the effects jet aircraft would have upon the quality of urban living before they were widely introduced, the problems they have created, such as noise, safety and pollution, are reaching the brink of chaos, especially in the industrialized nations.

2. Growth of Air Passenger Traffic:

Until World War II, the civilian use of air transport was confined to a certain exclusive segment of our society. After the war, however, civilian air travel experienced a sudden boom, particularly (but not exclusively) in the more industrialized countries of the world. Canada, which is a country of vast resources and where geography is quite suitable for airways, also expanded on the use of air transport and substantially contributed to the global air boom. Historical studies indicate that, on the average, passenger traffic by Air Canada[13] has grown at the rate of twelve per cent a year[14] between 1950 and 1965. This

13. Air Canada, before June 1, 1964, was known as T.C.A. (Trans-Canada Airlines).

14. The annual growth rate of passengers by Air Canada 1950-1965:

Period	Annual Growth Rate
1950 - 1955	15.0%
1955 - 1960	6.75%
1960 - 1965	15.0%
1950 - 1965	12.0%

Source: Mr. Sawyer, Public Relations Office, Air Canada, Winnipeg, February, 1969.

growth rate is of considerable interest since the national importance of Air Canada as an air-carrier is such that its growth can be taken to represent the nation-wide growth of air transportation. In the actual practice, it is very rare that we have to plan the airports keeping in mind the national growth rate. We are always dealing with the airports having growth rates either below or above that of national average. The major Canadian international airports, such as Toronto, Montreal or Vancouver, belong to the latter category because their growth rates are far above the national average. It has been determined that the annual growth rates at these airports have been over 20 per cent[15] in the last five years.

This phenomenal growth has created quite serious problems for those who are responsible for planning air services at the federal, provincial and local levels. For the Airport Maintenance Branch of the Department of Transport of Canada, the growth meant the expansion of the existing airports or the building of new ones (airports) where the growth could not have been accommodated otherwise. It is most unfortunate that so little attention has been paid to the fact that the huge air-traffic volumes do have some deeper sociological meanings. The present and future city planners have yet to discover what major interests (economic or otherwise) are represented by the growing air traffic, and what consequent changes are imposed on practices of city design.

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15. Personal correspondence with the managers of these airports, March, 1969.

3. Air Freight and Its Development:

Unlike air passenger regular flights, air freight services remained of little significance until after World War II.[16] Although no specific reasons have been found, it is widely agreed upon that the technological inability of the aircraft and comparatively higher transportation costs were prime limitations to its potential growth. The piston-engined aircraft of those days were not powerful enough as freight carriers; the twin-engined aircraft could carry only 4 to 6 tons of load,[17] and then, the transportation costs on similar articles were 4 to 7 times the rates charged by surface carriers.[18] These limiting factors on the freight carrying capability of aircraft existed until the modern jet-type aircraft, capable of carrying huge freight, became available in the 1950's.

The early 1950's may be called a breaking point period. From then on, rapid and radical expansions of the air freight business continued with a spectacular growth rate through the 1950's and early 1960's in all the industrial countries. In Canada, a casual look at

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16. Notable exceptions to this statement are bush flying operations for the areas inaccessible by surface carriers.

17. The military aircraft were carrying over six tons of freight since the higher operational cost is generally not a limiting factor for them.

18. Stanley H. Brewer, Air Cargo Comes of Age, Seattle, Graduate School of Business Administration, University of Washington, 1966, p. vi.

historical statistics[19] is sufficient to show the extent of the air freight boom of the postwar period. Furthermore, the Canadian freight of the early 1960's if compared to that of the 1950's, displays a still greater upsurge. The present day growth rates in Canada range between 20 to 25 per cent per year[20] which is exceedingly high. For the significant increases of the 1950's and especially of the 1960's, there can be three main reasons as brought out by Professor Brewer.[21] First, with the availibility of modern jet, most of the airlines were faced with surplus

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19. Volume of Air Freight Moved by Air Canada (1950-1966):

Year	Air Freight in 1000 Ton-Miles	% Increase over Preceding Year
1950	3,556	-
1951	4,223	19%
1952	5,584	32%
1953	6,192	11%
1954	8,325	35%
1955	9,916	19%
1956	11,870	20%
1957	12,832	8%
1958	12,836	-
1959	14,964	16%
1960	17,901	19%
1961	20,990	17%
1962	26,304	25%
1963	32,022	22%
1964	41,197	28%
1965	56,100	36%
1966	74,887	34%

Source: Mr. Sawyer, Public Relations Office, Air Canada, Winnipeg Office, Winnipeg. Telephone call on February 17, 1969.

20. "Cost Savings, attract more varied cargoes - such as machines, tomatoes," The Financial Post, February 8, 1969, p. T-3.

21. Prof. Brewer has done extensive research work on the development of air freight business. He is a faculty member of the Graduate School of Business Administration, University of Washington, Seattle.

piston-engined aircraft which were subsequently converted to strictly freight service. Second, the postwar production of exclusive air freighters also contributed to the freight business. Third, and the main reason, is the availability of larger freight capacity of modern jets, which have replaced old aircraft, on scheduled passenger routes. In addition to these three factors, Brewer seems to think that certain socio-economic factors (related to the transportation costs and acceptance of air services) have also contributed to the freight boom. On the basis of his extensive research in this field, Professor Brewer believes that:

> ...the freight business is now a brand new ball game! Present jet airplanes can carry 45 tons of freight at about the same direct cost per-plane-mile as the most efficient piston planes which moved less than half this payload. Airplanes expected to be available in the few years will move 100 or more tons of freight at direct operating cost, 25 to 35 per cent less than the jet freighter now being used.[22]

Like Brewer, there are other experts in the field holding the same views. However desirable a greater volume of air freight from the business viewpoint may be, it will not come by itself: since air freight is the shipment of goods by air it must be carefully planned at the origin as well as at the destination centres. Unlike that of air passengers, the needs of air freight operation have not been identified and analyzed on a larger scale. The knowledge of the basic requirements of the operation is vital for the development of the existing as well as the future airports.

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22. Brewer, *op. cit.*, p. vi.

B. AIRPORTS AND URBANIZATION IN POSTWAR YEARS

The phenomenon of postwar urbanization will have made its indelible mark in the history of the city. A definite trend of rural to urban shift of population meant that towns had to grow into cities and cities into large metropolitan areas. The pressure of urbanization was such that a large part of the growth, unfortunately, occurred in an unplanned and haphazard fashion. The result of this urban growth is that we now have bigger cities, largely comprised of incompatible and independent land uses - suffering from inefficiency and isolation.

Over the same period, airports, because of the increased air traffic, have become both functionally and spatially important components in our cities. Although it has been fully realized that the business and commerce sectors of a community are heavily dependent upon air transportation, the proper development of the airport region within the metropolitan framework has remained largely an unsolved problem. The result of this is that airports in the metropolitan areas have developed an improper and incompatible urban growth around them. In other words, the surrounding urban development of the postwar years interferes vastly with their function.

The examples of incompatible functions near the airports are numerous. Amongst the several land-use surveys made, it seems appropriate to include the findings of the one conducted by the Department of Housing and Urban Development of the U.S. Government.[23] This is a

23. E.J. Bulban, "Joint Planning Urged for Large Airports," Aviation Week and Space Technology, April 24, 1967, p. 42.

survey of actual land-use, including building type, occupancy and value in the jet noise exposure areas near New York's J.F. Kennedy International Airport, Chicago's O'Hare and Los Angeles International Airport, as a prelude to similar studies planned for other major and smaller airports across the United States. Initial findings have brought to light the magnitude of the jet noise problem at these three airports. According to this survey there are over 300,000 people living in the critical noise zones of these three airports. Added to this population, there are hundreds of schools and several hospitals existing at undesirable locations.[24] It is necessary to add here that the problem of incompatible development does not exist only at the major airports in the United States. Even smaller airports, according to Dorn C. McGrath,[25] occupy up to 2,000 acres of critically located urban land.[26]

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24. The critical noise zones of Chicago O'Hare Airport, excluding the airport itself, amount to approximately 35 square miles, or three times the size of the airport by 1975. More than 106,000 people were already living in this area in 1960, according to U.S. census.

    Los Angeles International Airport, which has a more uni-directional landing pattern backed to water, still has critical areas amounting to 12 square miles, and the population in this area totals approximately 129,000 with 47,000 dwellings, 33 schools and more than three hospitals.

    The results at New York's Kennedy Airport show that the noise zones include 35,000 dwelling units and 33 public schools according to the same survey.

25. Dorn C. McGrath is Director of the Metropolitan Area Analysis Division of the Department of HUD (U.S.).

26. Bulban, <u>op. cit</u>., p. 42.

C. SPECIAL PROBLEMS OF AIRPORTS

In the previous section of this chapter, it has been demonstrated that airports and the postwar urbanization have grown side by side, but generally with a great degree of incompatibility. In addition to this highly undesirable situation, airports have further serious problems. Some of them which deserve to be mentioned in this thesis are namely the physical size of airports, their access and their public acceptance.

1. Problem of Physical Size of Airports:

Airports, since the war, have enormously multiplied in absolute number in North America. Furthermore, the operational necessities of modern jets have exerted considerable demands for their ever increasing acreages and length of runways. In Canada, this trend of expanding airports is obviously revealed by the fact that there had been hardly any sizeable Canadian airport without a development plan. The physical expansion of airports is necessarily warranted by both the increasing air traffic and the demanding habits of modern jets. The development of the Dulles International Airport can provide an extremely good example. This airport has been designed from the very beginning to satisfy the operational needs of the modern jets. While looking into land transactions, the Federal Aviation Administration (F.A.A.) considered the recommendations of the Doolittle Report, "Airport Land Needs," and estimated that 5,000 acres of land would be sufficient. But in order to make sure that no problems of easements are encountered later, the F.A.A. eventually decided to buy 9,800 acres of land which is approximately 15 square miles. This amount of land is large enough to build a community of 100,000 population at the comfortable density of slightly over 6,000 persons per square mile or approximately ten persons per acre. From the viewpoint of land use planning, it is appropriate time to realize that the existing jet airports and the future ones, simply because of their physical size, are one of the serious problems of the modern age.

2. Problem of Airport Access:

The term airport access is used here to mean the intra-city transportation means between the airport and the different air-traffic generating areas within the city. The airport access of desirable standard has become a serious problem of large North American cities. A good proportion of time gained in the air by the faster jets is lost on the ground. The impact of the inefficient airport access on the growth of aviation and the functioning of cities has been interpreted by different persons in different ways according to the thesis to be supported. Some specialists in the field of air transportation are of the opinion that if nothing is done to improve the travel time and traffic jams on airport access, airlines in North America may lose some of their short-haul business to the competing forms of surface carriers. In connection with jam-ups at some of the major U.S. airports, the former President of the U.S. (L.B. Johnson), stated "today's big aviation problem is not in the air, it is on the ground."[27] A similar line of thinking developed a few years ago at the European Civil Aviation

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27. "Jam-up at Airports - Growing Problem for Travellers," U.S. News & World Report, December 12, 1966, p. 32.

Conference. The Facilitation Commission of the E.C.A.O. made special resolution to draw the attention of city planning and other concerned agencies for the generally poor services of airport access. In view of these facts and the ever increasing volume of air traffic, it is apparent that, unless something drastic is done, congestion of airport access would reach the point of no return.

3. Problem of Integration in the Community:

In addition to the serious problems of physical development, airports are experiencing a great deal of difficulty in being accepted socially by the public. There are obvious signs of gross inability on the part of the public and some civic leaders, to regard airports in the same fashion as they view railroad terminals - that is - as an integral part of the community service and development. The operation of existing airports and the proposed locations of future ones are, often, focuses of severe attack and criticism. The typical example of extremely unfavourable public reaction[28] exists to Governor Rockefeller's proposal to have the fourth regional airport for New York-New Jersey in Suffolk County. Airports, in the present-day world, are getting a very unfair deal: their problems are unnecessarily exaggerated and community benefits are largely overlooked. The continuation of this kind of public attitude will do no good for their proper physical development, and henceforth, airports may remain liabilities rather than assets.

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28. "Monstrous jetport would mean higher taxes, nerve-racking noise and disaster and carnage for the farmlands and resort areas of Eastern Island."

D. ANALYSIS OF THE PROBLEM

The preceding discussion describes how the simultaneous growth of aviation and cities took place and what the end results are. It is easy to conclude that the fast pace of growth (of air traffic and cities), in itself, is the principal cause for expanding airports and growing cities, and hence responsible for the numerous problems in the field of physical planning. Unfortunately, it is not true. The growth in itself is neither good nor bad, the core of the problem lies in the planning process: how the growth was planned through the deliberate efforts, if there were made any. The investigation indicates that the urban development surrounding airports had been largely the result of market forces of the postwar urbanization rather than imagination and foresight of planners. There had been a general lack of understanding as to what an airport is and what its surrounding development should be. This unsolved problem is again with us and forms the vital core of research work of this thesis.

CHAPTER II

AIRCRAFT NOISE AND LAND USE IMPLICATIONS

A. PHYSICAL AND BIOLOGICAL CHARACTERISTICS

1. Noise - Definition, Measurements and Propagation:

As defined in Webster's Dictionary, noise is any sound unwanted by human beings. Regardless of the fact that this definition is general and non-technical, it is relevant and quite adequate while dealing with aircraft noise. While planning for aircraft noise, it is assumed that the noise is unwanted by the population that is exposed to its effects. However, a simple definition of noise falls short of the requirements of a scientific analysis of the problem at hand. Hence, both quantitative and qualitative methods of noise measurements should be applied to assess the total effect of airport noise on the surrounding area.

The quantitative measurements of noise is generally expressed in 'decibels' (abbreviated 'db'). When the pressure of noise (sound waves) is measured in decibels, a reference level is implied; this reference level is a sound pressure of 0.0002 microbar and represents the starting point of the scale of noise referring to zero decibels.[29] The measurement of noise in decibels, therefore, is the measurement of sound pressure

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29. Peterson and Beranels, Handbook of Noise Measurements, General Radio Company, Cambridge, (Mass.), 1953, Chapter II, p. 3.

level (S.P.L.). The rating of noise in decibels strictly represents the total loudness of noise without any consideration to its character, pitch or frequency of the waves. But, while dealing with the aircraft noise, the different frequencies of noise are important because the biological mechanism of human ear is less sensitive to low than medium or high frequency noise.[30] The use of this system which measures only the pressure of sound, is, therefore, not without gross discrepancies when applied to aircraft noise problems.

As an improvement over the system of quantitative measurement of the noise, there exists another system of Perceived Noise Level (PNdb).[31] The PNdb measurement of noise in db also takes into account the factor of human subjective response to noise based upon its frequency or pitch. Since this system recognizes the human disturbance factor, it is often adopted while solving the problems of aircraft noise.

Besides these two systems, there has been developed a more sophisticated method of measuring the total effect of noise which is repeated

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30. Calgary Planning Department, Airport Study - McCall International Airport, Calgary Planning Department, 1965.

31. By and large, the noise measurement by the PNdb system is not much different from S.P.L. ratings in db. In some cases it may be simple to convert the OA-S.P.L. to PNdb and vice-versa. This conversion for aviation purposes can be approximately worked out by the use of the following table:

S.P.L. in Decibels	PNdb in Decibels
Below 85	S.P.L. - 9
86 - 95	S.P.L. - 10
96 - 105	S.P.L. - 11
106 - 110	S.P.L. - 12

Source: Airport Study - McCall International Airport, Calgary Planning Department, p. 4.

quite frequently, such as aircraft landings and take-offs. This method is called Composite Noise Rating (C.N.R.) and the noise level of a particular situation is expressed in C.N.R. rather than db. The following are the necessary components for obtaining C.N.R. measurement of the noise at an airport:

The measurement of the noise expressed in PNdb

The number of occurrences (landings and take-offs per day

The type of aircraft in use

Daytime versus night time operations

Time duration for ground operations

Though the use of PNdb is still common in dealing with airport noise, the adoption of the C.N.R. system is much more desirable because of greatly increasing air traffic at large airports in Canada. The practice of dealing with the individual take-offs or landing operations is no longer adequate since aviation is reaching the point where it is necessary to think in terms of the noise of airport environment which is a function of the total activity of the airport.[32]

The next step while studying noise is its propagation. The propagation of noise is a complex subject and the results can be greatly affected by the meteorological and physical conditions of the environments. The noise in the course of its propagation is reduced by almost any obstacle, both visible and non-visible. These environmental factors, as

32. For detailed procedure of estimating noise in C.N.R. under given conditions of an airport, refer to Appendix I.

applied to the propagation of the jet aircraft noise, have been studied by the F.A.A. and are described below:[33]

a. The absorption of sound occurs due to temperature changes and turbulence of air. If the air temperature varies, sound waves will bend in the direction away from higher temperature. Thus, on a hot summer day, sound waves bend away from the ground.

b. The physical characteristics of the terrain such as hills will affect the absorption and direction during the propagation of sound. Similarly, the presence of obstacles such as buildings, baffles, walls, and densely wooded areas will also cause significant changes in its absorption.

c. In studying the effect of noise from a source to a hearer, distance between the two is the most influential factor. The sound pressure from a simple source, in free space, diminishes according to the inverse distance law. For example, if S.P.L. produced by an aircraft is 110 db, at 1000 feet, it is reduced to 104 db. For each doubling of distance, the sound pressure level is approximately reduced by 6 db.

d. The main characteristics of the jet aircraft noise is that it is highly directional and pressure levels can vary by as much as 25 db at various points in the same radius range from the aircraft.

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33. Federal Aviation Administration, Aircraft Noise Abatement, Federal Aviation Administration, Washington, D.C., 1960, p. 3.

2. Effects of Noise on Human Life:

The effects of noise on human life is a rather broad subject. Investigators, making studies on the effect of noise on human beings, approach the subject with different sets of questions in mind. Some are interested in quantitative study of the effect of absolute Sound Pressure Level (S.P.L.) on the human body, and others seem to emphasize the aspect of human physiological or psychological reaction to noise. Still there exists a third group of investigators who have shown keen interest in studying the effect of noise on the performance of physical or mental work. Whatever the specific or stated objectives of such a study may be, the ultimate goal of all the studies is the same: to catalogue sufficient information which would be helpful in devising ways to reduce, to minimize, or to escape completely the deleterious effects of noise on the human body and human activities.

During the preliminary discussions on the development of the Halifax-New Jet Airport, one aviation specialist has explained the effects of noise with the example of the "Iroquois," the newest engine developed by A.V. Roe. He described that the inventors of the engine discovered during early tests that they had created the world's most powerful engine together with the loudest noise. He added that the noise of the Iroquois when it was test run, could be heard as far away as ten miles. The observers in the immediate area have had reported after-effects of the noise: such as dullness of hearing, nausea, overall aching sensation and deep exhaustion.[34] These effects of noise on human

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34. Halifax County Planning Board, Our New Jet Airport, Preliminary discussion on the future development of the Airport, 1968. (Underlining mine).

beings occurred when the engine under test was reasonably muffled. According to some specialists in the field, if the Iroquois were made to run at full throttle, its noise is sufficient to cause permanent loss of hearing; in fact, some have said it is possible that the noise would kill a man standing one hundred feet away![35]

The noise level of the Iroquois and its effects on human beings are the extremes. It is reasonable to believe that normal jet aircraft operation at our airports will not create such unpleasant conditions. But the longer exposure to noise of even lower intensity (in db) can cause a gradual deterioration of the hearing mechanism and furthermore can affect the performance of duties. In addition to the stated physical effects of high level noise, the signs of psychological effects are also becoming evident. Psychologically, the noise is louder at night, because there is less masking noise generated by the surrounding environment. This masking effect of noise may be difficult to take into account since there are no precise methods of measuring its effect on human activities and sleep. However, Kryter[36] in his article, "Psychological Reactions to Aircraft Noise," has emphasized the point that the allowable aircraft noise during evening hours must be kept ten PNdb less than that during the day, and twenty PNdb less during the hours from one a.m. to seven a.m. to cause equal complaint activity per aircraft operation.[37] For airport

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35. Ibid.

36. K.D. Kryter is the head of the Sensory Sciences Group, Stanford Research Institute, Menlo Park, California.

37. K.D. Kryter, "Psychological Reactions to Aircraft Noise," Science, Vol. 151, March 18, 1966.

planners, this masking effect of aircraft noise seems to be important since a critical acceptable noise during daytime may be quite untolerable during the night hours.

The third set of studies have been made objectively to study the relationship of noise and work efficiency. Numerous laboratory and industrial studies have been made to measure the effect of noise on the performance of physical and mental work. By and large, the results according to Kryter, have shown that noise as such probably has little adverse effect upon the performance provided the work done does not require auditory communication. Kryter seems to be speaking in generalities and has not explicitly described the noise levels he has in his mind. For any noise level that can cause some physical adverse effect on human body and mind, it is very likely that it can affect the efficiency of a worker as well. For preparing physical land use plans, it should be understood that the noise, in addition to its physical effects, does affect the performance of work, and hence a minimum possible number of workers should be exposed to the noise higher than the psychologically acceptable limit.

B. COMMUNITY REACTION AND ACCEPTABLE AIRCRAFT NOISE LEVEL

1. Effects of Noise on Community Life:

One of the most common problems of a modern airport as experienced by the planners is the reaction of jet aircraft noise by the nearby residential communities, as frequently witnessed by individual complaints, and at times organized group actions. The complaints are generally based on the argument that the aircraft noise causes disruption of the normal routine activities in addition to its effect on the physical health of people. It is often stated that the noise causes disturbance to children's naps, loss of rest and night sleep, interruption of telephone calls, familial conversation, and television viewing.

2. Nature of the Community Reaction:

In principle, the community reaction to the aircraft noise is a statistical proposition. Some people will be annoyed and consequently will not tolerate the noise that may be quite acceptable to others. The reason for such a wide range of difference in reaction can be attributed to a variety of the sociological characteristics (such as nature and place of work, attitude towards noise, etc.) of the people concerned. It is difficult, therefore, to determine the full extent of the effects of aircraft noise on the communities exposed to it, and hence a general consensus on the acceptable noise level is impossible to achieve. We shall not, therefore, attempt to establish a universally acceptable aircraft noise level for urban living, but confine ourselves to a discussion of case studies and other scattered facts dealing with the allowable noise level for the communities nearby the airport.

3. Acceptable Noise Level:

London's Heathrow International Airport is one of the world's worst examples of the effects aircraft noise has on nearby communities. In the late 1950's, the Government of Britain established Wilson's Commission to study the effects of the airport noise on the population living in a ten mile radius of the airport.[38] In 1961, the analysis and various recommendations of the Commission were reported to the British Ministry of Aviation. Of all the findings regarding the community reaction to the aircraft noise, two significant points, made by the Wilson Commission, are of relevance to this thesis. First, the Commission discovered that the community concern originates only when an overflying aircraft noise level on the ground exceeds 80 PNdb. This fact is important and may be of some value to further research on the subject, but does not provide a practical answer to the question of acceptable noise level for the nearby communities. The adoption of 80 PNdb as an allowable noise level of aircraft operation while flying over the residential areas, can cause some serious economic and safety problems for the airlines. The emission of jet aircraft noise is a direct function of the thrust power of the engine. The adopted level of 80 PNdb would mean that the thrust power would have to be curtailed enormously which is not possible without endangering the aircraft safety and imposing unreasonable economic sacrifices for the airlines.

The second point is that because of the aforesaid disadvantages in adopting 80 PNdb as an upper limit, and the recommendations of the Wilson's Commission, in 1961 the British Ministry of Aviation adopted for the nearby residential areas, an upper limit of 110 PNdb and 102 PNdb during daytime and night time operations respectively.[39] The legislation

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38. "The Control of Aircraft Noise," Journal of Royal Aeronautical Society, May, 1964, p. 45.

39. Ibid.

of allowable aircraft noise for the residential communities near Heathrow International Airport has proved itself both successful and practical in its objective. For the airlines, only two per cent infringements have been reported which implies that a great number of the aircraft operations must have been well within the noise limits imposed. Furthermore, the number of complaints from the nearby population have sharply declined.[40] A similar nature of studies have also been made in some other parts of the world and necessary regulations of allowable aircraft noise have been imposed.

In North America, the Port of New York Authority, henceforth to be called P.N.Y.A., has taken the pioneer step to solve the problems of the aircraft noise at its regional airports. The results of the comprehensive studies enabled the P.N.Y.A. to legislate that the aircraft noise level in the residential areas adjacent to New York-New Jersey regional airports will not exceed 112 PNdb.[41] The adoption of the noise

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40. The following are the statistics of complaints at London's Heathrow International Airport prior to and after the legislation of the upper limit of aircraft noise:

Year	No. of Complaints	Total No. of Air Transport Movements	Estimated No. of Jet Aircraft Movements
1956	87	109,046	Nil
1957	161	116,101	Nil
1958	350	117,295	Negligible
1959	840	118,809	4,750
1960	1,205	135,468	21,500
1961*	984	146,700	38,000
1962	541	145,500	51,000

*1961 is the year the legislation was enforced.

Source: Ibid.

41. Kryter, Science, op. cit.

level of 112 PNdb, in this case, represents an allowable upper limit beyond which some legal action against the airline and the pilots concerned seems inevitable.

The results of such preventive steps for coping with the problem of aircraft noise are appreciable, but do not provide an ideal solution to the problem. The restrictions of the maximum allowable noise level of 110 PNdb, in the case of London's Airport, and 112 PNdb for the P.N.Y.A. airports, have considerably improved the residential environmental conditions, but much more control on the noise would be required for a complete escape from its nuisance. A further step in this direction is pointed out by Kryter in his works. He seems to believe that thirty to forty or less repetitions of the noise of 100 PNdb would be acceptable to a majority of people concerned.[42] As the number of daily aircraft operations at an airport exceeds forty, a noise level of 100 PNdb would be unacceptable to more than 50 per cent of the population subjected to it, hence, organized community action can be anticipated. It should be carefully noted that the aircraft noise level of 100 PNdb may be quite acceptable in the case of a small airport where the daily operations do not exceed forty, but the same noise at a busy airport where the daily operations are well over this limit, would be quite unsatisfactory. For a busy airport, the adoption of 100 C.N.R. would produce the same results as are produced by the noise limit of 100 PNdb at the small airport.

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42. *Ibid*.

In essence, it is concluded that for the surrounding communities of a small airport, 100 PNdb can be considered an acceptable noise limit. But, as the daily number of operations at an airport exceed forty, then it is necessary to take into consideration the total operations, daytime versus night time flights, and duration of ground noise, in addition to the perceived noise level of the aircraft. This would mean that the airport noise level will be expressed in C.N.R. and the allowable noise level for the nearby communities will be 100 C.N.R.

C. IDENTIFICATION OF AIRCRAFT NOISE ZONES AND THEIR USE

The noise areas of a modern airport can be divided into two major categories; namely 'airport regions' and 'flight paths.' The airport region refers to the airport site itself which comparatively speaking, is subjected to higher noise levels than any other place in the metropolitan area. Noise in this area is created by both the aircraft waiting to land and the ones on taxiways. Apart from these two sources of noise, the noise level of the airport region is sometimes considerably increased by the overhauling of aircraft and the testing of engines in the nearby locations. In view of the effects of the noise on some of the community activities, the physical extent of an airport region can be described as an area of approximately three miles' radius[43] of an airport.

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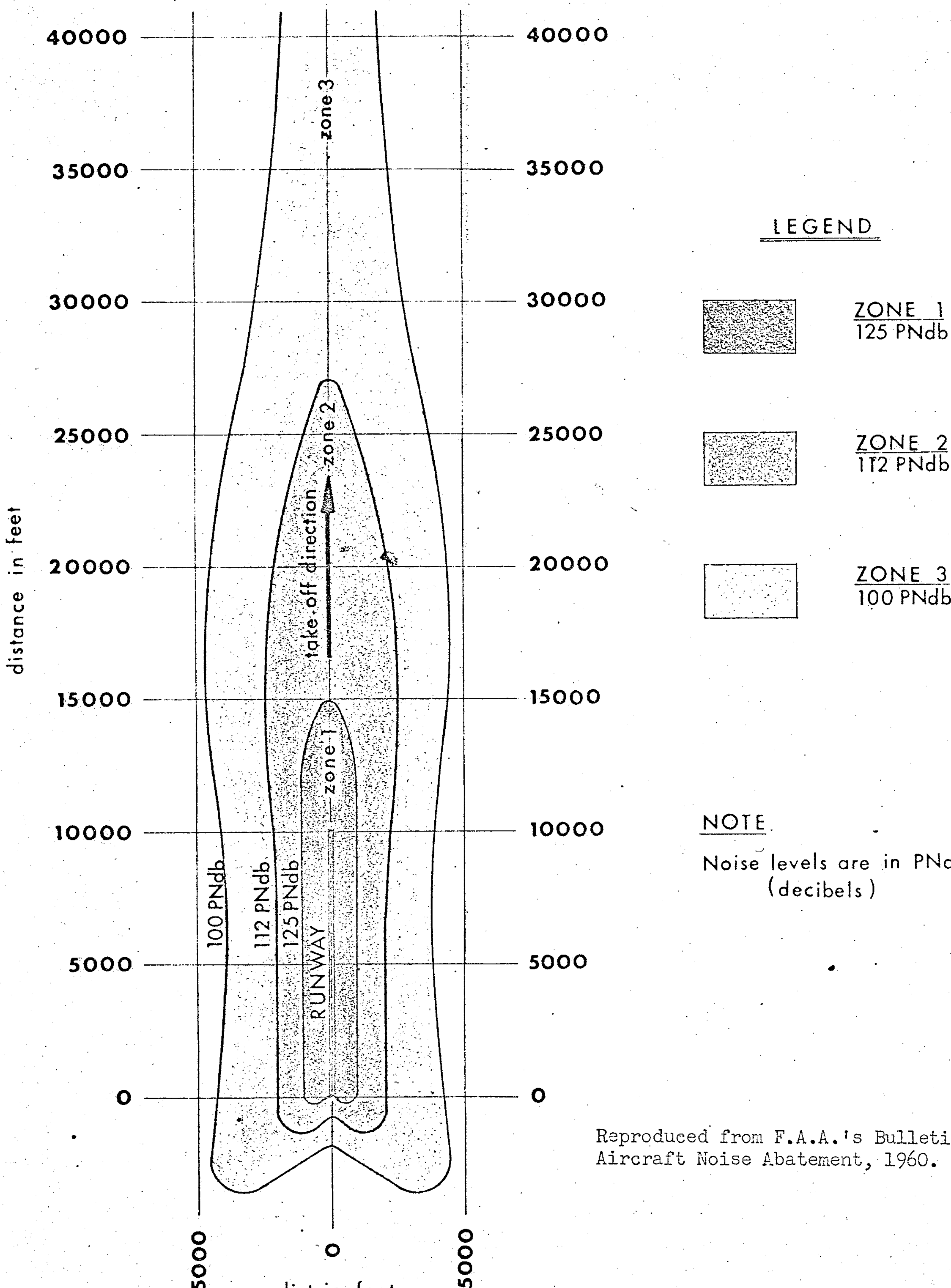
43. (i) Halifax County Planning Board, Our New Jet Airport, op. cit.

(ii) Compatible Land Use Planning on and around Airports, The F.A.A. Publication, Washington, D.C., 1966, p. 8.

Flight paths at the end of each runway of a modern airport represent another set of areas exposed to quite higher noise level, depending upon the position of the hearer. This is the 'approach' or 'climb-out' zone for the incoming and the outgoing aircraft respectively. The noise produced is, of course, dependent on the type of the aircraft engine, weight of the aircraft, the take-off thrust, the glide angle, etc. The immediate problem is to determine the physical extent of this area which is exposed to aircraft noise during a normal aircraft landing or take-off. For this, a much better understanding of the effect of the noise around and at the ends of a runway is possible if noise contours are drawn as a jet aircraft takes off. The noise contours as a Boeing jet aircraft Model 707-120 (247,500 lbs. gross weight) takes off are shown in Figure 1. Of all the jet aircraft presently in use, the decision to use the noise contours of the Boeing 707-120 has been made for the following reasons. First, the airlines all over the world have Boeing 707-120 in their fleet and hence the major airports frequently experience their use. Second, its weight, size and the thrust are such that it can be classified as a big and heavy jet aircraft in service to date. Third, it has been understood by the aircraft manufacturers that the noise characteristics of the Boeing 707-120 are similar to that of the Douglas DC-8 or DC-9 which are the favourite of Canadian airlines. Fourth, in the light of the present-day knowledge about the jumbo jets, it is indicated by the Boeing officials that Boeing 747 jumbo jet aircraft will not be any noisier than the Boeing 707.[44]

44. Boeing 747, A pamphlet put out by the Boeing Airplane Co., 1968.



NOTE

Noise levels are in PNdb (decibels)

Reproduced from F.A.A.'s Bulletin, Aircraft Noise Abatement, 1960.

NOISE CONTOURS, BOEING 707 - 120

Gross Weight 247500 lbs.

Fig. 1

It is evident from Figure 1 that modern jet aircraft operation affects a huge acreage of land around and at the end of a runway. It has been shown earlier in this chapter that 100 PNdb (or 100 C.N.R. for a busy airport) should be regarded as an acceptable noise level for the nearby residential communities. Therefore, it is possible to work out the acreage of land exposed to the noise as the jet aircraft takes off:

Noise Contours	Acreage of Land Affected
Above 125 PNdb	650 acres
112 - 125 PNdb	1,850 acres
100 - 112 PNdb	More than 4,500 acres

For the land under and adjacent to flight paths affected by the operation of the jet aircraft, certain urban functions, which are least affected by the noise, should form the most compatible use. For this purpose, the area exposed to the aircraft noise will be divided into three distinct noise zones, based on the noise ratings:

Zone 1: The area bounded by the contour of 125 PNdb.

Zone 2: The area enclosed between the noise contours of 112 and 125 PNdb.

Zone 3: The area enclosed between the noise contours of 100 and 112 PNdb.

D. COMPATIBLE LAND USES FOR NOISE AFFECTED AREAS

The 'airport region' which is within the terms of reference approximately three miles' radius of the airport, does not provide desirable environmental conditions for living. The reason is the excessive aircraft noise in the area. Therefore, it is suggested that residential and certain institutional uses, such as schools, churches, hospitals, etc. should not be allowed to be located closer than three miles by the airport.[45]

'Flight paths' subjected to unacceptable noise levels often extend beyond the limits of the 'airport region.' Since aircraft noise in flight areas is much higher, it is important that land use should be carefully chosen. The following discussion will attempt to suggest the desirable use of Zone 1, Zone 2, and Zone 3 as given in Figure 1 on page 34:

Zone 1 represents an area of more or less rectangular shape - 1,000 feet lateral on either side and extending approximately a mile beyond the end of the runway - and is exposed to noise ratings of equivalent to, or greater than 125 PNdb. The effect of such a noise on normal human beings and their activities will be no less than just disastrous.[46] The utilization of the area does not present serious problems for municipal planners since a large part of it is generally contained within the boundaries of airport property. Second, at the modern airports,

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45. F.A.A. Publication, Compatible Land Use Planning on and around Airports, op. cit.

46. The noise level of 125 PNdb is termed "disastrous" as can be seen from these examples:

Noise Level	Familiar Reference
80 PNdb	Average speech at 3 ft.
90 PNdb	Noisy Restaurant
100 PNdb	Noisy Factory
112 PNdb	Elevated Train Overhead
125 PNdb	Noisy Boiler Workshop
135 PNdb	Auto Horn at 3 ft.
150 PNdb	Threshold of Painful Sound

Source: Calgary Planning Department, Airport Study - McCall International Airport, op. cit.

the installation of Instrument Landing System (I.L.S.) at the end of a runway requires some of the area as "Clear Zone for I.L.S." The provision of this system leaves approximately 300 acres of Zone 1 which is suitable only for '<u>open land use functions</u>' or some '<u>agricultural uses</u>,' not only because of higher noise, but also higher crash probability and strict building height restrictions imposed by the Department of Transport of Canada.

'Zone 2' represents an area of parabolic shape - about 1,000 feet lateral on either side of Zone 1 and extending about three miles beyond the end of the runway - and is subjected to noise levels ranging between 112 to 125 PNdb. In view of the established acceptable noise for living areas, the location of residential and certain institutional uses (like schools, churches and hospitals), can be highly objectionable and may cause organized community protest against the noise. Even the general commercial and certain industrial functions may find unsatisfactory locations in this zone because of interruption to conversation in cases of inadequate noise-proofing of buildings and the effects of noise on the outdoor activities. Keeping in view the prevailing noise level in the zone, higher crash probability and cost of providing noise-proof buildings, the following can be considered desirable activities in this zone:

a. <u>Agricultural Uses</u>: In a recent F.A.A. report[47] on the use of the aircraft noise affected areas, the following are some of the

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47. <u>Ibid</u>.

agriculture land uses which can be allowed in this zone:

(i) non-grain crop farming
(ii) truck farming
(iii) dairy farming
(iv) stock farming
(v) stockyards

In addition to this list, there are certain other agricultural uses which can also be considered in this zone. The only discredit against them originates from the fact that they can be an attraction for different kinds of birds which present serious hazards to the safety of aircraft.[48] The local planners depending upon the conditions of bird hazard, may be able to locate some of them in this zone. These are:

(i) landscape nurseries
(ii) sod and seed farming
(iii) gardening and tree farming
(iv) grain crop farming
(v) pig farming[49]

Apart from these uses, the location of poultry and mink farms are also sometimes considered desirable functions. But some people involved in the business are of the opinion that poultry crowding caused by the noise may suffocate the chicks and also may affect the production of eggs. Likewise the location of mink farms are also criticized since the noise tends to cause the mink to destroy their young.

b. Golf Courses and Cemeteries: Golf courses and cemeteries are considered compatible uses by a large number of airport planners for

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48. For further details, see Chapter III, "Bird Strikes."

49. Pig farms can become infested with birds if garbage is used as fodder.

three reasons. First, these are open-type uses and present no hazard to the aircraft safety. Second, these are extensive uses and consume large tracts of the noise affected areas. Third, even at the time of peak utility, the density of users (per acre) is very low which is desirable from the aircraft noise and crash probability point of view. Because of these factors, allocation of the noise zone for golf courses and cemeteries should be considered seriously by the planners, while preparing land use plans of the noise areas.

c. Municipal Utilities: The present-day development of the airports and the rapid implementation of the concept "air city" indicates that siting of municipal utilities nearby would be vital. As far as the effects of the aircraft noise is concerned, some of the municipal utilities can be located in the noisy zones - these are water treatment plants and sewage disposal units.

The noise level in 'Zone 3' ranges between 100 to 112 PNdb, thus[50] the area is not desirable for the residential and certain institutional uses. Since in Zone 3 the noise conditions and hazards of crash are much less, therefore all the allowable uses of 'Zone 1' and 'Zone 2' can be considered highly desirable in this zone. Moreover, certain recreational uses not recommended for the Zones 1 and 2 are quite compatible in Zone 3. These are the following:

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50. Refer to Section B, Acceptable Noise Level, p. 28.

(i) City parks and picnic areas
(ii) Riding academies and trails
(iii) Athletic fields and playgrounds
(iv) Swimming pools
(v) Outdoor theatres

In addition to these, the industrial and commercial uses recommended in Chapters IV and V should be considered quite compatible in Zone 3.

CHAPTER III

AIRCRAFT SAFETY AND URBAN GROWTH AROUND AIRPORTS

A. SIGNIFICANCE OF AIRCRAFT ACCIDENTS

1. Losses Through Aircraft Accidents:

A severe challenge to the progress of air transportation exists in the considerable losses[51] which occur through aircraft accidents. Such accidents are costly for the airlines and disastrous for the public. This chapter will attempt to analyze the causes of modern jet aircraft accidents, with special reference to unsafe conditions of physical obstructions which generally prevail, or can prevail, around a major jet airport. It is, then, intended to determine the most compatible use of the airport vicinity in order to achieve desirable safety conditions for the operation of modern jets.[52]

Air transportation has achieved a great degree of sophistication for safe and reliable service to its passengers. This, however, should not lead to the belief that the degree of risk is negligible. The larger and faster jets in service are no doubt more reliable than the old piston-engined airplanes, but whenever mishaps with the jets do

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51. 'Losses' of various kinds are explained on the following page.

52. 'Jet aircraft' hereafter will be referred to as 'jets' in this chapter.

occur, the losses are enormous.[53] Considering the ever increasing use of air transportation, the probabilities of such mishaps in the future which would involve still greater numbers of human lives, are not so difficult to imagine.

Besides the loss of human lives, aircraft accidents cause substantial economic losses to the airlines. It is important to realize that modern jets are expensive and still more expensive will be the products of the future. In the event of wreckage of the aircraft, the cost of human effort alone represents a loss of several man-years of skilled work. Large numbers of such accidents, therefore, can constitute an intolerable economic loss in addition to other consequences such as the unfavourable public attitude towards air travel and withdrawal of financial support for aviation industry. The losses caused by aircraft accidents have never been, nor will they ever be, so small that they can be overlooked. An urgent need, therefore, exists to develop a comprehensive program so as to minimize aircrash hazards. The aircraft manufacturers and the Department of Transport of Canada are doing their best toward achieving a safe air transport system. Hence it is timely that 'City Planning' came forward and made its already overdue contribution. The logical approach here suggests that those causes of aircraft

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53. The loss of human lives in case of mishaps with the jets like Boeing 707 or DC-8 carrying 150-180 passengers is considered significant. A look ahead at the jumbo jets (Boeing 747 or Lockheed L-500) with a carrying capacity of 500-1,000 passengers, crashing over a metropolitan area would be a still more frightening experience.

accidents that may be caused in the remotest by the practices of city-building around airports should be carefully studied and appropriate preventive steps devised.

2. <u>Causes of Aircraft Accidents</u>:

Like other vehicular mishaps, aircraft accidents do not just happen; they are caused by mechanical failures, inadequate navigational aids, bad meteorological conditions, physical obstructions in the flight paths, or negligence on the part of the pilots and crew. The practice of reporting data on aircraft accidents indicates that a description of the type of accident and the cause of the accident are very often synonymous.[54] The type of accident ordinarily is the description of the phase of flight at the time of the crash.[55] Therefore, past statistical records of accidents can give a valuable indication as to the areas where concern and preventive efforts should be focussed. Table 1, page 44 gives the total number of civilian aircraft accidents broken down into standard categories by the Civil Aeronautical Board of the United States for the year 1956.

A closer examination of the table clearly brings out two things: first, most of the accidents which occurred (not necessarily fatal ones) are associated one way or another with the approach or landing phases of the flights. Second, every fourth accident involves some collision -

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54. "Aircraft Accidents and Flight Safety," Human Factors in Jet and Space Travel, ed. S.B. Sells and Charles A. Berry, The Ronald Press, New York, 1961.

55. The exception to this exists in the sabotage cases.

TABLE 1

TYPES OF CIVILIAN AIRCRAFT ACCIDENTS IN THE UNITED STATES (1956)

S. No.	Type of Aircraft Accident	Number of Accidents	Percentage of Total Accidents
1.	Ground loop	578	17.8
2.	Wheels-up landing	148	4.5
3.	Hard landing	206	6.3
4.	Collapse-retract landing gear	109	3.4
5.	Undershoot	219	6.7
6.	Overshoot	181	5.6
7.	Nose up or over	184	5.7
8.	Mid-air collision	16	0.5
9.	Collision with other aircraft	51	1.6
10.	Collision with objects, ground or water	786	24.2
11.	Spin and stall	609	18.7
12.	Fire in air	11	0.4
13.	Airframe failure	32	1.0
14.	Others	122	3.6
	Total	3,252	100.0

with other aircraft, physical objects, ground, or water. It should be noted that since most of the aircraft at the time of mishaps are in their approach or landing phases of flights, airports and physical conditions in their immediate environs are of vital concern to their safety. The past experience with modern jets and their accidents as demonstrated in Table 2, page 46 also strengthens this view. In his statistical study, N.E. Rowe[56] indicates that 47.7 per cent of all jet fatalities have occurred while the jets were approaching or landing at the airports. Rowe has further demonstrated that, of all these approaching or landing mishaps, 85.6 per cent of the fatalities involved collision (high ground, water or obstructions) in the proximity of the airports. Therefore, for the safety of modern air transport services, the airports represent one major area of concern and hence should be tackled first.

B. CONDITIONS OF AIRCRAFT SAFETY AROUND AIRPORTS

The problem of aircraft safety around airports is as old as are airports and aircraft themselves. The factors of aircraft safety have been the fundamental force by which the government realized that growth of aviation is not possible unless its safety becomes a governmental function. Since then, the governmental legislation power has been extensively used to ensure safe conditions of air-space around the airports. One effect of such a governmental involvement in aviation

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56. N.E. Rowe is the Vice-President of the 'de Havilland Aircraft of Canada, Ltd., Downsview, Ontario.

TABLE 2

JET PASSENGER SERVICE FATALITY RECORD[57] (1959-65)

Type of Accident	Fatalities	% of Approach and Landing Fatalities	% of all Jet Fatalities
ON APPROACH:			
Hit level ground/water	230	25.6%	12.2%
Hit high ground/obstruction	539	60.0%	28.6%
ON LANDING:			
Gear failed to extend	-	-	-
Damaged tire caused landing accident	-	-	-
Undershot	-	-	-
Bounce/hard landing and consequent gear failure	-	-	-
Skid/swerve off runway	17	1.9%	0.9%
Scraped pod or tip or hit obstruction during landing run	-	-	-
Gear retracted or collapsed during landing run	41	4.5%	2.2%
Overran			
Crash attempting overshoot	72	8.2%	3.8%
TOTAL FATALITIES:			
Approach and landing accidents	899	100.0%	-
All jet accidents	1,886	-	47.7%

57. N.E. Rowe, "Flight Safety in the New Jet Era," Astronauts and Aeronautics, Sept. 1966, p. 85.

affairs is that a large part of physical planning around the airports is subjected to and hence has to conform to the zoning regulations of the concerned government. Therefore, physical planning around airports is a twofold problem: first, the development should ensure the safety conditions for the aircraft; second, the development should be such that in the event of a mishap, the losses on the ground should be minimum. These two objectives will be the prime considerations for the remaining discussion of this chapter.

1. Danger of Physical Obstructions:

For the safe navigation of the aircraft, abnormally tall structures (such as tall buildings, towers, chimney stocks, etc.) present serious hazardous conditions. Since the modern aircraft can fly high in the sky, the danger of such collisions exists largely on or in the proximity of airports. Governments all over the world have assumed the full responsibility of ensuring adequate conditions of safety around airports. In Canada, such governmental power, according to the Aeronautics Act,[58] has been bestowed upon the Minister of Transport of Canada.

The federal safety regulations as they affect the operation of airports in Canada, concern themselves mainly with the aircraft itself,

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58. "Under the Aeronautics Act, R.S.C. 1952, C.2, S.4 (as amended R.S.C. 1952, C.302) the Minister of Transport may, with the approval of the Governor in Council, make regulations with respect to... (2)(j) the height, use and location of buildings, structures and objects, including objects of natural growth, situated on lands adjacent to or in the vicinity of airports, for purposes relating to navigation of aircraft and use and operation of airports, and including, for such purposes, restricting, regulating or prohibiting the doing of anything or the suffering of anything to be done on any such lands, on the construction or use of any such building, structure or object."

the pilots and crew, and the airport environs. The regulations of the first two elements (of air transport), namely, the aircraft itself and the pilots and crew are very important to the overall safety of aircraft, but in view of the subject of this thesis, they do not fall within its scope. It would be proper, therefore, to emphasize the federal zoning regulations as they exist to control the location of the hazardous physical structures around airports. The implementation of such zoning regulations is the responsibility of the Civil Aviation Branch of the Department of Transport of Canada. In actual practice, these regulations control the location and height of physical structures at all the airports, which may be real or potential hazards for the aircraft. The detailed information of the zoning regulations which condition the urban development adjacent to airports is given in Appendix II.

The federal regulations strictly control the location and height of structures within 13,000 feet or 2.47 miles of the airports.[59] However, such regulations and their proper implementation alone cannot ensure that some day we will achieve absolutely safe aviation conditions and full freedom from the total losses which are likely to occur through the accidents. The possibility of a huge jet airliner crashing over an intensely built-up area in the future and causing tremendous loss on the ground should not be completely ignored. It is true that within the areas of high aircrash probability, the location and height of

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59. Maximum allowable height of buildings in this zone called Horizontal Surface is 150 feet. For further information see Appendix II.

buildings is controlled by the Department of Transport of Canada, but this is not enough to minimize the loss on the ground. The restrictions on higher-value structures and their very intensive use still remain the responsibility of the local planning bodies. It is, therefore, strongly recommended that in the areas where the federal height restrictions are applicable at the airports, the following land uses or functions should generally be discouraged:

a. Higher-value structures should not be allowed.

b. Amongst the open land use types, the ones involving large assemblies (both outdoor and indoor) should be considered highly undesirable.

2. Hazard of Aircraft-Bird Collisions:

In the past, the incidents of aircraft-bird collisions were viewed as only occasional nuisances, simply because the losses involved were negligible. This was the case prior to 1958 when a significant part of the world air transport fleet was made up by piston-driven aircraft. The piston-driven aircraft of those days, also experienced bird strikes, but the resulting damages were so small that they could be ignored. With the present-day fleet having large proportion of the jets, the consequences of aircraft-bird collision are such that birds cannot be regarded any longer occasional nuisance, but have become a real hazard to the safety of air transportation. The basic reason of the serious consequences of bird strikes with the jets lies in their operational and design characteristics. Because of their size and the system of the jet propulsion, the modern jets are much more prone to bird strikes. As compared with the old piston engines, the new turbine engines are more vulnerable to bird ingestion and hence damage to the engine when a bird is sucked in can easily reach $250,000.[60] Furthermore, the jets are faster and are liable to incur much greater physical damage to the plane structure when the collision occurs. All these factors lead to the conclusion that the total loss to the jet aircraft per bird strike is much greater than that to the conventional piston-propelled type.[61]

It is true that no great loss of lives have been reported through bird strikes in Canada. However, in view of the potential hazard, the problem of birds has already been recognized at the federal level. The Deputy Minister of Transport of Canada, in 1962, requested the National Research Council of Canada to study the problem of bird strikes and[62] recommend the possible means of alleviating it. Some preliminary findings and recommendations of the study have been included in the remaining part of this section.

a. Airport Environments and Bird Strikes: Most of the bird strikes occur in the area of airports. This viewpoint has been fully supported by the statistical figures of the reported bird strikes. In a detailed survey undertaken by the International Civil Aviation Organization (I.C.A.O.), it has been discovered that two-thirds of

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60. The Albertan, November 16, 1967.

61. If a jet travelling 600 m.p.h. strikes a four pound eider duck, the effect on the aircraft would be that of a blow from an object weighing 54 tons.
Source: The Albertan, November 16, 1967.

62. W.H. Bird, "Bird Strike Hazard can be Reduced," A paper presented at Fifth Annual National Conference on Environmental Effects on Aircraft and Propulsion Systems, Princeton, (N.J.), September 20-22, 1965.

all the reported bird strikes in the western countries occur at altitudes below 500 feet - approximately within two miles' radius of airports.[63] Second, there is evidence in the data provided by the Canadian Commercial Carriers that 75 to 80 per cent of the strikes have occurred on or in the immediate vicinity of the airports.[64] Third, most of the serious jet-engine ingestions are experienced during the take-offs since suction is directly correlated to the amount of thrust power of the aircraft which is maximum for a take-off. In view of these facts and for solving the problem of bird hazard, airports should be considered the prime area of concern.

Dr. W.H. Drury, Jr.,[65] in his report to the National Research Council of Canada, in 1966, described that certain topographical and vegetative elements of airport areas are a great attraction for various types of birds. The following are the important points relevant to this thesis:

(i) The location of an airport in the metropolitan area often may represent a relatively undisturbed area amidst the noisy urban activities. Lack of human activity between runways and the disturbance of surrounding areas may help loafing birds to congregate at airports.

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63. "Birds Cost $2 Million Damages," The Albertan, November 16, 1967.

64. Ibid.

65. Dr. W.H. Drury, Jr. is the Research Director of Massachusetts Audubon Society, Lincoln, Mass. He reported to the National Research Council the findings of his field trips to the airports at Goose Bay, Labrador and Dorvel.

(ii) The combined effect of physiographic features and dense vegetation areas of an airport which can be described as wetland vegetation (such as open grasslands, forest edge, etc.), is that they provide attractive and sheltered places for birds.

(iii) The third factor for attracting birds to airports is the availability of fresh water and food. Certain species can be attracted by the combination of garbage dumps or corn crops or grass areas and lakes or any other source of water.

Of these, the first two factors provide a set of conditions which are especially favourable to the congregation of the "stationary birds" - pheasants, starlings, blackbirds, and even ducks in some cases. Since this category of birds are attracted by the inherent physiographic features of airports, there is nothing much in actual practice that can be done to get rid of them, except the use of some 'scaring devices' such as shotgun patrols at the airports. Another category of birds known as "semi-locals" such as various gull species, owls, hawks, starlings, etc., are generally attracted to the airports by availability of food and water. These birds generally congregate in large numbers over the food and water areas and therefore present much greater degree of hazard to the aircraft. It is possible to control the congregations of these birds at the airports by eliminating the food and water areas like garbage dumps, grain crops, sloughs and lakes.

b. Land Use Planning For Alleviating Bird Hazards: It has long been the traditional practice to plan open land uses such as natural open spaces, agriculture uses, etc., in the vicinity of an airport. These uses are still considered desirable particularly in the areas where the aircraft noise is nerve-racking, building height restrictions are severe and the crash probability is really high. With the increasing degree of bird hazard to aviation, the desirability of some of them which are attraction for birds, has begun to be questioned. The following are some of the land uses which should be critically examined by the local planners before the final approval is granted:

(i) Natural Areas: The preservation of natural areas near an airport is not desirable if there are large lakes and a particular type of vegetation giving shelter to birds. If food is also available in nearby places, the airport is likely to be infested by all kinds of birds.

(ii) Agricultural Uses: The agricultural uses in the vicinity of an airport are generally recommended for the clear zones and areas of high noise level. For the attraction of birds, it is only the grain crops like wheat, oats and barley which are considered objectionable. Other non-grain crops like rye, alfalfa, etc., should be considered satisfactory.

(iii) Market Gardening and Sod Farming: Any type of market gardening in general and sod farming in particular are not desirable in the airport region, since good loamy soil and manure are an attraction for gulls and other birds.[66]

(iv) Garbage Dumps: Most of the birds congregate at the garbage dump sites and thus become hazards to aircraft if those sites are close to airports. Gulls are the

66. The recent history of the Vancouver International Airport presents an ideal example of congregation of birds because of market gardening. There is evidence the Department of Transport had to cancel the old lease agreement allowing use of the airport vicinity for market gardening because of bird strikes and hazard potential.

species greatly attracted by such sites.[67] W.H. Bird[68] once said that gulls will commute over fifty miles a day to a suitable feeding place. Some officials in the Department of Transport seem to hold the same view when they advised the Calgary Planning Department that sanitary land-fill sites should not be located within a four mile radius of the local airport.[69] In fact, gulls are a serious problem at the Canadian airports and a suitable nation-wide policy should be devised.

(v) Golf Courses and Cemeteries: Golf courses and cemeteries are commonly regarded most compatible land uses in the airport areas except the clear zones or areas of high noise level. As far as the question of bird hazard goes, these uses are satisfactory, but some care should be exercised while landscaping so that no suitable shelters are provided for birds.

Certain activities which are inherently noisy, if encouraged around airports prone to infestation by birds, can considerably help to scare them away. The following are some of the examples:

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67. An outstanding success of the experiment at Fort William, Ontario with gulls has become a case in history. A land-fill site was located only a few hundred yards from one of the airport runways. The danger from gulls became so severe that the use of the runway had to be suspended at some times in a year because thousands of gulls from Lake Superior, about three miles distant, obtained ample food at the dump, then congregated on the runway. The gulls were responsible for an average of six strikes a year. Representation to the City Council resulted an immediate closure of the dump and the opening of another on the shore of the lake. The gulls deserted the airport and there have been no strikes for more than two years.

68. W.H. Bird worked with the Engineering Research and Development Department of Air Canada (Montreal) on the problem of birds in Canada, as a special assignment.

69. Dr. R.D. Harris of the Canadian Wildlife Service mentioned this in his report while visiting the Calgary and Edmonton airports on June 23-24, 1965.

(i) Shooting ranges
(ii) Large machinery testing grounds
(iii) Auto driving areas
(iv) Trucking terminals

However, while allowing such uses, it should be noted that they do not create large assemblies of people especially in the high crash probability areas (clear zones at the ends of runways) so that the number of potential casualties on the ground would be low in case of aircrash.

3. <u>Conditions of Poor Visibility Around Airports</u>:

The polluted air of cities is a relatively new addition to the long list of nuisances of city life. Since the direct effect of polluted air is largely on the public health, the subject is frequently discussed among the public or civic officials, medical personnel, and sometimes by the zoning officials. Airport planners have not, so far, looked carefully to see if the polluted air of metropolitan areas can also create conditions of poor visibility around airports for the incoming and outgoing aircraft. With the present trend of industrial development near airports, unless some selective approach to discourage the smoke emitting industries and other urban functions, such as trash burning, is practised, the polluted air over the airports could create poor visibility conditions for the pilots and hence hazardous to the aircraft safety. It is true that airport environments are also prone to air pollution by the emission of jet exhaust. But, this is something inherent to jet airports and the only hope exists that some day technology will overcome it. As far as the scope of physical planning around airports goes, certain dense smoke emitting urban functions (such as incinerators, trash burning, sometimes burning of crop left-overs) and industrial operations should not be located in the vicinity of airports. For industrial development, it is recommended that the airport areas should only be considered for light industry as defined in zoning by-laws.[70]

4. Other Factors:

The factors of aircraft safety related to the aspects of physical planning have been discussed earlier. But apart from these factors, there are some major decisions on the part of governments or airlines which seem to affect the safety of aircraft to a noticeable extent. It is intended in this section to describe briefly those vital practices which have been popularly adopted in the past and very likely will continue in the future unless they are brought to examination.

a. Hazard of General Aviation Planes:[71] The use of the major airports by general aviation (G.A.) aircraft along with the commercial airliners is an old and popular practice. However, with the development of air transportation and universal patronization of air travel by a large population, it is time to check the validity of this practice. The argument is developed that at a major commercial airport handling domestic and international traffic, G.A.

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70. For further details, see Chapter IV, "Light or Heavy Industry."

71. General Aviation includes operations of trainees flying, recreational and charter flights.

traffic presents a great degree of hazard to the scheduled air-carriers. In order to test the validity of this argument, it would be helpful to go over the points against and for the proposition:

First, at a small commercial airport, it is usually uneconomical and may even be unnecessary in view of the total number of operations to segregate the G.A. traffic and scheduled traffic. This view seems to be logical only in case of a town or small city where to operate two separate airports would be uneconomical and moreover, unnecessary. However, for a large metropolis where there is a question of a second airport, in order to accommodate the present or anticipated traffic volume, this argument seems to carry no weight.

Second, the use of an airport by both G.A. and scheduled traffic, makes it possible to share some of the ground facilities and navigational aids which is, of course, a desirable arrangement. But G.A. planes are small, less powerful and normally of low performance, and hence are far less demanding in terms of their needs for operational facilities. Mr. Pocock, Chief Executive Officer (Boaz-Allen Applied Research, Inc., Chicago) has suggested that even well-prepared sod strips would perform all right as landing and take-off facilities for G.A. planes. It may be argued that even if G.A. planes are far less demanding, the same large facilities primarily designed for scheduled air-carriers, can also be used by G.A. fleet. It was perhaps true during the 1950's and is probably true to a certain extent even today. But, present day air-traffic volume is taking the capacity of the existing airports. In a survey done by the Canadian Aviation, it is indicated that the G.A. fleet is increasing at a rate of around 13 per cent per year.[72] With some degree of approximation, it may be said that scheduled traffic is also growing at a rate of 10 to 13 per cent per year.[73] The G.A. planes can use the facilities, but when they do use them they blank out the capacity for the air-carriers. The result is overcrowded airspace and a greater degree of aircraft accident hazard.

For those who oppose the basic argument in question, the most favourable factor is that certain G.A. services such as air-taxi, charter and other airline-oriented flights cannot be segregated from the place-scheduled flights. These services are most vital at any commercial airport and cannot be removed.

Those who support the argument hold the opinion that G.A. airplanes are of old design and hence, less reliable and ill-equipped insofar as the use of modern safety devices and navigational aids is concerned. In a comprehensive study done on the Canadian G.A. fleet, it has been discovered that compared with the U.S. fleet, the G.A. planes in Canada are poorly equipped in terms of radio equipment[74]

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72. "Survey Probes Civil Aviation Potential," Canadian Aviation, October, 1960.

73. Refer to Chapter I, "Growth of Air Passengers."

74. "Survey Probes Civil Aviation Potential," Canadian Aviation, op. cit.

and other instrumental navigational aids. However, the point may be raised that if the technical design limitations are the prime movers in this respect, the Minister of Transport of Canada could impose the necessary minimal safety equipment standards for G.A. planes before they could use the major busy airports. This alternative, in addition to harassing the companies in this business, would not be a tangible solution since the old fleet below the acceptable standards would have to be accommodated again at the separate airports.

Those who advocate completely separate airport facilities for G.A. planes have obtained tremendous support from the fact that the pilots of G.A. planes are only trainees or persons with little experience in flying. During difficult conditions of flying, they present a serious hazard[75] for large jet aircraft if the airport and air space are shared.

In the present-day trends it is becoming evident that the progressive followers of the belief that G.A. planes are hazardous to the scheduled air-carriers at the major commercial airports, are victorious. Leaving aside the large cities like Toronto, Montreal and Vancouver, the second-rank cities like Winnipeg, Edmonton and Calgary appear to be in favour of the belief. In Winnipeg, a large

75. In a "near-miss collision survey" the F.A.A. discovered that out of the total 554 reported cases during early 1968, 339 occurred within the airport areas. G.A. were held responsible for 251 of the total 339 at the airports.
Source: The Albertan, April 26, 1964.

part of the G.A. activities will immediately move to the St. Andrew Airport as soon as it opens up. In Edmonton, the G.A. traffic already separate from that of the airlines. In a recent study on the expansion of the Calgary International Airport,[76] it was recommended that all the G.A. activities, except the ones highly airline-oriented such as air-taxi and charter services, should be moved to the proposed satellite airport.

In conclusion, it may be added that the operation of G.A. at a growing commercial airport seriously affects the safety of air-carriers and curtails the operational capacity of the airport as a facility. Only certain G.A. activities (such as air-taxi, charter services, etc.) which are necessary for the scheduled passengers should be allowed to operate at the scheduled airports.

b. Noise Abatement Procedures:[77] Amongst the other means of overcoming the problem of jet aircraft noise, the practice of reducing the

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76. It is understood that, although sufficient land is available adjacent to the existing hangars for future expansion of general aviation facilities, further expansion of general aviation activities are advised at the satellite airport. It was further urged that local flying could be moved to the satellite airport in the first phase of its development. As the general aviation facilities expand at the satellite airport, a greater portion of all general aviation activities can be induced to move from the International Airport. Only the ones which are airline-oriented such as air-taxi and charter services may be expected to remain at the International Airport.

77. Noise Abatement Procedures is generally known as N.A.P. by the pilots and crew.

take-off thrust while aircraft flies over the residential areas is becoming quite common. Although this method is not so popular in Canada, it is widely used in the United States and some other parts of the world. In the cases of serious community protest against the noise of overflying aircraft, the airlines are subjected to governmental pressure for advising their pilots to use N.A.P. while taking off over the inhabited areas. Amongst several examples, it would be helpful to go over the typical announcement by a captain to the passengers:

> "Shortly after take-off you will notice a marked decrease in engine noise, due to a reduction in power. This is perfectly normal and is done as a courtesy to those who live near the airport and in the direct flight path." [78]

This is the sort of announcement which aircrews would like least under any normal or difficult weather conditions. The reduction of power thrust is neither normal nor desirable. This is imposed on the airline pilots as a sort of public relations gesture which involves a great risk to the safety of the aircraft and human life. At the most critical point of take-off when the best engine power is required, the pilots are compelled to throttle back drastically. After flying over the prescribed areas at low altitude and lower speed, the pilots again have to regain the full power for the steeper climb and thus deliberately shower the maximum possible noise all over the city areas. For the safety of aircraft and human lives

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78. Arthur Hailey, Airport, New York: Bantam Books, Inc., Madison Avenue, 1969, p. 271.

involved, the use of N.A.P. is a highly dangerous practice; hence some other alternative should be adhered to.

c. Interference to Flight Information: The reception of weather reports and flight information by pilots is vital to the safety of aircraft. Some people argue that the reception by aircraft of certain signals from commercial and amateur radio stations, T.V. towers, medical diathermy, industrial heating equipment and certain electrical firms can interfere with aircraft safety. In the historical records of aircraft accidents, there is to date no realistic evidence of such hazards to aviation. One reason for this is that the communication equipment on modern aircraft have adequate selectivity and thus can overcome any minor interference. For the powerful radio or T.V. stations, however, the Department of Transport endeavours to avoid making frequency assignments which might result in interference to aircraft's communication with the ground stations.

C. COMPATIBLE LAND USES

In Canada, the function of aircraft safety is the responsibility of the federal government. The existing federal zoning regulations restrict the height of structures to 150 feet within 2.47 miles radius of an airport. Also, the location and height of structures is much more severely controlled under the flight paths where the degree of aircrash probability is quite higher. These days, aircraft accidents are not caused by the hazardous structures but rather by some other environmental factors such as G.A. planes, use of the noise abating procedures and possibly electro-magnetic interference to internal and external flight information. Since these environmental factors are quite extensive and identical at all the Canadian airports, their comprehensive study and their necessary preventive policies are the responsibility of the federal government.

This is not to suggest that local governments and their planners have to stand idly by. The safety of aircraft is also affected by some environmental factors beyond federal control such as bird strikes and poor visibility conditions around airports. Since the planners are concerned not only with the aircraft safety but also they have to minimize the losses on the ground in case of a aircrash. Therefore, location of the uses involving large assemblies of people should generally be discouraged around airports. These uses are:

(i) Open-air theatres
(ii) Playfields (spectators use)
(iii) Parks

The hazard of bird strikes is largely caused by some of the open-type or agricultural land uses around airports. These uses are:

(i) Grain crops like wheat, oat, barley etc.
(ii) Nurseries, sod and tree farming
(iii) Pig farming (when garbage is used as fodder)
(iv) Sanitary land-fill sites

Certain activities which do not cause large assemblies of people, but are inherently noisy if encouraged near airports prone to infestation by birds, can considerably help to scare them away. These are:

(i) Outdoor shooting ranges
(ii) Large machinery testing grounds
(iii) Auto driving areas
(iv) Trucking terminals
(v) Auto dumps

The conditions of poor visibility around airports are generally caused by the smoke emitting industries and some other urban functions such as incinerators, trash burning and sometimes burning of stubble. Therefore, the airport vicinity could generally be considered suitable for light industry only.

CHAPTER IV

POTENTIALS OF INDUSTRIAL DEVELOPMENT IN THE VICINITY OF AIRPORTS - WITH SPECIAL EMPHASIS ON AIR-FREIGHT ORIENTED INDUSTRIES

A. AIRPORTS AND INDUSTRIAL LOCATION

1. General Significance of the Phenomenon:

Until the late 1950's most of the industrial location experts were not attracted by airports while looking for industrial sites. On the contrary, some of them preferred to consider the other potential sites than the vicinity of airports. The possible reason can be that the airports of those days simply did not offer any special locational advantages to industry. But, since then airports have developed a strong 'magnetic force' for industrial locations. The magnetic pull as such, is a relatively new phenomenon, but has been quickly recognized. Leigh Fisher[79], a famous Airport Consultant of California, has invariably pointed out in his works that a modern airport is a causal factor and should be utilized to direct, to guide and to focus industrial growth.

The findings of another recent study[80] made to determine the impact of major airports on the real estate business, also support the hypothesis

79. Leigh Fisher has been extensively involved in the development plans of several airports of the U.S. He has made valuable contribution to the subject of "airport planning" through his speeches at various conferences, and by his articles in the journals related to the field of city planning. For the Urban Land Institute he wrote series of comprehensive articles in Vol. 21, No. 9, October 1962, and Vol. 25, No. 2, February 1966.

80. Reference to this study has been made in Planning the Airport Industrial Park, F.A.A. Publication, A C 150/5070-3, p. 2.

that modern airports have become increasingly attractive to industry. The study, in its scope, considered the trend of industrial development at the three major U.S. airports, namely New York International, Chicago O'Hare and San Francisco International Airports. The author of this study, H.O. Walther, specifically stated that the Center Industrial District, located in the vicinity of the Chicago O'Hare International Airport, is one of the most active and vigorous industrial developments in the whole metropolitan area of Chicago. Furthermore, it should be carefully noted that the reason for such a rapid growth of the district, according to H.O. Walther, is largely attributed to its proximity to the airport. It would be unfair not to point out that scope of Walther's study was rather restricted to the extremely large airports of the United States. It is, however, becoming evident that even smaller or moderate size airports exert a considerable influence on the pattern of industrial growth of the communities they serve. The airports of the second rank Canadian cities such as Calgary, Winnipeg, Halifax, etc., are in the process of attracting large scale industrial development.

The fact that the proximity of the modern airports provide attractive locations for a variety of industrial uses has been properly recognized by most of the land development agencies. Indeed, some industrial realtors seem to think that airports may have as great impact on the pattern of future industrial growth as suburban shopping centres have had on the physical allocation of retail activity.[81] At this moment,

81. "Airports Attract Industry," Urban Land, Vol. 21, No. 9, October 1962.

the reader may wonder, after all what are the reasons behind such predictions of industrial realtors? The reasons for such gravitational force of airports are mainly attributed to the physical environments of the airports (including airport accessibility) and the availability of air services which are great attraction to the modern industry. Robert Boyle in his article for the Urban Land Institute has outlined six factors of airport sites which seem to be responsible for attracting industry.[82]

a. High quality highway access provided to serve the airport can also be used by the nearby industrial development.

b. Large amounts of open or undeveloped land around airports can fulfill the space requirements of modern horizontal type industrial growth

c. Relatively flat terrain of airport areas provide attractive sites for large scale industrial development plans.

d. Utilities installed to serve the airports can also serve the adjacent industries.

e. Readily available air service is an additional benefit which may be a necessity for certain industries dependent upon air freight.

f. The locations in the proximity of an airport generally carry the image of higher architectural standard and social prestige.

2. Heavy or Light Industry:

The foregoing discussion has concluded that the proximity of airports for physical development lend themselves to industrial growth.

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82. "Industrial Districts - Principles in Practice," Urban Land, Technical Bulletin 41.

This conclusion is rather general and raises two fundamental questions. Does any type of industry form compatible use with airports? If not, what kind of industry should be planned so that there is minimal conflict between the two uses? Not only that these questions are important from the reader's point of view, but they are more important for applying 'planning' approach to the problem. Theoretically speaking, 'planning' is optimizing a situation; the most relevant question seeking answer, then, would be: what kind of industry is most desirable or undesirable near airports in order to optimize the results of the gravitational pull between airport and industry. In order to answer this question, the hypothesis is put forward that heavy industry[83] generally does not form desirable use of land in the vicinity of airports. Conversely, the location of light industry adjacent to airports would be a most desirable choice.

First, the basic argument in favour of the hypothesis, hinges on the inherent characteristics (such as smoke, dust, odour, etc.) of heavy industry which are essentially unwanted elements insofar as the requisites of an airport environment are clean and clear atmospheric conditions in order to provide the best visibility conditions for the pilots in the air. The operation of heavy industry is basically a major source of air pollution in a metropolitan area. When located near airports, it would create air pollution conditions which are hazardous for navigation of

83. In its definition "heavy industry" includes those manufacturing and processing industries which produce dense smoke, dust or odour and hence affect the surrounding uses. Heavy industry as discussed in this thesis conforms in principles to the contemporary Zoning By-laws of a city.

incoming and outgoing aircraft.

Second, certain air-passenger facilities such as hotels, motels and amusement places, and air freight offices near airports are vital for any airport to be functionally effective. Because of higher architectural standard of such facilities, the commercial areas in the vicinity of airports generally carry the image of social prestige. It is necessary that this image of the airport area should be maintained for attracting new investment and developer's initiative. From this viewpoint, the location of heavy industry in the proximity areas of the airports can be a great obstacle in their growth as viable organisms.

It is, therefore, suggested that the location of any type of heavy industry even if it is dependent upon air transportation which is generally not the case, should be discouraged in the vicinity of airports. It is natural that the reader will conclude that airport sites are generally suitable for a variety of light industrial uses. In principles, this conclusion is valid throughout. At the same time, it is necessary to point out that airport sites have much greater degree of attraction for certain type of light industries than others. These are the industries which heavily depend upon air freight for their day to day activities. The function of an airport as a transportation facility is vital for them and, therefore, the ideal situation of industrial growth around airport emerges when airport and light industry relate to each other through the operation of air-freight. For this reason the discussion in the next section will deal with the air-freight oriented light industries.

B. AIR-FREIGHT

1. Definition and its Characteristics:

Generally the term 'air-freight' like rail or road freight refers to the movement of all the goods except air mail or air express and passenger baggage by air transportation.[84] The operation of air-freight is not identical to the movement of air-passengers but displays certain characteristics of its own, as discussed below:

a. Unlike air-passenger traffic, air-freight normally represents a unidirectional movement of goods. The recognization of this characteristic for scheduled air-freight service is more important for a country-like Canada where the west and east bound total air-freight shipments are in the ratio of 70:30.[85]

b. The air-freight customers are usually of two kinds: big buyers who may not necessarily be frequent users, and small buyers who are necessarily frequent users. For the airlines, the services to the individual users of air-freight as compared to that of individual air-passengers are therefore of much more economic significance.

With this brief introduction of air-freight as a mode of transportation, it would be appropriate to discuss the specific advantages/disadvantages of air-freight and the nature of commodities more frequently shipped by air.

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84. A.E. Richards, The Role of Aviation in the Domestic Freight Transportation System of the United States, Montreal: McGill University, 1963. Ph.D. Thesis, Department of Economics & Political Science.

85. Morton Stern, "Air Freight Takes Off," Canadian Business, Vol. 40, No. 6, June 1967, p. 72.

2. Advantages and Disadvantages over Surface Transportation:

The decision of a shipper who has the choice of using air-freight or conventional means of surface transportation, in favour of using air services, depends upon the advantages of benefits offered by air-freight as a means of transport. There are two main advantages of air-freight over the competitive surface carriers:

a. Speedy Delivery: The main advantage of transporting goods by air transportation rather than by surface transportation is speedy delivery, which means saving of time in completing transactions. These days it is possible to provide regular overnight domestic and international air-freight service. For a country like Canada, travel time is an important element in the movement of people and goods. By rail or truck, goods in transit from Montreal or Toronto to Vancouver can easily take up to six days; whereas by air-freight the same trip can be made overnight. At present there is a regular freight service (Air Canada) on this route. The goods ordered from Vancouver by teletype or telephone can be delivered the next day although the distance involved is over 3,000 miles. This advantage of air-freight service is extensively exploited in the modern economies of the world. In fact, air-freight is viewed not only as a fast means of transport but also a new marketing tool for exploiting the distant markets which are beyond the reach of surface carriers.

b. Protection of Goods: Air-freight service provides greater protection[86] against physical damage and theft for the goods in transit. This

86. Because of more sophisticated methods of handling the goods and comparatively shorter transit time, there are much less chances of theft.

nature of protection is essential for certain goods, which are easily liable to physical damage, and affects the decisions of con cerned shippers in favour of air-freight. The use of air services in such cases, not only makes possible the quick and safe delivery of the goods, but also considerable savings in packing, crating, replacement and high insurance which are necessary for surface transport, are realized. These savings, sometimes, offset the costs of air services to a significant extent.

After discussing the major advantages of air-freight service, it seems necessary to go over its vivid disadvantages against the use of surface transportation. The major disadvantage of air-freight service to a shipper is relatively higher cost of transportation. As already pointed out in Chapter I, the cost of shipment by air generally ranges between four to seven times the rates charged by surface carriers on the similar articles. In addition to higher costs, there are severe restrictions on the size of unit freight, imposed by the physical design of cargo space in the aircraft. At times, some shippers complain of infrequent and irregular air-freight services at small airports. If the air-freight rates are reduced to be comparable with that of surface carriers, the minor complaints about the services would readily disappear. The large volumes of shipment that would then be generated (because of comparable rates) would make it possible to use the suitable type of air freighters and provide satisfactory and regular services.

C. USE OF AIR-FREIGHT SERVICE

The use of air-freight service for the movement of goods can be discussed in two broad categories. First, the use of air transportation is essential for certain commodities which are not preferred to be moved by surface carriers for several reasons, such as danger of damage, spoilage, etc. Second, in certain situations of the modern business and economics, air-freight, being the fastest means, is the only desirable mode of transport.

1. Nature of Air-Freight Commodities:

a. High Value per Unite Weight: Generally speaking, the majority of the commodities of high value per unit of weight are always shipped by air. In such cases, the transportation costs represent a negligible proportion of the total value. By using air-freight service, the high priced commodities are protected from physical damage and the probability of theft is considerably reduced since the transit time is comparatively short. Some of the examples of commodities belonging to this category are gold, jewelry, precious metals, optical and scientific instruments, watches, certain drugs, etc.

b. Perishable Commodities: Several perishable commodities deteriorate because of the normal transit time of surface carriers and hence are moved by air-freight. The various perishables commonly moved by air are fruits, vegetables, flowers, fish, live animals, baby chicks, etc. In addition to these items, the current trend is to ship by air newspapers, periodicals, newsreels, press reports and sometimes business and technical documents.

2. Business Situations of Air-Freight Use:

a. Conditions of Urgent Delivery: The faster pace of modern life and heavy inter-dependence of urban business frequently require the services of the fastest mode of transport for urgent delivery. And the only answer available to date is 'air-freight.' The situations of urgent delivery are caused by sudden breakdown of machinery, emergency relief supplies and drugs or medical equipment. The urgently required items, in fact, make a considerable proportion of the total domestic as well as international volumes of air freight.

b. Supplies for Remote Areas: The use of air freight service is also popular for moving commodities of almost any sort for the remote areas being explored, where surface transportation is exceedingly slow or very expensive or unreliable or impossible.

3. Major Air-Freight Commodities:

The subject of air-freight business in Canada and its growth in the postwar years have been discussed in details in Chapter I. Thus far, it has been proven that the air-freight volume over the last decade had multiplied itself several-fold. The knowledge of this overall increase is of course, necessary, but may not satisfy those who are interested in details of commodities that make up the freight volume. The unfortunate thing about it is that this information is simply not available in such detail. If an experienced air-freight salesman or manager is questioned, "What are the commodities shipped by air-freight these days?" The frequent and typical answer received is, "almost everything." Since the precise information of air-freight commodities is not easily available, the scope of this investigation will limit to those commodities that are shipped frequently in large volumes.

Table 3, page 76, represents the list of the top ranking ten commodities (in terms of volume-ton miles) moved by Air Canada during the years 1956 and 1966. The higher ranking commodities are the ones that are shipped either (a) frequently, or (b) in large volume, or (c) for longer distance. Since the distance factor is generally the same for most of the commodities, the top ranking commodities indicated in the table are the frequent and big buyers of air-freight service. This is probably the reason that universally regarded high valued goods such as gold, jewels, diamonds, etc. are not found in the table. These goods are still transported by air, but their volume and frequency of shipment is comparatively low and hence do not qualify for the top ten commodities. The table also indicates that over the period of 1956 to 1966, the basic hierarchy of the air-freight commodities has not undergone any major changes, nevertheless the following conclusive points are of some relevance to this thesis:

a. A bulk of the air-freight commodities is made up by 'machinery spare parts and related equipment.' It is conceivable that the use of air-freight service for such commodities is necessitated by the

TABLE 3

TOP RANKING AIR FREIGHT COMMODITIES MOVED BY AIR CANADA IN 1956 AND 1966[87]
(VOLUME-TON MILES)

No.	1956	1966	No.
1.	Machinery parts and equipment	Machinery parts and equipment	1
2.	Auto parts and accessories	Cut flowers	2
3.	Wearing apparel	Electrical products	3
4.	Printed matter	Wearing apparel	4
5	Electrical products	Printed matter	5
6	Fresh fruit, vegetables and berries	Auto parts and accessories	6
7	Cut flowers	Aircraft parts	7
8	Magazines and books	General hardware	8
9	General hardware	Advertising display matter	9
10	Metal products	Photographic films	10

87. Morton Stern, op. cit., p. 72.

situations of urgent deliveries during the times of sudden breakdown of machines. A significant part of air-freight shipment is, therefore, a function of wholesale business at both the exporting and importing centres.

b. The shipment by air freight of 'perishable commodities' which deteriorate in transit seems to be the trend of the present. It is likely that this trend may continue in the future since air-freight is regarded a valuable market tool for expanding markets of perishable goods.

4. Air-Freight Oriented Industries:

The knowledge of air-freight oriented industries - be those manufacturing plants, wholesale businesses or assembly workshops - can be extremely useful for airport planners in preparing the physical development plans of airport areas. This viewpoint has been largely agreed upon by people in business and planning fields. But the unfortunate thing is that there has not been enough relevant information available on the subject so that the next step of devising a way of implementing such a plan should be seriously considered. This is a subject of considerable interest and some governmental agencies like the F.A.A. in the U.S. and some private corporations and cities have started to catalogue the industries oriented towards air transportation. Amongst the cities, the efforts of the city of Houston (Texas) to develop the industrial potential of its airport are of great relevance and hence worth mentioning. The city of Houston had sought the services of private consulting firms or preparing the comprehensive plan for its local[88] International Airport. During the preparation of this plan, visits were made to eight other airports in the U.S., which have active plans for industrial development at their airports. And, some twenty-six other airports and related agencies were contacted to obtain the necessary and up-to-date relevant information. With the help of the preceding discussion and enormous co-operation of the Air Canada freight office in Winnipeg,[89] a collection of the air-freight oriented industries is given below:

a. Electronics:

(i) Tubes and component parts
(ii) Electronic instruments
(iii) Computing machines
(iv) Controls
(v) General management or regional sales offices

b. Machinery Parts and Equipment:

(i) Small and heavy oil field tools and equipment
(ii) Well logging instruments
(iii) Pipeline replacement parts
(iv) General machinery parts
(v) Agriculture machinery parts
(vi) Metal fabrication parts

c. Auto Parts and Accessories:

(i) Wholesale shipments of auto parts and accessories

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88. The comprehensive plan is entitle: Plan of Development Land Use, Houston International Airport, Vol. III, Engineers of the Southwest, Lockwood, Andrews & Newman, Inc., Turner & Collie Consulting Engineers, Inc. and Bovay Engineers, Inc., December 1965.

89. The list of air-freight oriented industries of Winnipeg is contained by Appendix II.

d. <u>Pharmaceuticals and Supplies:</u>

(i) Patent medicines
(ii) Prescription formulations
(iii) Medical and dental supplies

e. <u>Electrical Products:</u>

(i) Electrical instruments and equipment
(ii) Household appliances
(iii) Switchgear

f. <u>Chemicals, Rubber and Plastics:</u>

(i) Chemicals - samples
(ii) Plastic - bulk
(iii) Rubber and miscellaneous plastic products

g. <u>Garments, Fabrics and Mercantile Supply:</u>

(i) Cotton - samples
(ii) High fashion garments
(iii) Individual mail orders

h. <u>Perishable Products:</u>

(i) Fruits and vegetables
(ii) Cut flowers and plants
(iii) Manufactured and processed foods

D. COMPATIBLE LAND USES

Airport sites offer special locational advantages to modern industry. It is recommended that heavy industry within the terms of reference, should not be allowed in the proximity areas of an airport. A wide variety of light industrial operations are quite compatible with the function of airports, therefore, the vicinity of an airport should be utilized for locating light industry.

Whereas light industry is generally a compatible use with airports, certain type of light industries, which are heavily dependent upon air-freight service for their day to day operation, are most desirous to locate in the proximity areas of the airport. These air-freight oriented industries can be manufacturing operations, warehouses for wholesale business and assembly workshops which use air transportation for getting their parts from other urban centres. While developing airport sites, air-freight oriented industries should be given preference. This can be done through the use of a special 'zoning' category such as 'airport industrial park.'

CHAPTER V

LOCATION OF AIR PASSENGERS' FACILITIES IN AIRPORT VICINITY

A. CHARACTERISTICS OF MODERN AIR TRAVEL

1. Generation of Air Travel:

Air travel generated in a city or region is a function of several local factors such as economic base conditions, socio-economic characteristics of its inhabitants and geographic relationship to other trade centres or regions.[90] Besides these local characteristics, the other factors, which greatly influence the volume of inter-city air traffic, are the overall corporate structures of large production companies (head offices, branches, etc.) and the integrative arrangement of delivery of goods in the national and regional markets. In this chapter, the characteristics of air travellers are intended to be studied in greater details. In order to fulfill the needs of air travellers it is considered necessary to analyze the purpose of travel and to study the characteristics of air passengers (with particular reference to their being airport users). From the viewpoint of physical planning, it is ultimately intended to study the possibility of locating air passenger oriented facilities in the vicinity of airports so as to build airports as viable organisms.

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90. The exception to this exists for specialized, single purpose centres, for example capital cities, university cities, resort towns, etc.

2. The Survey of Air Travellers:

Since most of the information concerning the characteristics of air travellers can be supplied readily by the passengers themselves, it would be wise to refer to the past surveys conducted for this purpose. In North America, The P.N.Y.A. was perhaps the first agency since the war to undertake an extensive and comprehensive survey of the air travellers of the New York-New Jersey region.[91] The example of this survey and its findings will be elaborated on in the following pages because of the following three reasons:

a. The New York-New Jersey region produces air traffic that is extensively diversified in terms of purpose of air trips. Hence, this survey is quite comprehensive for the composition and characteristics of air travellers.

b. During this survey, there were 194,000 passengers interviewed in a short period. The findings of this survey, therefore, represent the results of a large scale investigation.

c. In Canada there have been no such surveys conducted to date which can serve the purpose. However, the Marketing Research Branch of Air Canada intends to conduct such a nation-wide study this year, but the results would be available only sometime next year.[92]

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91. The P.N.Y.A., Aviation Department and Analysis Division, New York's Air Travellers, The Eno Foundations for Highway Traffic Control, Sangatuck, Connecticut, 1956.

92. Personal letter received from the Public Relations Department of Air Canada, 39th Floor, Place Ville Marie, Montreal 2, March 25, 1969.

The "New York's Air Travellers" survey was conducted as a joint undertaking by the domestic airlines serving La Guardia, J.F. Kennedy International, and the Newark Airports and the P.N.Y.A. Since it was considered a difficult and impractical task to study the characteristics of all the passengers who pass through the airports of the Port Authority, it was decided in the summer of 1954 to conduct a sample survey of passengers departing from the three airports for domestic destinations.

The findings of this survey as to the purposes of air trips indicated by the air passengers are given in Table 4, page 84. It is evident that 60 per cent of them travelled for 'business purposes' while the remaining 40 per cent made the trips for 'personal reasons.' Of the business passengers, 65 per cent belonged to manufacturing; 25 per cent indicated their businesses as 'wholesale concerns.' The third and fourth ranking businesses were 'entertainment' and 'insurance, finance, and real estate' respectively. In the second category of personal air traffic, the people travelling for vacation, holidays and leave accounted for 25 per cent of the total number of passengers (194,000). Since the survey was conducted during the summer time when a large number of people are on holidays, it is possible that this percentage of 25 is slightly higher than the annual average.

3. <u>Social Characteristics of Air Travellers</u>:

The "New York's Air Travellers" survey has also collected some relevant information of the socio-economic conditions of the air passengers departing from their airports. This information mainly deals with their

TABLE 4

CATEGORIES OF AIR PASSENGERS[93]

Purpose of Trip	% of Passengers	No. of Passengers
ALL PURPOSES	100%	194,100
A. Business	60%	115,400
1. Manufacturing	39%	75,700
2. Wholesale	15%	27,115
3. Others	6%	11,645
B. Personal - Total	39%	76,900
1. Vacation, Holiday Leave	25%	48,200
2. To or from School	3%	6,400
3. Personal Surveying	3%	5,500
4. Others	5%	10,100
C. Business & Personal	1%	1,800

93. P.N.Y.A. New York's Air Travellers, op. cit.

social characteristics such as age and sex, family income and occupation and is contained by the following tables in the same order.

The results of the survey clearly point out that the generation of air traffic is a direction function of the reported family income. (Table 5, page 86.) Another important finding of the survey is that the frequency of air travel is also largely dependent upon the family income. Of all the respondents, the average number of air trips reported for the last twelve months were 19.4. For those having a family income over $20,000, the average number of trips during the last twelve months were 35.8. The lower income group, for example under $6,000, reported the average number of trips as 5.2 in the last year. This relationship between family income and frequency of air travel can serve a useful function in forecasting air traffic for the given socio-economic conditions of a community.

Table 6, page 87, relates to the occupation of the respondents of the survey. Of all the air passengers interviewed, the 'professional group' accounted for 30 per cent of the total passengers and 80 per cent of them stated that they were on business trips. Next to professionals, 'manager-official' category represented 28 per cent of the total passengers and 85 per cent of them were on business trips. The third position was filled by 'salesmen' representing 9 per cent of the total passengers and 90 per cent of them travelled for business purposes. These three occupational groups stand for over 90 per cent of the total passengers who travel for business reasons. The air traffic volume representing passengers on personal trips generally emerge from housewives, secretaries,

TABLE 5

FAMILY INCOME OF PASSENGERS AND FREQUENCY OF AIR TRAVEL [94]

Family Income	No. of Passengers	Percentage of Passengers	Average No. of trips in last 12 mo.
	194,100	100	19.4
Under $3,000	7,700	4	3.9
$3,000-$5,999	27,900	14	6.6
$6,000-$9,999	43,300	22	14.8
$10,000-$19,999	55,800	29	22.8
$20,000 & Over	40,300	21	35.8
Unknown Income	19,100	10	10.0

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94. *Ibid.*, p. 50.

TABLE 6

OCCUPATION OF PASSENGERS[95]

Occupation	No. of Passengers	Percentage of Passengers	Purpose of Trip	
			Business	Personal
	194,100	100	60	40
Professionals (Technical)	58,000	30	24	6
Managers, Officials	53,600	28	24	4
Salesmen	17,700	9	8	1
Secretaries, Clerks	9,700	5	1	4
Mechanics, Draftsmen Factory Workers	4,500	2		
Housewives	23,700	12		
Students	9,700	5		
Armed Forces	9,700	5		
Retired	2,300	1		
Others	6,200	3		

95. *Ibid.*, p. 53.

clerks, students, factory workers, armed forces and retired people.

B. PASSENGER FACILITIES ADJACENT TO AIRPORTS

The findings of the "New York's Air Travellers" survey bring about an important point that air traffic generated by a city or region splits clearly into two categories - 'business' and 'personal.' The business travellers are much more sensitive to the quality and frequency of air service, and relatively much less sensitive to cost of air travel. For the departing business travellers, the travelling time from the point of origin (home or office) to the point of destination (in the other city) is of considerable importance and hence a critical factor to their satisfaction. Whenever the journey to and from the airports consumes a good proportion of total trip time, it becomes untolerable and a source of dissatisfaction for business air travellers. This is the case of cities where either the airports are quite far away from the business centres or the ground transportation means to the airports are exceedingly inefficient, unreliable and slow.

The growth of air travel is likely to continue at an accelerating pace and the greater volume of business oriented air traffic seems to be a substantial contributing factor. The greater volume of businessmen and their movements to and from airports pose a serious problem for the transportation experts. One solution, which is not necessarily a complete answer to the problem, is to develop the airport sites as large business and commerce centres. The specialized functions carried in such airport business centres would be mainly oriented to serve the business needs of air passengers. In fact, large airports have already started experiencing in their proximity, assortments of hotels, motels, conference halls, convention facilities and entertainment establishments. Some may think that such development would take place at the expense of development in the downtown areas. But, it is important to understand that the airport business district would function as supplemental to the downtown business core. The local businessman will then have opportunity to meet and attend the air-transported businessman at the airport business district and thus save him a trip downtown. This concept has already become a reality at several places. The Hilton Inn, located in the vicinity of the San Francisco International Airport, provides a variety of accommodation and business transaction facilities. A year after its opening, the business demands of air passengers were such that the plans to increase its capacity by 50 per cent were announced. This kind of development is desirable near airports and, according to the manager of the Hilton Inn, a stay of 1.3 nights at the airport hotels is comparable to that of 3.3 nights' stay in downtown hotels.[96]

The 'airport business district' can also be planned to include the facilities to fulfill the needs and interests of the air passengers who travel strictly for non-business or personal reasons. This category of air passengers has already shown spectacular growth and there are predictions that due to increasing family income and more economical fleet of aircraft in the foreseeable future, the volume of non-business traffic would still increase enormously. The greater proportion of the

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96. "Experience with Jets - and a Look Ahead," Planning 1961, p. 105.

non-business traffic would consist of air passengers on vacation, holidays or social visits. The effect of such an inter-city movement of population would be that the airport of the future city would tend to become its 'gateway.' To a large extent, the image of the future city will then be reflected by the services and standard of its airport. A well-planned airport, therefore, will be a great community asset. The following are the two suggestions made to realize this end:

a. The proposed airport business district besides the provision of the facilities for businessmen should also provide for a variety of tourists' facilities for those air travellers who are visiting the city. The nature of such facilities can be commercial and recreational, such as tourist hotels, specialty restaurants, souvenir shops, theatres, night clubs and other entertainment places.

b. A higher architectural and landscape standard of the development around the airport and along the airport access corridors should be maintained so that airport areas enhance the image of the city.

A well-planned airport in accordance with the above recommendations, will experience intensive development of business, commerce and recreational facilities which, for the financial support or necessary market, will be mainly dependent upon the airport operation. Thus, the airport of the future will not only be a transportation facility but will also constitute a major employment centre within the metropolitan area.

CHAPTER VI

GROUND TRANSPORTATION TO AND FROM AIRPORT

A. ELEMENTS OF DESIGN

1. Travel Time:

The subject of ground transportation between the modern airport and the city centre is widely discussed by the concerned transportation specialists of North America. It is generally held that ground transportation services to airport in large urban centres has excessively deteriorated and that travel times to and from the airports have considerably increased. Since the efficiency and reliability of the airport accessibility do not provide the required satisfaction to air passengers, some people in aviation fear that, if such deterioration continues, it may become a great limitation for the use and growth of air transportation. It has been observed that for the completion of short-haul trips of less than 500 miles, approximately 60 per cent of the total trip time is spent on the ground.[97] The longer-haul trips, such as New York - London, are also affected by the poor ground transportation, but ground travel time in these cases makes only 22 per cent of the total trip time which is over eight hours.[98] Therefore, the effect

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97. B.G. Hutchinson and P.M. Peason, An Evaluation of Ground Transportation Requirements for Airports, A paper presented to the Canadian Transportation Research Forum, Vancouver, 1968.

98. K.R. Sealy, The Geography of Air Transport, Hutchinson University Library, London, 1966, p. 177.

of poor airport accessibility on the short-haul air traffic which is mostly domestic is much more severe as compared to that on longer-haul international flights.

The airport accessibility by surface transportation is generally measured by the travel time between the airport and the C.B.D. It would, therefore, be easy to conclude that the travel time is basically a function of the distance involved, and hence the airport location should be the primary determinant for its accessibility. But it is not so. In order to analyze and illustrate this point, Table 7 provides the relevant information of location and travel times of the twenty-two major airports of the U.S. The table clearly brings about two conclusive points:

a. The travel time between the airports and the C.B.D.'s bears some relationship to the distance or location of the airport with respect to the C.B.D. However, the location of an airport closer to the C.B.D. does not necessarily ensure that the travel time will also be proportionately less. To illustrate this point, the example of the airports at New York (La Guardia), Atlanta and Chicago (Midway) located respectively 8, 9 and 10 miles from the C.B.D.'s may be elaborated on. For these airports the travel times given in the same order are 30, 15 and 40-60 minutes. Although the range of distance under consideration is 8 to 10 miles, the travel time ranges between 15 and 60 minutes.

b. Since the location of the airport is not the only and primary factor in determining the travel time to and from it, consideration

TABLE 7

DISTANCE AND TRAVEL TIMES[99] - AIRPORTS TO CENTRAL BUSINESS DISTRICTS

S.No.	City	Airport	Distance from CBD (mi.)	Travel Time from CBD (min.)
1	Boston	Logan International	3	20-40
2	Washington	National	4	15-30
3	Philadelphia	International	6	15-25
4	Dallas	Love	7	25-30
5	Denver	Stapleton	7	15
6	New York	La Guardia	8	30
7	Atlanta	Municipal	9	15
8	Minneapolis-St.Paul	Wold-Chamberlain	9	25-30
9	Chicago	Midway	10	40-60
10	Houston	International	10	20-30
11	San Juan	Puerto Rico Int'l	10	15
12	New York	Newark	12	30
13	New Orleans	Moisant International	13	40
14	Cleveland	Hopkins	14	35
15	Los Angeles	International	14	60
16	San Francisco	International	14	25-30
17	New York	International	15	30-45
18	Pittsburgh	Greater Pittsburgh	16	25
19	Detroit	Metropolitan	17	25
20	Chicago	O'Hare	23	50-65
21	Washington	International	24	40-50
22	Detroit	Willow Run	30	45

99. V.J. Roggeveen & L.V. Hammal, Ground Transport of People to and from the Civil Airports, Proceedings of the American Society of Civil Engineers, _Journal of Air Transport_, Paper 2108, p. 39, July, 1959.

to other factors, such as capacity of the airport access and the traffic conditions, is imperative in order to find a realistic solution to the problem. It seems that the large cities like New York, Chicago, Los Angeles have congestion and traffic jams on their airport accesses, not only because of large numbers of air passengers, but also because of a greater number of non-passengers who use the same transport facilities. More information of the composition and characteristics of airport access users follows in the next section.

2. Users of Airport Access:

The knowledge of various kinds of airport access users and their desired trips (to and from the airport) can be valuable for planning the ground transportation needs of an airport. Generally, there are four main categories of traffic frequently using the airport access:

a. Service[100] and air-freight traffic

b. Airport employees[101]

c. Visitors, shoppers and sightseers

d. Air passengers

The percentage breakdown of total traffic into these categories depends upon the size of the airport and the nature of development in its

100. Some of the 'service traffic' is generated by commercial and industrial functions centred at airports.

101. The category of 'airport employees' means, not only the people employed at the airport proper, but also accounts for the employment of the airport neighbourhood using the airport access.

vicinity. In the U.S. some studies have been conducted at New York International, Chicago O'Hare and Midway, Dallas-Fort Worth and Nashville to determine the composition of the airport access users.[102] The results of the studies are as follows:

S. No.	Category	Percentage of Total Traffic Volume
1	Service Traffic	3-7
2	Airport Employees	11-16
3	Visitors, Shoppers & Sightseers	31-42
4	Air Passengers	33-56

The volume of service traffic is generally low for any airport and their trips to an airport corresponds to no fixed or regular times of a day or night. A high proportion of service vehicles are trucks and delivery vans and originate from the C.B.D. or industrial districts producing consumption goods. For service traffic, a high quality highway access to the airport seems the best mode of movement of goods.

Employment at the airports and in their neighbourhood areas are on the increase. In his letter, J.P. Dunne[103] stated that the Chicago O'Hare Airport itself employs 16,000 people and the business and

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102. B.A. Schriever and W.W. Seifert (Co chairmen), Air Transport 1975 and Beyond, Cambridge, Mass., M.I.T. Press, 1968, p. 450.

103. J.P. Dunne is the First Deputy Commissioner of the Department of Aviation, Chicago O'Hare International Airport.

commercial uses in its vicinity which are dependent upon the airport operations, are another employment source of a minimum of 50,000 employees. Any airport planned by adopting the recommendation of this thesis would become a major employment centre of the metropolitan area. It is natural that airport employees would base their selection of residence on a number of convenience and personal factors and thus would be widely distributed over the city. For their trips to work it has been observed that a high proportion of them make use of their private automobiles,[104] hence well-planned highways connecting the airport to all the major metropolitan thoroughfares is the only solution.

Vistors generally accompany air passengers on their trips to and from the airport in private automobiles and are an important factor in planning highway access to the airport site. A greater proportion of the shoppers and sightseers make their trips in the evenings or on the weekends when the volume of air passengers and airport employees are lowest. Although a greater number of them use their own private transportation, they are not an important factor in determining the

104. The following are the result of a survey done for some of the U.S. cities.

		Percentage of Airport Employees Using Each Mode		
S.No.	City	Auto	Public Bus	Others
1	New York Int'l	87	9	4
2	Boston	93	7	-
3	Minneapolis-St.Paul	89	6	5
4	San Francisco	74	17	9

Source: V.J. Roggeveen and L.V. Hammal, *op. cit.*, p. 46.

the total traffic carrying capacity of the airport access.

The access needs of air passengers are most important of all the categories of airport access users. The place of their origin or destination from the airport can be the C.B.D. and other parts of the city. With the modern trend of suburban industrial sites and professional offices in the shopping centres, there are, in addition to the C.B.D., emerging other passenger generating nodes. In their comprehensive survey of the various U.S. cities, Roggeveen and Hammal[105] concluded that only 40 per cent of the air passengers' traffice is generated by the C.B.D. It seems logical to assume that the air traffic generated by the C.B.D. is all in all business oriented and hence travel time to and from the airport plays a significant role in their business. As explained earlier, although airport access users come from all parts of a city, the C.B.D. is nevertheless the major generator of air traffic and hence should be highly accessible.

Table 8, page 98, gives the results of a survey of the mode of travel to and from airports observed in some cities. Over 50 per cent of the air passengers seem to prefer to use their private automobiles to reach the airports. Taxi and limousine service ranks next as a popular mode of travel. A very low percentage of the air passengers seem to be interested in using public transit. Even if scheduled helicopter service was available, less than one per cent have had used it.

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105. Ibid.

TABLE 8

AIR PASSENGERS - TRAVEL BY MODE[106]

City	Percentage Using Each Mode				
	Auto	Taxi	Limousine	Public Bus	Scheduled Helicopter
Cleveland[a]	57	14	27	1	1
Dallas	55	22	20	2	
Houston	74	-- 26	--		
Minneapolis-St. Paul	59	23	18		
New York					
International[c]	42	26	31	1	less than 1
La Guardia[b]	37	41	20	2	
Newark[b]	46	12	38	4	

a. Estimated
b. Enplaning Passengers only
c. Domestic Enplaning

106. *Ibid.*, p. 45.

B. RECOMMENDATIONS

1. Besides the air passengers, the airport access is extensively used by various types of other people who make their trip to an airport from any part of the city. It is important that the transportation needs of the non-passenger category of airport access users should be properly recognized and an airport, like any other public facility, should be made accessible to all the inhabitants of the community it serves. In order to do so, airport accessibility should be regarded as an integral part of the total transportation plan of intra-city travel.

2. The airport access needs of air passengers are most vital and consequently any traffic jam, congestion or delay in their trip to and from the airport severely affects their business. Since the volume of air passengers is not a high proportion of the total traffic on airport access, the conditions of traffic jams or congestion on airport access are largely caused by non-passenger traffic. One possible solution would be to segregate the air passengers' traffic whenever practicable. This would mean that for the total airport bound traffic a separate highway facility to accommodate private automobiles, taxis or limousines, and public transit, if any, and serving exclusively the air passengers, should be built.

3. A rapid transit system for carrying airport bound traffic is another possibility. Travel time to and from airports can be considerably reduced through the service of rapid transit, but the implications of

its financing and feasibility make it generally impracticable. However, the rapid transit link should be extended to the airports in the case of the cities which have adopted rapid transit system as a mode of intra-city movement.

4. For the airport located far away from the C.B.D.'s of the cities they serve, the possibility of having scheduled helicopter service can considerably reduce the trip time to and from the airports.

CHAPTER VII

CONCLUSIONS

A. PHYSICAL BOUNDARIES OF AIRPORT VICINITY AREA

In the body of the thesis, the major area of concern has been the comprehensive study of the jet airport operation as it affects the use of its surrounding area. Based on the contents of the thesis, there are three main constraints which determine the physical extent of the vicinity of a modern commercial jet airport handling mainly scheduled domestic and international air traffic:

1. The 'Horizontal Surface' as defined in the existing federal zoning regulations is one important factor determining the physical extent of the airport vicinity area. The outer limit of the horizontal surface extend to a radius of 2.47 miles from the geometric centre of the landing area, and all the structures within it have to be less than 150 feet height.

2. For the safety of modern jet aircraft, some degree of bird-hazard exists at all the Canadian jet airports. The Department of Transport officials state that bird-hazard exists largely within 4 miles radius of an airport. The considerations of bird-hazard around jet airports constitute another factor to determine the airport vicinity area.

3. The effect of the jet aircraft is the third and most important force delimiting the airport's vicinity area. From the noise standpoint, the

airport vicinity should extend either to a radius of 3 miles from the geometric centre of the landing area, or to the outer limits of a strip 1 1/2 mile wide and extending 5 miles, at either end of the runways (being used by the jets) whichever is greater. The physical extent of the area affected by the noise is such that it largely covers areas of the federal zoning regulations and bird-hazard. It is quite logical that the area affected by the aircraft noise should be considered the delimitation of the airport vicinity.

Therefore, this study recommends that for physical planning purposes, the outer limit of the airport vicinity should be a circle of 3 miles radius from the geometric centre of the landing area, plus strips of 1 1/2 mile wide, extending 5 miles at either end of the runways being used by the jets. The outer boundary of the airport vicinity as such, would be star-shaped rather than a regular circle of 3 miles radius. For an airport having two runways being used by the jets, the acreage of the airport vicinity as defined in this thesis, excluding the airport property, would be in the order of 12,000-16,000 acres.

It is not difficult to anticipate that this delimitation of an airport vicinity area will be subjected to criticism by some planners. It is probable that some of them would think that the indicated vicinity area represents such a large acreage that it is impossible - or impracticable to keep it open or sterile. In doing so, these critics are grossly mistaken. There are two simple facts on the support of the proposition. First, the vicinity as such is simply the area surrounding an airport which is subjected the effects of airport operation. The physical extent of the vicinity could not be any less or any more than what it is. Second, the critics' viewpoint that the airport vicinity area is good for nothing and hence sterile, is not valid. In the light of the conclusions of this thesis, there are basically only three categories of uses - residential, certain institutional and a variety of heavy industrial operations - which are highly undesirable in the vicinity area of an airport. With the exception of these uses, the airport vicinity, like any other part of the city, can be utilized for a variety of agricultural, recreational, commercial and industrial functions. The important point is that, while planning such functions in the area, proper cognizance of the effects of and upon the airport is necessary.

B. DESIRABLE LAND USES

1. Any type of residential and certain institutional uses such as churches, schools and hospitals are highly undesirable in the vicinity of the airport.

2. The tradition of allowing any type of agricultural or open land uses is no longer valid. There are some uses of this category which are highly incompatible in the vicinity of the airport. These uses are:

(i) Grain crops like wheat, oat, barley, etc.
(ii) Nurseries, sod and tree farming
(iii) Sanitary land-fill sites
(iv) Pig farms (when garbage is used as fodder)

3. The airport vicinity represents an extensive area and the degree of physical constraints (such as noise, safety etc.) affecting land uses,

varies greatly in it. The airport vicinity for physical planning purposes, should be divided into the following four areas:

(i) Aircraft Noise Affected Areas
(ii) Areas Along Airport Access Corridor
(iii) Areas of Other Accessible Locations
(iv) Areas of Poor Accessibility

a. Use of Aircraft Noise Affected Areas: 'Flight path'[107] areas at the end of each runway exposed to over 112 PNdb noise level, are not recommended for any (commercial, industrial or recreational uses) built-up urban functions. These areas should be used only for selected agriculture or open land uses. As shown in Table 9, page 107, these uses are:

A_1 Non-grain crops
Dairy farming
Stock farming
Stockyards

A_2 Outdoor shooting clubs
Hunting areas
Auto driving grounds
Heavy machinery testing areas
Auto dumps
Parking lots

In addition to these uses, the flight path areas can also be considered for locating some of the municipal utilities such as covered sewage treatment units and water storage tanks.

The remaining area of flight paths where the aircraft noise is comparatively less severe and the crash probability is low, are

107. The area is approximately one mile wide and extends three miles at the either end of a runway.

recommended for various agricultural, recreational, commercial and industrial uses. As also given in Table 9, these uses are:

A_3 Golf Courses and cemeteries

A_4 City parks
Picnic areas
Riding trails
Playfields (spectator use)

C_1 Air passenger oriented facilities like hotels, motels, conventional halls, amusement areas, taxi and bus terminals, air-freight offices, etc.

C_2 Non-aviation commercial uses such as department stores, strip commercials, shopping centres, etc.

M_1 Air-freight oriented light industry

M_2 Non-aviation light industry

In addition, there are some transportation oriented functions such as highways, railroads, truck terminals, transit repair and maintenance shops, that can also be located in the flight paths.

b. Use of Areas Along Airport Access Corridor: The locations along the airport access corridor and near terminal buildings should generally be preferred for airport oriented commercial uses indicated by type C_1 in Table 9. In addition, some of the air-freight functions which need good transportation to the rest of the metropolitan area should also form desirable developments if located along the airport access. These air-freight functions are warehouses, regional freight offices, freight collectors and forwarders etc. Also, if some public buildings such as fire halls, police stations etc., and private offices are located along the airport access, they will form satisfactory urban development in the vicinity of the airport.

c. Areas of Other Accessible Locations: The accessible locations other than the proximity of the airport access corridor, are suitable for light industry of M_1 and M_2 type.

d. Areas of Poor Accessibility: The areas of poor accessibility within the airport vicinity, can be used for agriculture uses of A_1 type and some municipal utilities like sewage plants and water tanks.

Table 9, page 107, presents a summary of all the findings as they apply to physical planning in the vicinity of the airport. The various land uses depending upon the area of the airport vicinity and physical contraints of airport operation, have been rated as 'desirable,' 'satisfactory,' 'marginal' and 'undesirable.' There are two types of 'index' shown in the table:

(i) 'Desirability Index' measures the compatibility of a land use with the airport operation. Higher index of land use means that it is suitable for various locations of the airport vicinity.

(ii) 'Choice Index' relates to a particular area of the airport vicinity and measures the extent of choice of land uses suitable for the area. Higher index of an area means that there is a greater number of uses that can be located in it. Conversely, lower index of an area refers to strict conditions of physical planning and narrow choice of uses that can be located in it.

TABLE 9

DESIRABLE LAND USES FOR AN AIRPORT VICINITY

S.No.	DETAIL AREAS WITHIN THE AIR-PORT VICINITY	AGRICULTURAL & OPEN LAND USES					COMMERCIAL		INDUSTRIAL USES			OTHER USES		P PUBLIC BUILDINGS & OFFICES	I INSTITUTIONAL USES LIKE SCHOOLS, CHURCHES, HOSPITALS	R RESIDENTIAL USES	CHOICE INDEX
		A_1	A_2	A_3	A_4	A_5	C_1	C_2	M_1	M_2	M_3	T	U				
1	Noise 125 PNdb or over	33	3	0	0	0	0	0	0	0	0	0	2	0	0	0	8
2	Noise 112-1125 PNdb	3	3	0	0	0	0	0	0	0	0	1	2	0	0	0	9
3	Noise 100-112 PNdb	1	1	3	2	0	3	2	3	3	0	3	2	1	0	0	24
4	Areas Along Airport Access Corridor	1	1	3	2	0	3	2	3	3	0	2	1	2	0	0	23
5	Other Accessible Locations	1	1	3	2	0	3	2	3	3	0	3	1	3	0	0	25
6	Areas of Poor Accessi-bility	3	3	0	0	0	0	0	0	0	0	0	1	3	0	0	7
	DESIRABILITY INDEX	12	12	9	6	0	9	6	9	9	0	9	6	6	0	0	96

CODING SYSTEM

CODE NO.	LOCATIONAL CRITERION
3	Desirable
2	Satisfactory
1	Marginal
0	Undesirable

AGRICULTURE AND OPEN LAND USES

Sub Cat.	Uses
A_1	Non-grain crops, truck farming, dairy farming, stock farming and stockyards
A_2	Outdoor shooting clubs, hunting areas, driving grounds, machinery testing areas
A_3	Golf courses and cemeteries
A_4	City parks, picnic areas, play-fields (spectator use) outdoor drive-in theatres
A_5	Grain crops, nurseries, sod and tree farming, sanitary land-fill sites, pig farms (garbage as fodder)

COMMERCIAL USES

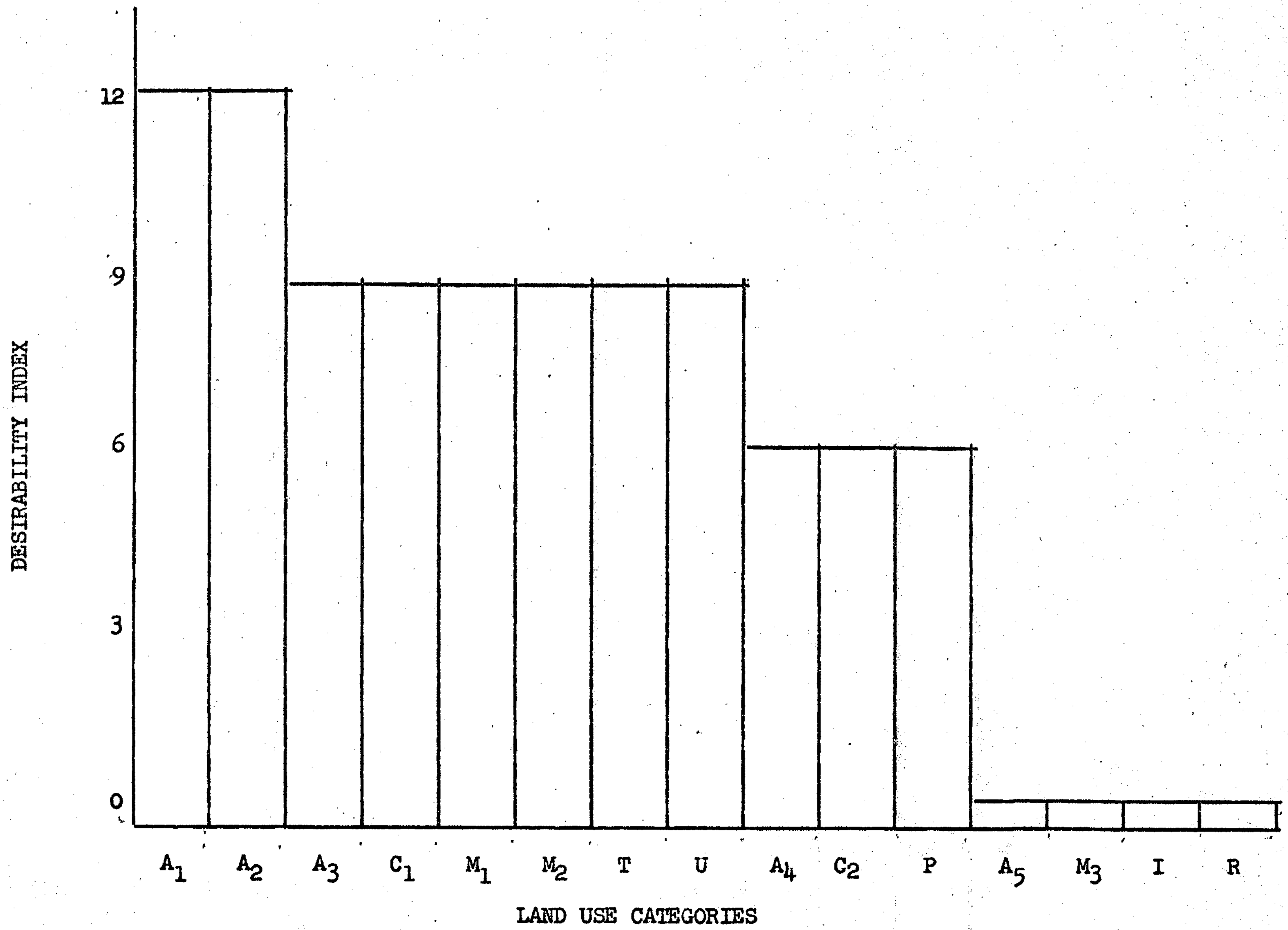
Sub Cat.	Uses
C_1	Air passenger oriented facilities; hotels, motels, Convention halls, etc. Amusement areas, taxi and bus terminals, air-freight commercial offices, etc.
C_2	Non-aviation commercial uses like general stores, shopping centres, strip commercials

INDUSTRIAL USES

Sub Cat.	Uses
M_1	General light industry light industry
M_2	General light industry
M_3	Heavy industry

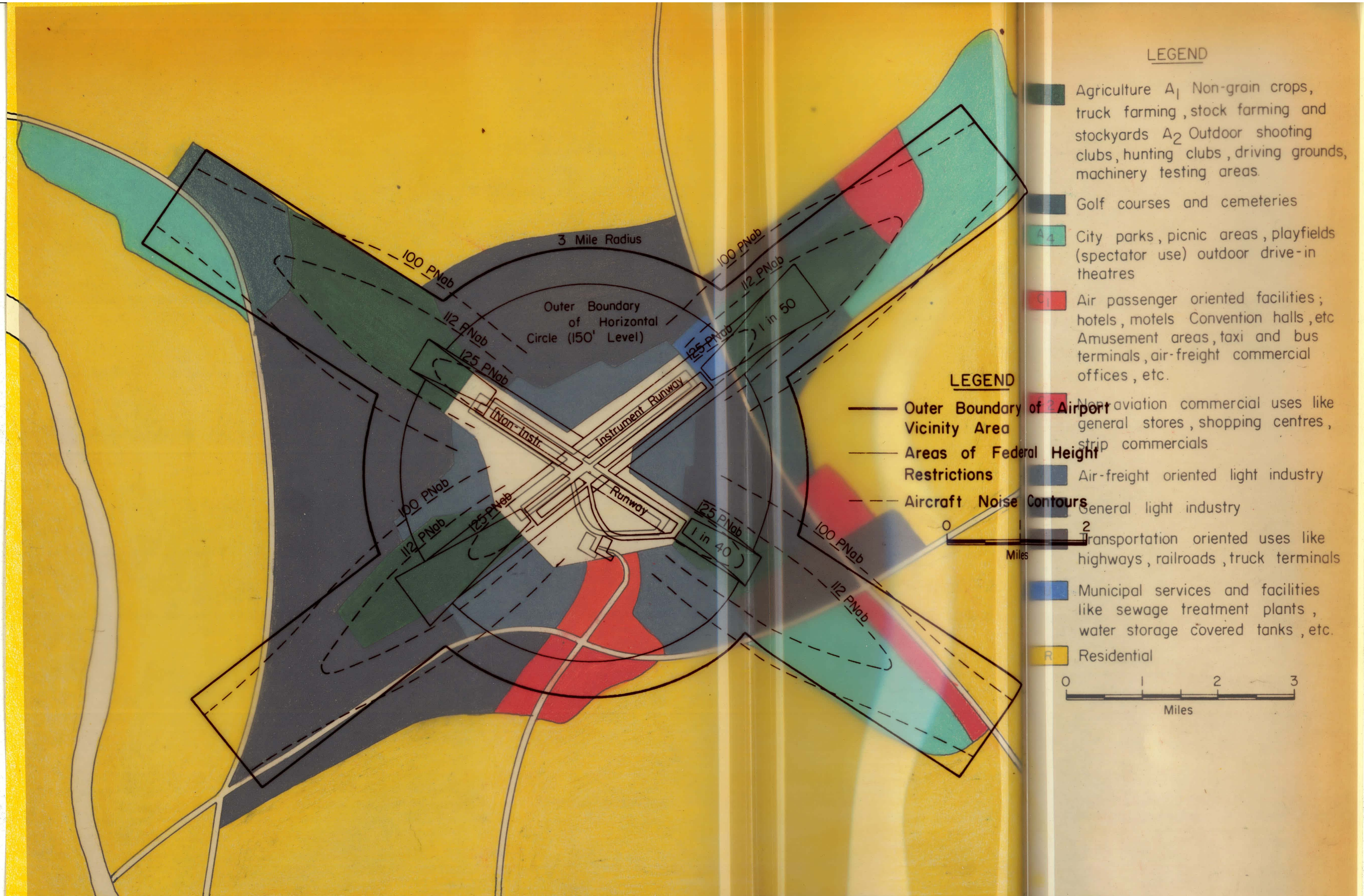
OTHER USES

Sub Cat.	Uses
T	Transportation oriented uses like highways railroads, truck terminals, transit repair & maintenance shops
U	Municipal services & facilities like sewage treatment plants, water storage covered tanks etc.



DESIRABILITY INDEX
12
9
6
3
0
A_1 A_2 A_3 C_1 M_1 M_2 T U A_4 C_2 P A_5 M_3 I R
LAND USE CATEGORIES

Fig. 2



PHYSICAL CONSTRANTS AT AN AIRPORT

MAP I

DESIRABLE LAND USE PATTERN AT HYPOTHETICAL AIRPORT

In conclusion, Map 1, page 111, is a 'land use model' at a hypothetical jet airport handling mainly scheduled domestic as well as international air traffic. The model outlines the physical constraints created by the operation of the jets and the federal zoning regulations, and suggests the most desirable pattern of land uses.

C. IMPLEMENTATION

The vicinity of an airport is an extensive area and its proper development or redevelopment can be achieved only over a longer period of time. Furthermore, the physical shape of the airport vicinity is such that it is bound to exert a tremendous impact on the future form of the city. The proper recognition of these two factors is important before suitable planning tools can be devised and effectively used to develop the area. One method of doing so is to relate the development of an airport vicinity area in a city to its 'Development Plan.' A Development Plan usually covers a period of twenty years which is long enough to give direction to a pattern of desirable growth in the vicinity of an airport. Theoretically speaking, a Development Plan is a set of policies or intended course of future actions to guide the physical growth of a city, hence the impact of the airport vicinity on the future form of the city can be accurately assessed and properly channelled.

The planning process of implementing the recommendations of this thesis would, therefore, consist of a series of steps outlined below while the Development Plan is being prepared.

1. Physical boundaries of the airport vicinity as explained earlier should be marked.

2. Field surveys should be conducted to determine the existing undesirable functions in the airport vicinity area. The findings of such surveys would detect the population living in the undesirable environmental conditions, institutions unsuitably located and ultimately the vacant or undeveloped land which may be consumed over the period of the plan.

3. Policies for correcting the past mistakes and guiding the future growth should be formulated embodying the principles enunciated in this thesis. The problem of existing development which is undesirable would need the services of urban renewal tools for clearing the area. Thereafter, long-term policies would direct the future growth.

4. The implementation of desirable growth is recommended through the application of the popular tool of 'zoning.'

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APPENDIX I

DETAILED PROCEDURE FOR ESTIMATING COMMUNITY REACTION TO AIRCRAFT NOISE*

The procedure for estimating community reaction to noise from military and civil aircraft operations is described and illustrated in this section. For ready reference, the six steps in the procedure are:

Step One:	Obtain data on aircraft operations
Step Two:	Select noise contours
Step Three:	Determine perceived noise levels
Step Four:	Determine proper corrections for operational factors
Step Five:	Determine Composite Noise Rating
Step Six:	Estimate community response

Step One: Obtaining Data on Aircraft Operations:

The first step in the procedure is to obtain a description of the aircraft operations occurring, or forecast to occur, at the airport in question. For flight operations, information is required by aircraft type on the total number of takeoffs and landings, on the per cent utilization of each runway, and on the flight paths used. For runup operations the type of aircraft, location of the runup area, aircraft orientation, and the nature of the runup operation are the required information. One or two-engine piston and turboprop aircraft need not be considered because in almost all instances requiring evaluation they

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*This is reproduced from: Bolt, Beranek & Newman, Inc. "Land Use Planning Relating to Aircraft Noise" 1964. A study done for the F.A.A.

do not contribute materially in establishing final Composite Noise Rating contours.

In recording takeoff and landing information, use the arithmetical average number of movements per time period (0700-2200 and 2200-0700) for the entire airport. The average values should be computed from long term data (i.e., annual movements). If the number of daily movements shows pronounced variations according to a weekly or seasonal pattern, use the average number of movements over the period of maximum activity.

After arriving at a figure to represent the total number of operations on the entire airport for each type of aircraft, obtain an estimate of the percentages of these movements which take place on each runway being considered.

A suggested format for collecting information on ground runup operations is shown in Table 10. The aircraft classes and associated engine power settings are entered in the first column. The number and duration of runups occurring for both daytime and nighttime periods are entered in the remaining columns. Table 10 should be filled out for each runup area. The number of runups shown should be the average number of single engine runups be computed from long term data, and allowances should be made for pronounced variations as previously discussed for flight operations. It is not necessary to record time during which water injection is used. However, estimates of afterburner use are required to allow approriate separations between runup groups 1 and 2 or 2 and 3, respectively.

When it is necessary to assess the effects of proposed or planned future operations, flight and runup information should be compiled from

TABLE 10

SUGGESTED FORMAT FOR COLLECTING INFORMATION ON RUNUP OPERATIONS CONDUCTED AT EACH RUNUP AREA* ON AN AIRPORT OR AIR BASE

Aircraft Category and Type		Average Number of Runups		Average Duration of Runup in Min.	
		0700 to 2200	2200 to 0700	0700 to 2200	2200 to 0700
Civil	Turbojets at "trim" (or "part") and takeoff power				
	Turbofans at 75% thrust to full takeoff power				
Military	Runup group 1				
	Runup group 2				
	Runup group 3				
	Runup group 4				

*When aircraft are oriented in more than one direction at a given runup location, consider each orientation as a separate "runup area."

forecasts as far into the future as possible. For civil airports, adequate information concerning current operations can usually be obtained from airport authorities, airline operations personnel, pilots and published schedules.

To explain the application of each step of the procedure, we will carry a running illustration throughout the course of this section. Let us assume that we are interested in the perceived noise levels and corresponding estimated response for an area adjacent to Runway 17 at a civil airport. To simplify the example, let us confine our analysis to the 0700-2200 period.

Illustration of Step 1: We determine the following information by inquiry and complete Table 10 accordingly:

a. Runway 17 is used only for takeoffs of turbofan and turbojet aircraft departing on trips greater than 2,000 miles.
b. For the entire airport, the average number of takeoffs of these aircraft types between 0700 and 2200 is 40 turbofans and 40 turbojets per day.
c. The runway utilization for Runway 17 is approximately 55 per cent for both types of aircraft.
d. The departure flight path is straight out along the runway heading.

Step Two: Selecting Noise Contours:

After the information on airport operations required has been collected, the next step in the procedure is to select the appropriate noise contours. The appropriate contours for a particular problem can be selected by referring to Table 11; in this table, civil and military

TABLE 11

CHART FOR SELECTING NOISE CONTOURS

Aircraft Category	Operation	Aircraft Type*	Contour Set	Correction to Contour
		Turbojets - Trips under 2,000 mi.	1A	0
		Turbojets - Trips over 2,000 mi.	1B	0
		Turbofans - Trips under 2,000 mi.	1A	-5 PNdb
		Turbofans - Trips over 2,000 mi.	1B	-5 PNdb
	Takeoffs	Four-engine piston	4	0
		Four-engine turboprop	4	-5 PNdb
		Helicopters (Sikorsky S-61, Vertol 107 and Vertol 44)	5A	0
Civil		Turbojet	3B	0
		Turbofan	3B	0
	Landings	Four-engine piston and turboprop	3A	0
		Helicopters - Vertol 44	5B	-10 PNdb
		Vertol 107, Sikorsky S-61	5B	0
	Runups	Turbojet	6	0
		Turbofan	7	0
		Jets - Flight group 1	2A	-5 PNdb
		" " 2	2A	0
		" " 3	2A	-5 PNdb
		" " 4	2B	-5 PNdb
Military	Takeoffs	" " 5	2B	0
		" " 6	2B	-5 PNdb

TABLE 11 (continued)

Aircraft Category	Operation	Aircraft Type*	Contour Set	Correction to Contour
		Jets - Flight group 7	2C	0
		" " 8	2C	-5 PNdb
		" " 9	2C	-10 PNdb
		" " 10	2D	0
	Takeoffs	Four-engine piston	4	0
		Four-engine turboprop	4	-5 PNdb
Military	Landings	All jets	3B	0
		Four-engine piston and turboprop	3A	0
	Runups	Runup group 1**	8	-5 PNdb
		" " 2	8	0
		" " 3	8	-5 PNdb
		" " 4	7	0

*For turbojet aircraft taking off, or during runup, the appropriate noise contours apply for water injection ("wet") as well as "dry" conditions.

**See group classifications for individual aircraft (Tables 1-1 and 1-2, attachment 1).

aircraft are separated, and each of these categories is divided into takeoffs, landings, and runups. Each of these operations is further divided by aircraft type. (The last column of Table 11 indicates corrections to be made to the designated contours depending on aircraft type and/or mission length; these corrections are made in Step 3.)

Illustration of Step 2: From the operational information collected in Step 1 and a study of Table 11 we find that the appropriate noise contours to use for takeoffs of these aircraft are those in Contour Set 1B.

For runups, the selection of the proper contours is made in the same manner. In the case of civil operations, one must determine only whether turbojet or turbofan aircraft (or both) are to be considered. Table 11 shows that the corresponding contours are given in Contour Sets 6 and 7. Contour Set 8 is used for all military turbojet runups; for military turbofans, Contour Set 7 applies.

If an area is exposed to noise from aircraft at the beginning or in early stages of the takeoff roll, the determination of expected response is made by a combination of the above procedures. This method is illustrated in Example Four.

Step Three: Determining Perceived Noise Levels:

After selecting the noise contours that correspond to the aircraft operations on the runways in question (and the appropriate runup contours, if runups are considered an important contributor to the noise levels in the residential area), the next step is to determine the perceived noise levels in PNdb for the area of interest. This is done by reading the perceived noise levels directly from the appropriate contour set and applying the corrections as noted in the last column of Table 11.

One way to determine the perceived noise levels for in-flight activity from the noise contours is to outline the runway, flight path, and the area(s) in question on a sheet of translucent (tracing) paper; this should be done to the same scale as the contours. This outline drawing can then be superimposed directly on to the contours. For takeoff operations, the beginning of the runway on the overlay drawing must coincide with the point for start of takeoff on the contours. For landings, the runway threshold on the overlay must coincide with the threshold on the contours. The perceived noise level at any given location can then be read directly.

Another way to determine perceived noise levels is to specify the location of the region with respect to the start of takeoff roll (for takeoffs) or runway threshold (for landings). For example, let us assume a particular community is located about 3,000 ft. to the side of the takeoff path at a point 28,000 ft. from the start of takeoff roll. For takeoffs, the noise levels are then determined simply by reading the perceived noise levels from the appropriate noise contours (and applying corrections from Table 11) at this same location.

Illustration of Step 3: In our running illustration, let us further suppose that the area is located approximately 20,000 feet from the start of takeoff roll and 2,500 feet to the side of the flight path. In Step 2, we determined that the appropriate noise contours to use were contained in Contour Set 1B. We read from Contour Set 1B that the perceived noise level at this location is 105 PNdb. Applying the corrections noted in Table 11 (0 PNdb for turbojets and -5 PNdb for turbofans), we find that the perceived noise levels at this location are:

Turbojets - 105 PNdb
Turbofans - 100 PNdb.

<u>Step Four</u>: <u>Determining Corrections for Operational Factors</u>:

The next step in the procedure is to apply corrections to the perceived noise levels determined by Step 3 for other factors important in affecting reaction to aircraft noise. For takeoffs and landings these factors are: number of operations, runway utilization, and time of day. The corrections for these factors are given in Table 12. For runup operations, the important factors are: number of runups, duration of runups, and time of day. The corrections for these factors are given in Table 13.

<u>Illustration of Step 4</u>: To show how corrections for operational factors are determined, let us continue with our running illustration. In Step 1, we found that there are a total of 40 turbojet takeoffs and 40 turbofan takeoffs per day during the 0700-2200 period; the utilization of Runway 17 is about 55 per cent. The correction from Table 12 for the number of operations is -5 for both types of aircraft. The correction for runway utilization is 0 for both types. Finally, the time of day was restricted here to the 0700-2200 period, so the applicable correction is 0. In summary, the total of the correction numbers for turbojet operations is -5, and for turbofan operations is -5.

TABLE 12

OPERATIONAL CORRECTIONS TO APPLY TO PERCEIVED NOISE LEVELS FOR TAKEOFFS AND LANDINGS

Number of Takeoffs or Landings per Period		Correction
Day (0700-2200)	Night (2200-0700)	
Less than 3*	Less than 2	-10
3-9	2-5	-5
10-30	6-15	0
31-100	16-50	-5
More than 100	More than 50	-10
	Per cent Runway Utilization	Correction
	31-100	0
	10-30	-5
	3-9	-10
	Less than 3	-15
	Time of Day**	Correction
	0700-2200	0
	2200-0700	-10

*If the average number of operations for an aircraft type is less than one per time period, that aircraft type should not be considered in the analysis.

**In general, the ratio of daytime-to-nighttime operations is such that daytime operations determine the Composite Noise Ratings at airports. Only when the nighttime activity is disproportionately high will the nighttime correction affect the composite noise rating.

Step Five: Determining Composite Noise Rating:

The Composite Noise Rating (CNR) for each type of flight operation is computed by adding algebraically the total of the correction numbers as described in Step 4 to the perceived noise level in PNdb as determined in Step 3.

Illustration of Step 5:

For turbojet takeoffs the Composite Noise Rating is:

CNR = 105 PNdb -(-5) = 110

For turbofan takeoffs it is:

CNR = 100 PNdb -(-5) = 105

At this point in the analysis, a CNR will result for each takeoff and landing operation being considered. From these various values one CNR must be chosen to apply to the area under study for all flight operations. Since both takeoffs and landings have been divided into various categories (see Table 11) and since the noise perceived at any given location will frequently come from operations on several runways and/or flight paths, provision must be made to recombine CNRs of comparable value. Only those CNRs that are within 3 units of the maximum CNR need be considered. If there are three or more CNRs fulfilling this requirement, add 5 units to the highest one to determine the CNR that applies for all flight operations; if there are less than three, the highest CNR applies.

Illustration of Step 5 (continued): In our illustration we found that the CNRs for the two types of takeoff operations were 110 and

105. According to the rules stated above, the CNR for takeoffs at the location in question is 110. Had there been three or more values of CNR between 107 and 110, the resultant CNR would have been 115.

If runup operations were also involved, their analysis would proceed in a similar manner. The appropriate runup contours would be employed and corrections from Table 13 would be applied to the perceived noise levels. If several runup operations were involved, a Composite Noise Rating would be determined for each one, and the highest CNR selected. If there were three or more CNRs within 3 units of the maximum CNR, 5 units would be added to the highest to determine the CNR for all runup operations. This CNR would not be directly combined or compared with the CNR for flight operations. As will be seen later, however, the estimates of community response which correspond to the controlling CNRs for flight and runup operations are combined or compared to arrive at the estimated overall response of a community to all aircraft operations.

Step Six: Estimating Community Response:

On the basis of case histories involving aircraft noise problems at various military installations and civil airports, an empirical relationship has been developed between Composite Noise Ratings and the expected response of residential communities. This relationship is given in Table 14. As a consequence of the various degrees of expected community response, the geographical area in the vicinity of an airport can be characterized by three response zones: Zone 1, Zone 2, or Zone 3.

TABLE 13

OPERATIONAL CORRECTIONS TO APPLY TO PERCEIVED NOISE LEVELS FROM ENGINE RUNUPS

Number of Single Engine Runups per Period		Correction
Day (0700-2200)	Night (2200-0700)	
5 or less	3 or less	0
More than 5	More than 3	-5
Duration of Runup (in minutes)		Correction
Less than 1		-5
More than 5		-5
Time of Day		Correction
0700-2200		0
2200-0700		-10

TABLE 14

CHART FOR ESTIMATING RESPONSE OF RESIDENTIAL COMMUNITIES FROM COMPOSITE NOISE RATING

Composite Noise Rating		Zone	Description of Expected Response
Takeoffs and Landings	Runups		
Less than 100	Less than 80	1	Essentially no complaints would be expected. The noise may, however, interfere occasionally with certain activities of the residents.
100 to 115	80 to 95	2	Individuals may complain, perhaps vigorously. Concerted group action is possible.
Greater than 115	Greater than 95	3	Individual reactions would likely include repeated, vigorous complaints. Concerted group action might be expected

It is stressed that these expected responses apply only to residential areas within the respective zones.

Note that one Composite Noise Rating Scale in Table 14 applies to runups and another to flight operations. This emphasizes again (as in Step 5) that runups must be analyzed separately from flight operations. In the practical application of this procedure, therefore, we can derive two separate descriptions of community response for one particular geographic location. The more severe description (e.g., Zone 2 description as opposed to Zone 1 description) will, of course, represent the community response at that location to all operations. In Example 4, Section C, this combination of the zones describing flight operations with those describing runup operations is demonstrated.

Illustration of Step 6: For the Composite Noise Rating of 110 for takeoffs, as determined in Step 5, we see that the area in question lies in Zone 2 and that the corresponding expected community response is described as:

> "Individuals may complain, perhaps vigorously. Concerted group action is possible."

This sixth step completes the procedure. The end product of this analysis is a description of the average response we can expect from the residents of communities lying in the three zones derived from the procedure.

APPENDIX II

LIST OF AIR-FREIGHT ORIENTED INDUSTRIES OF MANITOBA

Name		City/Prov./State
A.E.I. Telecommunications	419 Notre Dame Ave.	Winnipeg, Man.
Acme Garment Ltd.	155 Alexander Ave.	Winnipeg, Man.
*American Hospital Supply	535 Marjorie St.	Winnipeg, Man.
Ames Taping Tools	409 Notre Dame Ave.	Winnipeg, Man.
Ames Taping Tools of Can.	409 Notre Dame Ave.	Winnipeg, Man.
Assiniboine Park Zoo		Winnipeg, Man.
Atomic Energy of Canada		Winnipeg, Man.
Bodner Fish Distributors		Winnipeg, Man.
Booth Fisheries	King & Sutherland	Winnipeg, Man.
*Bristol Aero Ind.	Wpg. Intl. Airport	Winnipeg, Man.
British Columbia Packers		Winnipeg, Man.
*Brooks Equip. Ltd.	King Edward	Winnipeg, Man.
*Can. Bristol Aerojet	Wpg. Intl. Airport	Winnipeg, Man.
*Can. General Electric		Pinawa, Man.
Canadian Sportswear	70 Arthur Street	Winnipeg, Man.
*Cargo Agent A C-Conee	Distbrn, Wpg.	
*Cargo Agent A C-Shipper	Assembly, Wpg.	
Carter, J.B. Ltd.	Osborne & Mulvey	Winnipeg, Man.
C.B.C.	541 Portage Ave.	Winnipeg, Man.
C.B.W.T.	541 Portage Ave.	Winnipeg, Man.
*Can. Aviation Electronics	387 Sutherland Ave.	Winnipeg, Man.
Can. Broadcasting Corp.	541 Portage Avenue	Winnipeg, Man.
Can. Co-op Imp. Ltd.	501 Bowman Ave.	Winnipeg, Man.
Can. Fish Producers	311 Chambers St.	Winnipeg, Man.
Can. Garment Co. Ltd.	515 Notre Dame Ave.	Winnipeg, Man.
*Can. General Electric Co.	945 St. James St.	Winnipeg, Man.
*Can. Laboratory Supplies	535 Marjorie St.	Winnipeg, Man.
Can. National Railways	All Departments	Winnipeg, Man.
Can. Pacific Air Service		Winnipeg, Man.
*Can.Westinghouse Co.Ltd.	1460 Ellice Ave.	Winnipeg, Man.
Chicago Kosher Sausage	358 Flora Ave.	Winnipeg, Man.
*Chrysler Corp.	Wpg. Intl. Airport	Winnipeg, Man.
Clarks	All stores	Winnipeg, Man.
Cohn D. Trans. Can.	Poplar & Levis	Winnipeg, Man.
*Construction Equip. Ltd.	661 Wall St.	Winnipeg, Man.
*Cummins Diesel	King Edward	Winnipeg, Man.
*Deere, John Ltd.	1500 Notre Dame	Winnipeg, Man.
*Delro Ind. Ltd.	860 King Edward St.	Winnipeg, Man.
Der Courier	Trinity & Alexander	Winnipeg, Man.

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*Industries located in the vicinity of the Winnipeg International Airport.

Diamond & Co	290 McDermot Ave.	Winnipeg, Man.
Display Industries	223 Archibald St.	St. Boniface, Man.
Dom./Soudack Fur Auction	294 William Ave.	Winnipeg, Man.
Dominion/Soudack Fur Auct.	294 William Ave.	Winnipeg, Man.
E.B.S. Import Ltd.	1765 Main St.	Winnipeg, Man.
Eaton, T. Co. Can. Ltd.	Retail Store	Winnipeg, Man.
Eaton, T. Co. Dept. 122	Mail Order	Winnipeg, Man.
Eaton, T. Co. Outbound only	Mail Order	Winnipeg, Man.
Eaton T. Co. Inbound only	Retail Store	Winnipeg, Man.
Fashion Ease Ltd.	332 Bannatyne Ave.	Winnipeg, Man.
*Federal Electric Corp.	Wpg. Intl. Airport	Winnipeg, Man.
*Finlay Fish Co.		Winnipeg, Man.
Fischer Bearings	940 St. James St.	Winnipeg, Man.
*Florist Supply	696 McGee Street	Winnipeg, Man.
Ford Motor Co.	1725 Ellice Ave.	Winnipeg, Man.
Frank Roy Ltd.	110 Princess Ave.	Winnipeg, Man.
Freed & Freed Ltd.	474 Hargrave St.	Winnipeg, Man.
Galion Mfg.	701 Henry Ave.	Winnipeg, Man.
*General Motors Corp.	Redwood & Fife	Winnipeg, Man.
Goldberg Bros. Ltd.	563 Notre Dame Ave.	Winnipeg, Man.
Gunn Garment Ltd.	70 Arthur Street	Winnipeg, Man.
Hudson Bay Co.	Retail Store	Winnipeg, Man.
Hudson Bay Raw Fur	235 Princess Street	Winnipeg, Man.
I.B.M.	All Departments	Winnipeg, Man.
Imperial Leather	447 Bannatyne Ave.	Winnipeg, Man.
Imperial Oil Co.		Winnipeg, Man.
*Ind. Fish Co.	941 Sherbrook Street	Winnipeg, Man.
Intl. Harvester Co.	660 Wall Street	Winnipeg, Man.
Jackson, G.N.	267 Maryland Street	Winnipeg, Man.
Jacob Crowley	49 Adelaide St.	Winnipeg, Man.
Jacob Fashions Ltd.	49 Adelaide St.	Winnipeg, Man.
*Johnston Nat. Air Frt.		Winnipeg.
Junior Wear Ltd.	515 Notre Dame	Winnipeg, Man.
Kane Equipment	1500 Waverly	Winnipeg, Man.
Kenwoods Exp. Air Frt.	c/o Security Storage	Winnipeg, Man.
Keystone Fisheries Ltd.	16 Martha St.	Winnipeg, Man.
Kipp Kelly Ltd.	68 Higgins Ave.	Winnipeg, Man.
Knitrite Mills	168 Market Ave.	Winnipeg, Man.
Kuehne & Nagel Canada Ltd.	439 Main Street	Winnipeg, Man.
La France Textiles	902 Home Street	Winnipeg, Man.
Leventhal, Mr. J.A.	376 Niagara St.	Winnipeg, Man.
*Lloyds Electronics	1546 St. James St.	Winnipeg, Man.
Lloyds Electronics	246 McDermot Ave.	Winnipeg, Man.

London Records of Can.	23 Keith Road	Winnipeg, Man.
Loveday Mushroom Farms	Mission & McTavish	St. Boniface, Man.
*Mack Truck Mfg.	Sask. & Madison	Winnipeg, Man.
Mallabar Ltd.	375 Hargrave St.	Winnipeg, Man.
Manitoba Bridge	845 Logan Ave.	Winnipeg, Man.
Manitoba Fisheries	303 Owena St.	Winnipeg, Man.
*Manitoba Hydro	820 Taylor	Winnipeg, Man.
*Manitoba Telephone System	489 Empress St.	Winnipeg, Man.
*Marshall Wells of Can. Ltd.	1395 Ellice Ave.	Winnipeg, Man.
Meadows Airfreight Ltd.	Wpg. Intl. Airport	Winnipeg, Man.
Mid-Central Fish Co.	61 Heaton Ave.	Winnipeg, Man.
Mid-West Musical	1012 Wall St.	Winnipeg, Man.
*Mid-West Mining Supplies	1100 King Edward St.	Winnipeg, Man.
Miller Hatchery Ltd.	260 Main St.	Winnipeg, Man.
*Mitchell Merchandice	545 Ferry Street	Winnipeg, Man.
*Monarch Wear		Winnipeg, Man.
Mooney, I.	281 James Ave.	Winnipeg, Man.
Moore Business Forms Ltd.	711 Erin St.	Winnipeg, Man.
Mr. J.A. Leventhal	376 Niagara St.	Winnipeg, Man.
*Nat. Air Frt. Fwdg.		Winnipeg, Man.
Natl. Cloaks	70 Arthur St.	Winnipeg, Man.
*Natl. School Studios	565 Roseberry St.	Winnipeg, Man.
*New Holland Machine	547 King Edward St.	Winnipeg, Man.
*Northern Electric Co.	Berry St.	Winnipeg, Man.
*Northland Fisheries	286 Gunnell St.	Winnipeg, Man.
Nuclear Enterprises	550 Berry St.	Winnipeg, Man.
Olympic Knit & Sportswear	55 Arthur St.	Winnipeg, Man.
Paddon Wholesale	3014 Henderson Hwy	Winnipeg, Man.
Peerless Garments	515 Notre Dame Ave.	Winnipeg, Man.
Pioneer Electric Co.	101 Rockman St.	Winnipeg, Man.
Polaris Industries		Beausejour, Man.
Powell Equip. Supply Ltd.	McGillivray Blvd.	Winnipeg, Man.
Price Acme of Can. Ltd.	639 Golspie St.	Winnipeg, Man.
Quality Records Ltd.	103 Princess St.	Winnipeg, Man.
*R.C.A.F.	All Stations	Manitoba
Rathwell Ltd. Thomas	575 Roseberry St.	St. James, Man.
Redboine Wholesale Floral	310 Donald St.	Winnipeg, Man.
Rice Sportswear	168 Market Ave.	Winnipeg, Man.
Robinson S.I.	292 Vaughan St.	Winnipeg, Man.
Royal Winnipeg Ballet	322 Smith St.	Winnipeg, Man.
S. & S. Sportswear Ltd.	290 McDermot Ave.	Winnipeg, Man.
*Scott Fruit	1200 Sargent Ave.	Winnipeg, Man.
Secters Ltd.	52 Albert St.	Winnipeg, Man.
*Simpson Sears	1515 Portage Avenue	Winnipeg, Man.

Sportease Fashions Ltd.	281 McDermot Ave.	Winnipeg, Man.
Sportsmaster Apparel	49 Adelaide St.	Winnipeg, Man.
Stall Cos. Ltd.	Peck Bldg.	Winnipeg, Man.
Stall Fur Co. Ltd.	Peck Bldg.	Winnipeg, Man.
Stall Sportswear	Peck Bldg.	Winnipeg, Man.
Stalls & Sons	Peck Bldg.	Winnipeg, Man.
*Standard Aero Engine Ltd.	Wpg. Intl. Airport	Winnipeg, Man.
Sterling Cloak Co.	110 Princess St.	Winnipeg, Man.
Sydney I. Robinson	292 Vaughan St.	Winnipeg, Man.
Syndicate Products	1725 Main St.	Winnipeg, Man.
Systems Equipment Ltd.	1595 Buffalo Place	Winnipeg, Man.
Trans-Can. Fur Dressing	Poplar & Levis	Winnipeg, Man.
United Garment Ltd.	328 Main St.	Winnipeg, Man.
Universal Printers Ltd.	158 James Ave.	Winnipeg, Man.
University of Manitoba		
*USAF Fed. Electric Corp.	Wpg. Intl. Airport	Winnipeg, Man.
Versatile Mfg Ltd.	1260 Clarence Ave.	Winnipeg, Man.
*Victoria Leather Jacket	1266 Fife St.	Winnipeg, Man.
Volkswagen Ltd.	1300 Inkster Ave.	Winnipeg, Man.
W.G. Bell & Co.	200-181 Pioneer Ave.	Winnipeg, Man.
*Western Aero Engine	410 Madison St.	Winnipeg, Man.
Western Glove Works	McDermot & Adel	Winnipeg, Man.
Western Shirt & Overall	55 Arthur St.	Winnipeg, Man.
White Truck Sales	1284 Portage Ave.	Winnipeg, Man.
Winnipeg Leather	310 Ross Ave.	Winnipeg, Man.
Winnipeg Whlse. Florists	1035 Winnipeg Ave.	Winnipeg, Man.
Woolworth, F.W. Co.	All Stores	Manitoba,
Zellers	All Stores	Winnipeg, Man.

APPENDIX III

MINIMUM FEDERAL ZONING REGULATIONS

Day VFR Airports: Flightway approaches should be free of obstructions that exceed 1 foot in height for each 20 feet in distance from the end of the basic graded area, to a distance of 3,000 feet therefrom. The approach surfaces should be at least 200 feet wide at the threshold and 1,300 feet wide at 3,000 feet from the strip engs. In addition, obstructions on either side of the strip should not exceed 1 foot in height for each 7 feet in distance measured at right angles from the edge of the basic strip.

Day and Night VFR Airports: If the aerodrome is to be used at night, flightway approaches should be free of obstructions that exceed 1 foot in height for each 40 feet in distance from the end of the basic graded area, to a distance of 6,000 feet therefrom. The approach surfaces should be at least 200 feet wide at the threshold, and 2,400 feet wide at 6,000 feet from the strip ends.

IFR Airports:

(a) Basic Strip: The basic strip which contains an instrument runway should include at least 500 feet on either side of the runway centreline and 300 feet beyond the threshold. The basic strip may be reduced in width to include 250 feet on either side of the centreline of those runways, at IFR airports, which are used by VFR traffic only.

(b) Approach Surface: The approach surface which is normally 1,000 feet wide at the end of the basic strip, extends upwards along the extended runway centreline at a ratio of 1:50 and broadens uniformly to a width of 4,000 feet at a distance of 10,000 feet. The approach surface may be extended further upward from the 10,000 foot limit at a ratio of 1:40.

(c) Transitional Surface: The transitional surface lies laterally along both sides of the graded basic strip and approach surface, and extends upwards at a ratio of 1:7 at right angles to the runway centreline measured from the edges of the basic strip and the edges of the approach surface, until it intersects the horizontal surface.

(d) Horizontal Surface: The horizontal surface is contained in a horizontal plane 150 feet above the elevation of the aerodrome reference point and its outer limits are located at a horizontal radius of 13,000 feet measured from the approximate geometric center of the landing area.

(e) Conical Surface: The conical surface slopes upwards and outwards from the periphery of the horizontal surface at a ratio of 1:20 to a height of (a) 350 feet above the horizontal surface where the longest runway is over 7,000 feet in length, (b) 150 feet above the horizontal surface where the longest runway is between 4,200 and 7,000 feet in length.

NOTE: For zoning purposes, highways,and railroads shall be considered as 14' and 20' obstructions respectively above the elevation of the highest grade within the area concerned.