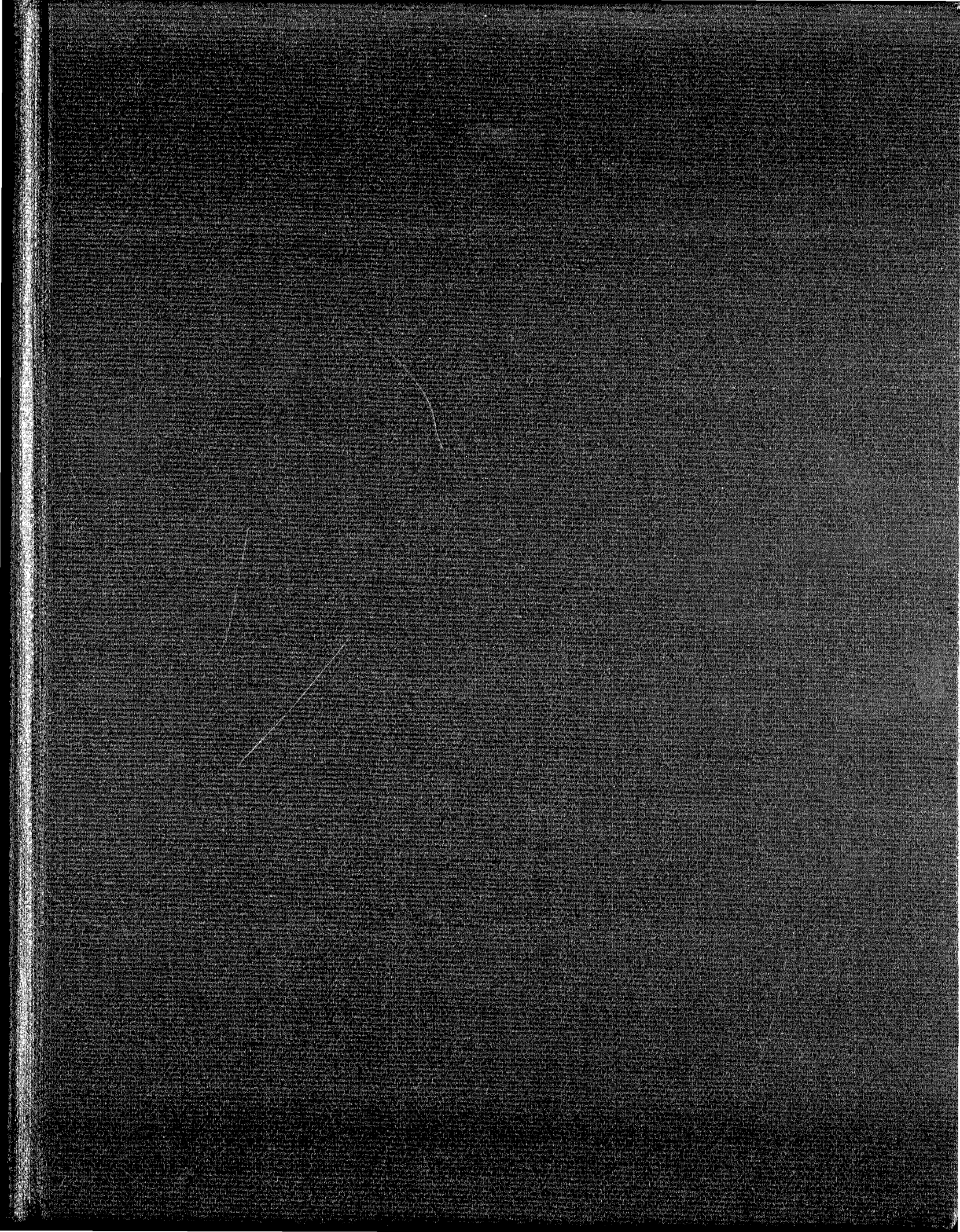

THE DEVELOPMENT OF THE AIR TRANSPORTATION INDUSTRY IN BRITISH COLUMBIA, 1900 - 1980

by

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ABSTRACT

The purpose of this essay is to examine the factors which played a role in shaping the spatial structure of the air transportation industry in British Columbia from the 1900's to 1980. The objectives of the essay are:

a) to identify and illustrate the spatial pattern of the commercial air transportation industry in British Columbia

b) to identify and analyze the conditions and factors responsible for the growth and expansion of the commercial air transportation industry.

The development of the air transportation industry in British Columbia is disaggregated into two distinct periods. The first period covers the time from 1908 to 1936 and the second period is from 1945 to 1980. Between 1937 and 1945 there is a transitional phase during which time virtually all commercial air transportation activities were temporarily halted. Each of the major periods is further disaggregated into two phases. Thus, the first period is broken into two phases between 1908 and 1918 and between 1919 and 1936. The second period is also divided into two phases, namely, between 1946 and 1960 and 1960 and 1980. Between successive phases there were fundamental changes in aircraft technology, entrepreneurial characteristics, economic conditions in Canada and British Columbia and in the air transportation regulations which had an impact on the structure of the airline network. Between 1908 and 1918, for example, the air transportation industry consisted of no more than experimentation and effectiveness tests of aircraft which took place in a number of larger cities in the province while the 1919 and 1936 phase was marked by the emergence of small scale commercial air transportation operations beginning with air mail, aerial photography and later, freight. The 1946 to 1960 phase witnessed the

beginning of the modern (but pre-jet) era in the commercial air transportation industry while after 1960 the commercial air industry became sophisticated and the air network structure more complex. To summarize the evolution of the air transportation network in British Columbia various measures of network structure are calculated for particular years between 1929 and 1979.

The essay identifies and discusses the interrelationship between technology, demand, organization, regulation and the spatial structure of the airline industry in British Columbia in the 20th Century. Information was obtained mainly from archival sources and extensive use is made of tables and figures to summarize selected characteristics of the airline network of British Columbia.

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I. INTRODUCTION

During the seventy years since the first practical heavier-than - air machine flew in British Columbia in 1910, the air transportation industry has developed into a complex network which connects the province with the national and international economy. The development of the commercial air transportation industry can be traced from the period immediately after World War I. The growth was gradual, however, until the outbreak of World War II.

The growth of the air transportation industry depended largely on rapid advances in aircraft technology and on changes in the provincial economy. Growth was particularly rapid after World War II. Aircraft technology, for example, changed from the piston engine aircraft of the 1940's and 1950's, to the turbo-propeller engine aircraft of the 1950's, to the early jet aircraft of the late 1950's and early 1960's, and to the wide-bodied jet aircraft of 1969 and the 1970's. The economic conditions favourable to investment in the air industry were the increase in natural resource development (both in the North and in British Columbia) and the increase in the levels of national and provincial income and savings which rose notably after World War II. In addition, there was a readiness among ex-War pilots, airline entrepreneurs and railway companies to invest in the air industry. Investment was also enhanced by a change in public attitude towards air transportation as a mode of transportation.

The nature and scope of the industry was altered as the type of investors in the air transportation industry changed from single,

owner/operator type investors to large-scale joint-stock investors. This transformation from small companies to large corporate airlines necessitated a well organized and better regulated transportation system. Indeed, the Federal Government involvement in the industry expanded to include not only technical and safety regulations but also the economic affairs of the commercial airlines. Thus, as of 1966, the route patterns for the commercial airlines within the domestic travel market began to be clearly defined and designated according to different airline classes (These classes are defined and discussed later in this paper). By the 1970's and the early 1980's, the provincial travel market was dominated by one trunk line, one regional airline and a substantial number of local service airlines.

Despite its remarkable growth, there are few studies of commercial air transportation in British Columbia. Duffy and Crane (1980), for example, examined the development of the air transportation industry in British Columbia as a whole. Their study, however, is restricted to the pre-1940 period and is a compilation of records, quotations, and perceptions by surviving pilots and airline operators who were actively engaged in early aviation in British Columbia. Another study by Anwick et al (1981) examined the development of the Vancouver International Airport from 1929 to 1979. As yet, there is no comprehensive and systematic analysis of the development of British Columbia's airline transportation system as a whole.

1.1 **Objectives and Scope**

The purpose of this study is to examine the factors which played a role in shaping the spatial structure of the air transportation industry in British Columbia from the 1900's to 1980. The objectives of the study are:

(1) To identify and illustrate the spatial pattern of the commercial air transportation industry in British Columbia.

(2) To identify and analyze conditions and factors responsible for the growth and expansion of the commercial air transportation industry.

For analytical purposes, the growth of the air transportation industry in British Columbia from 1900 to 1980 is disaggregated into two distinct periods. The first period covers the time interval between 1908 and 1936 and the second period covers the time span from 1945 to 1980. In between these major periods is a transitional phase covering 1937 to 1945. During this latter phase virtually all commercial air transportation activity was temporarily halted by the Federal Government due to World War II. The rationale for disaggregating the development of the commercial air transportation industry into two main periods is based on fundamental changes in aircraft technology, namely, the change from post World War I military aircraft (the low-wing cantilever monoplanes of Junkers, Fokker high-wing and Ford Tri-Motor high-wing monoplanes) to the modern jet aircraft.

Each of the major periods is further disaggregated into two phases. During the first phase of the first period, between 1908 and 1918, the air transportation industry consisted of no more than experimentation and effectiveness tests of aircraft which took place

in a number of the larger cities in the province. The commercial air transportation industry could be said to have come into existence after World War I. The second phase of the first period is between 1919 and 1936. This phase witnessed the emergence of small scale commercial air transportation operations beginning with air mail and air cargo experimentation in the early 1920's. These operations initially focused on the southern part of the province but by the late 1920's and early 1930's the network structure had expanded northward in response to various natural resource developments.

The second period is divided into two phases. The first phase is between 1946 and 1960 and marked the beginning of the modern era in the air transportation industry. Great expansion in the air transportation industry resulted because of advances in aircraft designs, emergence of a few large airline firms through mergers and acquisitions of smaller airline operators, and an increase in the air travel demand. The wider acceptance of air travel by the public influenced the increase in air traffic demand thus setting the stage for expansion of commercial aircraft capacity and route mileage. Hence, the expansion of the air transportation network followed.

The second phase of the second period is between 1960 and 1980. The significance of this phase lies in the increased sophistication of the commercial air industry, the intensification of the air network structure, and the classification of the air carriers into different categories.

1.2 Approach

The study analyzes the evolution of the air transportation industry in British Columbia through the identification of particular stages. The rationale for adopting such an approach is that over a period of time, the size, scope and nature of the airline network changes. The particular factors underlying these changes vary in relative importance. Moreover, it should also be recognized that the contemporary network has been very much influenced by decisions and developments in preceding periods.

There have been various empirical studies which have investigated the relationship between the factors shaping the air transportation industry and the network structure. For example, Wacht (1974), who studied the domestic air transportation network in the United States, found that technology, economic changes and government influence were important factors in shaping the network structure. Kanafani (1980) analyzed the relationship between aircraft technology and the network structure in short-haul air transportation in the Southeastern United States. He found that technology and economic characteristics of aircraft played an important role in the evolution of the air transportation networks. Studnicki-Gizbert (1960), Pendakur (1974), and Currie (1969) found the economic development and technology to have been the major factors which influenced the growth of the air transportation industry in Canada. Brooks (1966) observed that technological progress was the most important factor in the development of world air transportation. A few authors have adopted an historical perspective towards analyzing network structures. In one such study, for example, Fullerton (1975), identified geographical characteristics, population distribution, political influence,

and technology as the vital factors shaping the transportation networks of Great Britain.

The factors identified by these previous empirical studies are also relevant in analyzing the development of the air transportation industry in British Columbia. The study, by investigating the factors that shaped air transportation and its network in British Columbia, attempts to achieve two things. In particular, the study seeks to provide a better understanding and, second, an appreciation of the manner in which the air transportation industry has evolved in British Columbia and some of the underlying forces behind these developments. Thus, for each time period the factors shaping the network structure of the air transportation industry are identified and analyzed systematically. The general trends (growth and fluctuation) of the industry over the entire study period are also made explicit.

Finally, the structure of the airline networks is summarily described through the use of various aggregative network measures. The measures of network structure are calculated for particular points in time between 1920 and 1980. The purpose of using measures of network structure is to provide simple, comparative measures of the complexity and connectivity of the air transportation system between 1920 and 1980.

The various measures of network structure are well known and they have been described extensively in Kansky (1963), Garrison and Marble (1962 and 1965), Morlok (1967) and Taaffe and Gauthier (1973). In this study, the indices that measure the connectivity of networks are calculated. The connectivity indices include the

alpha and gamma indices, the cyclomatic number and the redundancy ratio. A few other indices which express the relationship between the arrangement of routes and the nodes within the network system are also calculated.

1.3 Data Source

The basic data for this study have been derived from secondary sources. The sources include archival records, government publications, annual reports from the British Columbia Aviation Council, relevant literature and periodicals.

For information on the early aviation in British Columbia archival records (from Vancouver City Archives and the Canadian Museum of Flights and Transportation) were used. These public records were supplemented by data from the Dominion Bureau of Statistics, Civil Aviation; statistics compiled by H.G. Brandreth in "The History and Economics of Canadian Commercial Aviation"; and Transport Canada records on early aircraft operations in Canada.

For the post World War II period (1947 to 1960) data were obtained from the air carrier reports to the Air Transport Board. The statistics from the air carrier reports were supplemented by other official compilations made by the statistics section, Department of Transport. Some additional estimates and calculations of derived statistics were published in K. Studnicki - Gizbert's (1960), the chief economist of the Department of Transport, "Structure and Growth of the Canadian Air Transport Industry".

The data for the period between 1960 and 1980 were obtained from Statistics Canada publications supplemented by annual reports

from a number of airline firms. The airline annual reports include those of Pacific Western Airlines and a few reports from third level carriers.

There are a few problems with the data on early aviation activity, with respect to consistency and quantity. Prior to 1936 there was no well organized system for traffic reporting at the Canadian airports. Most of the data available were compiled by individual researchers under the Air Transport Board. The statistics available from these compilations tend to cover only a few years so that there is a lack of continuity in the data. In addition, data are given on a national scale rather than provincial levels. These constraints limit the utilization of data to develop tables and graphs in order to analyze the development of the air transportation industry in British Columbia. Between the war years of 1939 and 1945 there is another break in continuity in the development of air carrier operations.

From 1941 to 1952 transborder traffic through Canadian air carriers was not published separately. Canadian Pacific Airlines, as well as Trans-Canada Airlines, operating between Seattle and Vancouver had American traffic which was classified domestic traffic. Although Canadian Pacific Airlines was a trans-continental airline its operation in British Columbia was considered a regional airline until the late 1950's.

Another problem with data prior to 1950 is that no clear-cut distinction was observed between the unit toll transportation and bulk transportation (charter and contract carriers). Therefore from 1944 to 1950 bulk operating revenues were reported under unit

toll operating statistics, for example, passengers, freight and mail. The difficulty imposed by the lack of classification between unit toll and bulk transportation is that it is difficult to identify and analyze the growth of the regional carriers separate from charter services.

The discrepancies between data from the 1940's to the 1960's are the result of the inconsistent methods of compilation. Prior to 1960 there was no well organized system of reporting and recording aviation statistics. Procedures of data collection and compilation became well organized and consistent in the 1960's with the rapid changes in technology, communication systems (remote sensing, radio transmitters) and the reporting system through air traffic control towers. As a result, data published prior to 1960 are not strictly comparable to data published subsequent to 1960.

Procedures of reporting and recording data on airline operations after 1959 were superior to previous methods. However, the data from Statistics Canada records are aggregative in character. For example, data on airline financial and operating statistics are given according to the classification of air carriers, levels I, II, and III, which are the dominant contributors in the commercial air transportation industry. The operating statistics for the trunk lines (level I), Air Canada and Canadian Pacific Airlines, and for the regional air carrier (level II), Pacific Western Airlines, are well classified on a monthly, quarterly and yearly basis. However, operating statistics for local air service carriers (level III) although given on a monthly, quarterly and yearly basis are reported mainly on a global scale, i.e. a national level. As a result, it

is difficult to identify the contribution of the third level carriers in British Columbia to the airline industry.

1.4 Format of the Study

The remainder of the study is divided into three sections. The next section presents early development of the air transportation industry from 1908 to 1936. The first part of this section gives a brief account on the influence of European, American and Eastern Canadian development in research in aircraft designs and the principles of aerodynamics. The second part of the section discusses the appearance of the early heavier-than-air machines in British Columbia flown by American pilots. This section also gives accounts on British Columbia's own aircraft inventions, aircraft designs and construction, experimental flights and air exhibitions.

The second section is the presentation of the growth of the air transportation industry after World War II, 1946 - 1980. The transition period between 1908 - 1936 and the 1946 - 1980 is briefly described prior to section three. The last section gives the summary and conclusion.

II. THE EARLY EVOLUTION OF THE AIR TRANSPORTATION INDUSTRY BETWEEN 1908 AND 1936

The development of the air transportation industry between 1908 and 1936 is divided into two phases: (1) the experimental phase from 1908 to 1918; and (2) the establishment of the commercial air transportation industry from 1919 to 1936.

2.1 The Experimental Phase, 1908 - 1918

By way of introduction to the first phase, a brief review of international development in aircraft technology provides relevant contextual material. There are two questions which are raised here. Why did the air transportation industry develop in British Columbia? Where did the ideas on aircraft technology and on the principles of aerodynamics come from and how did they come to British Columbia? In this latter regard it is clear that early ideas about the aircraft and aviation industry in British Columbia were initiated by a relatively small group of people. Enthusiasm in aviation was mainly among the people skilled in mechanical and electrical engineering. In Vancouver and Victoria (where aircraft were first adopted) aviation enthusiasts acted in response to the stimuli coming from an environment wider than their own. They were influenced by ideas and information from various sources such as European literature, American periodicals, as well as Canadian magazines and news bulletins from Eastern Canada. Thus, the British Columbian situation needs to be placed in an international context.

a) International Perspectives

The practical as well as the theoretical aspects of aircraft designs and construction were the result of the inventive abilities of the individuals who believed in the possibilities of flight. Various publications on aerodynamics were in circulation among engineers and mechanics in large cities even before the turn of the century. For example, Dr. Alexander Graham Bell, the inventor of the telephone, published his first paper on the "Kites with Radial Wings"

in 1899 in the National Academy of Science magazine (Ellis, 1962, pp. 10-12). In 1902 the Wright brothers, the American aircraft inventors, published a paper on their experiments with wind tunnels (Ellis, 1962, p. 3).

Research and development of balloons and aircraft (lighter-than - air and heavier-than-air machines) was going on at a faster rate in Europe than in the United States prior to 1910. By 1914, the Wright brothers' unstreamlined biplane was clearly outmoded by the German, French and British designs such as the Nieuport, Deperdussin, and Ponnier monoplanes and the Dornier, Handley-Page, and SE-4 biplanes (Statistics Canada, Cat. 51-501). In Europe there were even planes that could fly at a cruising speed of 130 miles per hour before World War I.

Parallel to aviation research and aircraft development in Europe and the United States were the private research activities in Eastern Canada in theoretical aspects of aeronautics and in practical flights (Milberry, 1979, p. 12 and Ellis, 1962, p. 3). The two outstanding aeronautical researchers in Eastern Canada were Wallace Rupert Turnbull of Rothesay, New Brunswick and Alexander Graham Bell of Cape Breton, Nova Scotia. Dr. Bell had been interested in the possibilities of flight long before the historic flight of the Wright brothers in 1903. For many years he had conducted various experiments with large kites of different designs in attempts to find out what types of lifting surfaces were most effective. He had established a flight research centre right at his summer home at Baddeck, Nova Scotia. Similarly, the research centre established by Wallace Rupert Turnbull of a wind tunnel was near his home. Turnbull was interested in

both theoretical and practical aspects of flying. Like Dr. Bell he conducted numerous experiments on different forms of flights ranging from flapping-wing ornithopters, to helicopters, airscrews, aerofoils, hydrofoils and paddle wheels. Through his experiments he discovered the use of propellers to produce the lift force for an aircraft. Turnbull's propeller was his main invention and lasting contribution to the aviation industry.

One of Turnbull's influential papers was published in 1909 (Ellis, 1962, p. 3). His paper was on the forms and stability of aeroplanes. Turnbull discussed the concepts of dihedral wing angles (two straight built wings), ground effects, and aerofoil construction. The impact of Turnbull's concepts was seen in the incorporation of aerofoils in the aircraft designs a few years after the spread of his concepts.

b) **The Situation in British Columbia**

In British Columbia the influence of the concepts of dihedral wing angles and use of aerofoils in aircraft design was seen in the work of William Wallace Gibson of Victoria. When Gibson built his second aircraft, a massive multi-plane, in 1910 he incorporated aerofoils resembling venetian blinds. The aerofoils produced the lifting force for the aircraft.

In British Columbia, Gibson was an equivalent of Turnbull in practical achievements. He was mainly interested in practical aeronautics which led him to the development of the first Canadian aero engine (a 210 pound, 60 horsepower engine) in 1908 (Vancouver, Matthew's collection 1933). His engine was used successfully in

both of his aircraft in 1909 and 1910. Like Turnbull, Gibson invented propellers which rotated in opposite directions creating a zero torque or twist (Pendakur, 1974, p. 8 and Aviation in Canada, Cat. 51-004, p. 127). This kind of propeller was used in both of his aircraft, the twin plane and multi plane as a means of propulsion for the aircraft. Gibson also introduced the use of battery ignition as a starting mechanism for aircraft which was an advanced step in the aviation of his time. It is true that aircraft ideas spread from Europe, the United States, and Eastern Canada. However, as it has been mentioned above, some of the earlier aviators in British Columbia showed their own ingenuity and originality in their inventive abilities.

The information flow and ideas on aircraft designs and the principles of aerodynamics appeared to spread across Canada from the Eastern provinces in a roughly hierarchical way. The ideas on aviation activity leapfrogged from one big city to another and temporarily bypassed small urban centres in each province. According to archival records and other sources of information, it is apparent that large urban centres in Canada such as Toronto, Winnipeg, Edmonton, Calgary, Vancouver and Victoria adopted aviation ideas first before they spread to smaller cities. For example, when the ideas on aircraft designs and the theoretical and practical aspects of flying reached British Columbia, they were first accepted in the two main commercial cities, Vancouver and Victoria. It took a few years before aviation was carried out to other cities such as those in the interior of British Columbia. Furthermore, when the ideas and information flow on aircraft designs and construction reached

Vancouver and Victoria they were accepted by a certain class of people primarily engaged in engineering, mechanics and shipbuilding. Between 1908 and 1910, prior to the appearance of the American stunt flyers in British Columbia, a few young men in Vancouver and Victoria were involved in aircraft designs and construction. They did not have formal training but followed instructions from various publications. A good example of such informal aircraft construction projects was the project undertaken by the Templeton brothers, William and Winston with their cousin, William McMullen. The construction of their aircraft began in 1909 in the basement suite of William McMullen's place in the West End of Vancouver (Vancouver, MSS. 54. Vol. 13, pp. 1-3). The construction of their aircraft was based solely on the information from books, magazines, and newspapers.

Apart from being skilled in engineering and in mechanics, the people who were interested in aircraft building and in the possibilities of flying were either from wealthy families or they had made money in their businesses. Aircraft projects were expensive and required good financial support including, with respect to spare parts such as engines, which had to be obtained either from Europe or the United States. Apart from aircraft engines, repeated tests of the effectiveness of the aircraft resulted in broken parts. The rebuilding and repairing of the aircraft required spare parts at a certain cost. In most cases, some of the aircraft parts had to be ordered from New York, Chicago or from Europe. The costs had to be met through the individual's own finances. During the early years of aviation aircraft projects were isolated ventures and there were no joint-stock finances to support aircraft construction.

Obviously, people who were interested in aviation and involved in aircraft experimentation had to have sufficient funds to support their projects.

William Gibson, for example, had made a considerable fortune in the mining industry in Victoria before pursuing flying as a hobby in 1910 (Duffy & Crane 1980, p. 2). William Stark, the first person to possess an official pilot's licence in British Columbia, was the son of a businessman in Vancouver, James Stark. One can infer that William (Billy) Stark was financially successful. For example, Billy was credited with driving the first gas-engined automobile in Vancouver in 1901. Fortune having favoured him with material means he was also able to pay his tuition fees at the Curtiss Aviation School in San Diego and purchase his own aircraft.

It has already been mentioned that aircraft ideas and techniques in British Columbia were first adopted in the two major cities, Vancouver and Victoria. The area which became the action place for experimental flights and aircraft testing soon after the introduction of aircraft ideas in Vancouver was Minoru Park. Minoru Park had been created as a racetrack located on farm lands of Lulu Island in Richmond. The racetrack was named after a famous racehorse in the Royal Stables, which was a favourite horse of Edward VII. Tents were set up at Minoru Park and used as hangars for the first aircraft, starting in 1909 with the construction of the McMullen-Templeton aircraft. The additional improvised landing air fields were established between 1912 and 1916. The geographical distribution of the early landing fields in the Vancouver area is given in Figure

1 (see also Table 1a and Appendix 1). These airstrips were primarily chosen on the basis of their quality and geographical advantages, that is, relatively flat areas beyond the city limits. In some cases the airstrips were simply cleared fields on the fringes of Vancouver. For example, Hastings Park which in 1912 was beyond the limits of Vancouver and required trees to be removed to accommodate a landing area. In collaboration with the Vancouver Exhibition Association the pilots cleared the forest and provided an airstrip that was more accessible than Minoru Park. The air shows at Minoru Park were not attracting large crowds after 1911. To attract more people the pilots decided to move exhibition flights to a more convenient location near the city where people could reach the exhibition site by car, bicycle or walking.

The disadvantages of Hastings Park were that it was hedged in on three sides by fir and cedar trees while on the fourth side it opened directly onto Burrard Inlet. However, the early aircraft were quite small and did not require long runways for takeoffs or landings. They could take off and land within a short distance and consequently did not need large areas.

The first heavier-than-air flight in Vancouver took place at Minoru Park on Lulu Island near Richmond on March 25, 1910. Charles Hamilton from Seattle, Washington made several flights between March 25 and 28. On one occasion he ventured up the Fraser River to New Westminster in 30 minutes. This was the longest flight made thus far. On the last day of the air show Hamilton set up a race against a racehorse over a distance of one mile. He lost the race. The first day of the air show drew a crowd of 3,500 at an admission

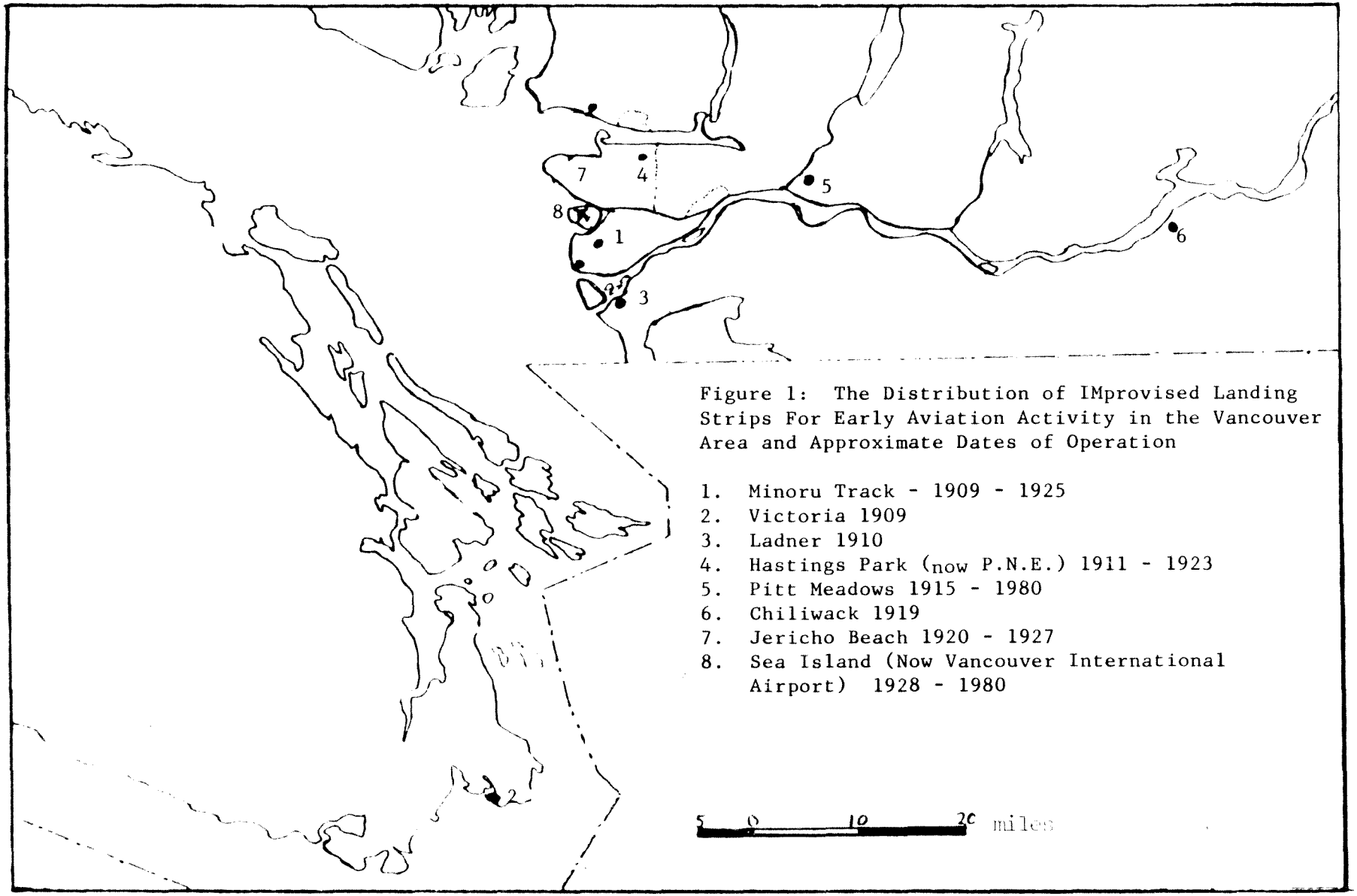


Figure 1: The Distribution of IMprovised Landing Strips For Early Aviation Activity in the Vancouver Area and Approximate Dates of Operation

1. Minoru Track - 1909 - 1925
2. Victoria 1909
3. Ladner 1910
4. Hastings Park (now P.N.E.) 1911 - 1923
5. Pitt Meadows 1915 - 1980
6. Chiliwack 1919
7. Jericho Beach 1920 - 1927
8. Sea Island (Now Vancouver International Airport) 1928 - 1980

fee of $1.00 per person. Access to the air show was provided through special trams by the British Columbia Electric Railway from Granville Street across Marpole Bridge to the tram station near Minoru Park (Vancouver, MSS. 54 Vol. 13).

The years between 1910 and 1916 introduced exhibition flying to British Columbia. The participants in the exhibition flights were American stunt pilots and British Columbia's own aviators. However, in the first few years, exhibition flights were mainly dominated by American pilots flying American aircraft which were technically superior models to those found in British Columbia. The predominance of American pilots was due to the lack of organized flight instructions, aircraft designs and manufacturers in British Columbia as well as Canada as a whole. Clearly, contact with American aviators had an important influence on the aviation industry in British Columbia. As an example, after the air shows staged by Manning Brothers and Jack DePries in 1911, all of whom were American, Bill Stark, a young famous Vancouver automobile racer, became fascinated by the flying skills demonstrated by DePries. A few months after that air show Billy went to the Glenn Curtiss Aviation School in San Diego, California (Vancouver, Folder 24).

The second influence of personal contact with American pilots was that aviators in Vancouver and Victoria adopted the ideas of exhibition flights and began to carry them to other urban centres in British Columbia. The aviation ideas introduced to the cities stimulated the possibility of generating the market for this new mode of transportation. By 1913 the air shows began to spread to the interior of British Columbia through national agricultural fairs

held occasionally by individual cities. The fairs served as a means of promoting aviation activity while stimulating interest in aviation among young people. As a result, a few training schools were founded in Vancouver and Victoria as well as in a few cities in the interior of British Columbia, particularly Kamloops, Vernon, Rutland, and Kelowna. The flying schools were either sponsored by the Aero Club of British Columbia which was founded in 1915, or by individual aviators in an attempt to raise aviation consciousness among young people as well as a means of earning salaries for their skills.

The distribution pattern of exhibition flights in British Columbia is shown in Figure 2. The prominent feature of the spatial pattern of the aviation activity evident in Figure 2 is the lack of connectivity between the cities where exhibition flights took place. The nodes appear in a scatter pattern without linkages. In fact, during the first decade of aviation in British Columbia aircraft were incapable of flying long distances. Consequently, air routes to connect cities could not be developed until the 1920's. Between 1910 and 1915 the typical aircraft could at the most take off and rise to an average height of 500 feet and fly a distance of a few hundred feet to a mile at approximately 20 to 30 minutes depending on the type of engine used. For example, Gibson's first twin-plane in 1910 made several successful hops at a distance ranging from 100 to 200 feet at a height of 20 to 25 feet. There were exceptionally successful flights where the aircraft could rise to a height exceeding 1,000 or 2,000 feet and could fly at a cruising speed of between 50 and 75 miles per hour (Pendakur, 1974, p. 7). Alys McKay, an American female pilot is a good example who, at the air

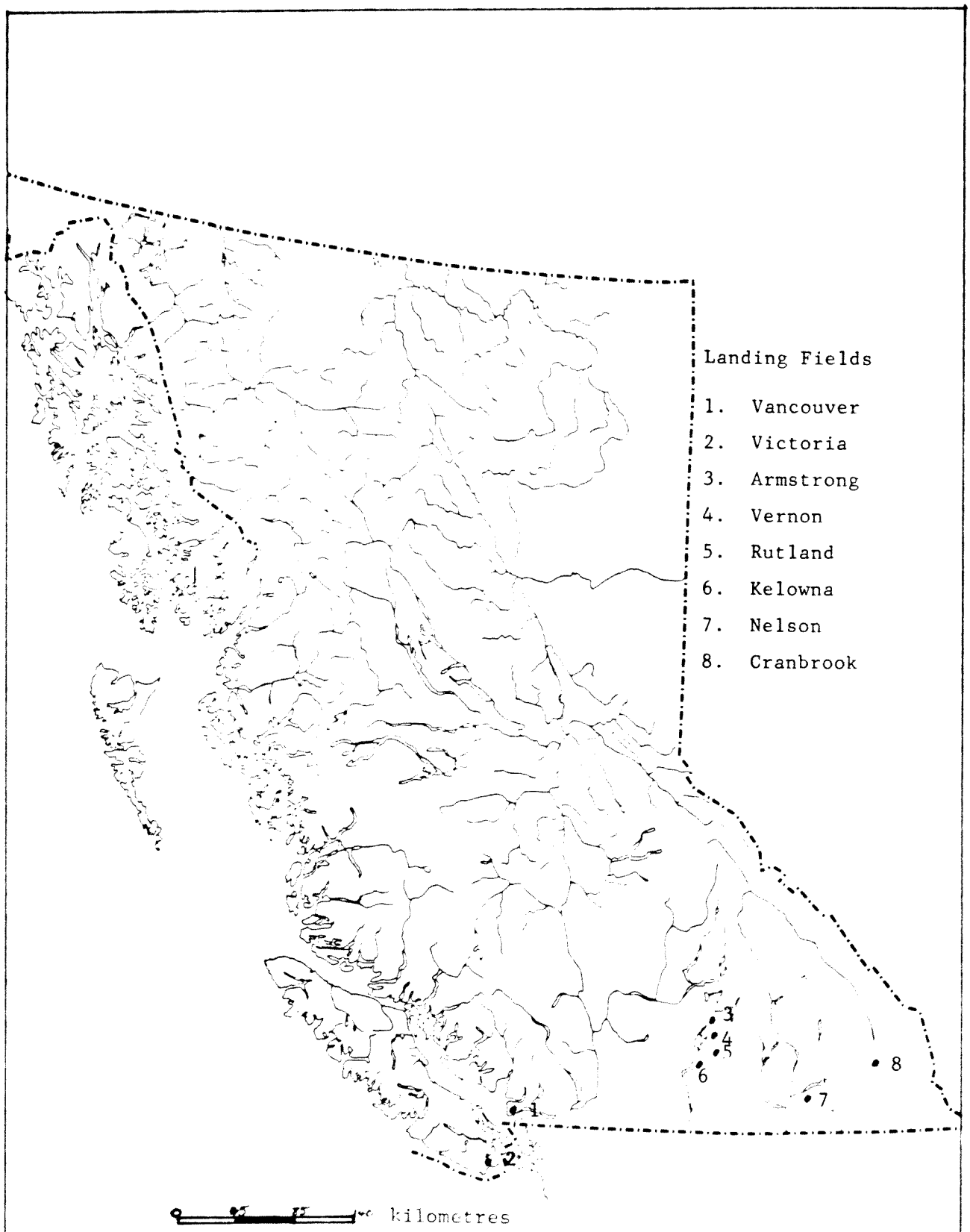


Figure 2: The Spatial Distribution of Early Aviation Activity: British Columbia, 1910 - 1916

show at Minoru Park in 1913, established an altitude record of 2,200 feet and flew at a relative speed of 75 miles per hour (Duffy and Crane 1980, pp. 7-8).

The establishment of air routes as links between cities where aviation activity was carried out was also affected by aircraft configurations which were inevitably cumbersome and wreathed with struts, wires, wood, fabric and other air-resistant protuberances. These crude frameworks rendered the early aircraft unsafe and unreliable. The improper designs restricted the early aircraft from flying at high altitudes at a fast speed. Although there was a substantial improvement in aircraft designs and manoeuverability the aircraft were still uncovered. It was difficult to fly at high altitudes with high wind velocity and uncovered fuselages. Moreover, it would have been hazardous to both the pilots and passengers. In the uncovered aircraft the passengers would be perched on the front edge of the lower wing with their feet dangling over in space. As might be expected, the pilots themselves paid dearly for their experimental flights. Many of them died in aircraft crashes and those who survived such accidents contacted pneumonia from exposures in the open cockpit of their aircraft.

The sporadic and isolated patterns of the aviation activity prior to 1920 reflect the character of the industry itself. Prior to World War I, aviation was purely experimental. Aircraft construction in British Columbia consisted of personal experimentation by inventive individuals with strong convictions in the possibilities of flights. The tests of the effectiveness of aircraft were done locally and if an aircraft proved to be successsful then exhibition

flights would be scheduled to different cities holding annual fairs. However, even though aircraft would prove to be effective when tested, they were still limited in their operations by both technical aspects and technical flying skills of the pilots. Consequently, aircraft could not attract air traffic between urban centres. The common procedure was to crate the aircraft and ship the aircraft parts by rail. At the destination the aircraft would be assembled immediately before the air show began.

Notable improvements in aircraft designs and in flying techniques were experienced after World War I. The pressure of the needs of the War changed the crudely built aircraft into better equipment. Thereafter, the advantages of air transportation began to receive wider recognition from the public and private companies.

2.2 The Development of Early Commercial Air Transportation 1919 - 1936

The commercial air transportation industry did not begin until the 1920's even though aviation dates from the early 1900's. It evolved as a byproduct of military aviation. The over-production of aircraft during the War years in Canada left a surplus of militar, aircraft on the post-War market. Consequently the price for aircraft dropped, particularly the Jennies. A Jenny, for example, could be purchased at a price ranging from $2,000 to $3,000 (Vancouver, MSS. 54, Vol. 13, pp. 1-6). As a result, a large number of small airlines sprung up throughout the country. Anyone with an interest in aviation and enough money could buy one or two aircraft and start a flying business. Furthermore, there was a surplus of

ex-War pilots who had returned from the War and were without jobs. Some of them were determined to continue flying as a career.

The commercial air transportation industry after the War was organized by a large number of small owner/operator airlines. Some of the pilots had formed small partnerships with friends and relatives. Air transportation was deceptively easy in this period. The government had no regulatory control on licences and there was no proof of competence required to enter into the air transportation industry. Once in the cockpit, the pilot/owner was in business, whether barnstorming, exhibition flying, or running an air taxi.

In British Columbia, the early part of commercial air transportation was characterised by stunt flying, aerial shows, sightseeing flights, air mail experimentation, and forest and fisheries patrols. The ex-War pilots popularized air transportation by barnstorming flights in every big city and town in British Columbia. During the first decade of commercial flying there was no demand for air travel. Commercial flying depended entirely on the creativity and ingenuity of the individual pilot to generate air traffic. In order to make commercial flying profitable and promote it as a mode of transport, the airline operators established the Aerial League of British Columbia in 1920. This league was actually the branch of the Aerial League of Canada inaugurated in 1915 by pilots in Toronto. Its objective was to convince the government and the public of the potential value of air transportation; for even though the government had been involved in aviation during the War, it was still skeptical about the potential advantages of civil aviation. The League's objective was implemented through air circuses (air shows),

air excursions (sightseeing) and exhibition flights which were staged at the annual fairs and town exhibitions in different cities in southern British Columbia. By 1924 other activities were added, such as timber cruising, aerial photography, forest patrols, forest spraying, fisheries patrols, detection of rum runners, surveys and mapping and agricultural spraying. These flying operations laid the foundation for commercial air transportation. Bush flying to northern British Columbia and as far as the Northwest Territories began as an offshoot of industrial flying activities, namely, survey mapping and observations.

The first airline to venture into forest and fisheries patrols and aerial photography was Pacific Airways. This airline obtained the provincial government contract to operate forest and fisheries patrols on the coastal areas from Vancouver Island to Queen Charlotte Islands and to Prince Rupert. Pacific Airways had 2 HS2L flying boats, a Boeing flying boat and a Vedette which it operated out of two main air bases, Jericho Beach and Swanson Bay. There were other intermediate landing areas along the coast. Forest and aerial photography flying activities were operated out of Jericho Beach and fisheries patrols out of Swanson Bay, a strate_ _ location for detecting poachers, rum runners and smugglers.

There were other small airlines which began to match the operations of Pacific Airways, doing industrial flying as well as offering charter services. The Pacific Aviation Company of Vancouver, Vancouver Island Aerial Transport and the Commercial Aviation School of Victoria were among the first airlines to dominate forest patrols, aerial photography and surveys and mapping. Their flying operations

influenced private companies engaged in forest products, petroleum and mineral exploration companies. For example, Imperial Oil Ltd. and Shell Oil Company recognized the advantages of using aircraft for their business activities in the early 1920's. As early as 1923 they began to hire airline companies to transport men, equipment, and supplies from Vancouver as well as from Calgary and Edmonton to oil discovery areas in the norther part of British Columbia and in the Northwest Territories (Imperial Oil Review, 1946, pp. 26-28). Apart from the oil companies, government agents and private companies involved in forest products realized the potential of aircraft in mapping, surveys and aerial photography. For example, the Topographic Division of the British Columbia Department of Lands and Forests and other companies in the mining industry such as Rico Copper Mines Ltd. began using aircraft for some of their operations (Canadian Museum of Flight, Carl C. Agar, p. 195). As a result, the airline companies began doing services such as geological surveys, mapping, filming and aerial photography for government agents. Mining companies used the airlines for mining and exploration activity. The demand for airline services in these areas had a substantial impact on the airline industry. Bush fliers, who [illegible]rated charter services to northern British Columbia and to the North came into being partly as a result of the demand for air services in forestry and mineral exploration. Records are not available for most of the operations of the bush fliers, but a report released by Canadian Airways (Pacific Airways) in 1928 pertaining to bush operations in British Columbia is probably quite typical. There were probably 20 airline operators in British Columbia between 1924 and 1926. This number includes

flying clubs and training schools. Passenger fares ran from 60¢ to 65¢ per passenger mile; freight at about $4.00 per ton mile (Main, 1967, pp. 59-60). At such rates it is doubtful whether the airlines made any profit.

Air mail transportation is another aspect of aviation that contributed to the early development of the commercial air transportation industry. Air mail experimentation began as a publicity stunt on March 3, 1919 when Eddie Hubbard, an American pilot for the Boeing company in Seattle, offered to carry a sack of mail from Vancouver to Seattle. The exercise, the carriage of mail, had substantial effects. It set a precedent for the approval of similar undertakings and after that, a number of air mail flights followed.

The same year Ernest Hay carried air mail from Vancouver to Lethbridge and Calgary. Captain Trimm carried air mail from Vancouver to Kelowna and to Vernon. So did Eckley and Hall between Vancouver and Victoria. Air mail services were somewhat sporadic but continued although without regularity until 1927 when a breakthrough took place. Selected characteristics of early air mail experimentation flights have been tabulated (Table 1a).

Air mail services were not subsidized by the post office. The position taken by the post office was permissive. It merely gave permission to carry mail but did not offer financial support. However, it allowed the airline operators to place a 25¢ sticker on the letters as a way of compensation. The lack of government financial support dictated a limited success for the early air mail flights. Despite the lack of encouragement from the post office, department air mail flights gave a considerable impetus to the concept

Selected Characteristics Of Airline Operations Between 1910-1917 - Table 1a

Date of Occasion	Owner/ Operator	Head Office	Aircraft Type	Airstrip	Routes	Function
March 25, 26,28, 1910	C.K. Hamilton	New York	Curtiss biplane (1 seat)	Minoru Park	Along Fraser River to New Westminster	Exhibition flights
September 8,1910-1912	W.Wallace Gibson	Victoria 1908-1911 relocated to Vancouver 1911-1913 relocated to Kamloops 1914-1917. Relocated to Calgary	Twin-plane (1 seat) multi-plane (1 seat)	Dean Farm Minoru Park Ladner (Peterson Farm)	Local	Experimental flight tests Exhibition flights
April 11, 12,14,15,17 1911	Manning Brothers	Portland Oregon	Curtiss bi-plane (1 seat)	Minoru Park	Local	Exhibitions
April 28 1911-1912	McMullen-Templeton Brothers	Vancouver	Tractor-bi-plane (1 seat)	Minoru Park	Local	Tests and exhibition flights
1911	Mr. Pomley	U.S.A.	Curtiss Jenny (1 seat)	Hastings Park		Exhibitions
April 20 1912	Billy Stark	Vancouver	Curtiss pusher (1 seat)	Minoru Park	Local	Exhibitions
1912-1913	Bill Stark	Vancouver	Curtiss (2 seats)	Hastings Park & Minoru Park	Local	Exhibitions

Selected Characteristics Of Airline Operations Between 1910-1917 Table 1a cont'd

Date of Occasion	Owner/ Operator	Head Office	Aircraft Type	Airstrip	Routes	Function
1913-1915	Billy Stark	Vancouver	Curtiss bi-plane (2 seats)	Interior B.C.	Regional routes	Barnstorming at fairs
May 24 1912	Phil Parmalee	U.S.A.	Curtiss Jenny (1 seat)	Hastings Park		Exhibitions parachute jumps
July 31 - August 6 1913	Alys Bryant	U.S.A.	Curtiss-pusher (1 seat)	Minoru Park		Exhibitions
	John Bryant	U.S.A.	Curtiss-pusher (1 seat)	Victoria Harbor		Exhibitions
1915-1917	Aero Club of B.C.	Vancouver	Curtiss-pusher (2 seats)	Minoru Park Pitt Meadows	Local	Flying schools
1916-1919	Hoffar Brothers	Vancouver	Seaplane H-1 (1 seat)	Burrard Inlet	Local	Experimental flights
1917	Hoffar Brothers	Vancouver	Seaplane H-2 (2 seats)	Burrard Inlet	Local	Experimental flights
July 17 1917	Jim Hoffar	Vancouver	Flying boat H-2 (2 seats)	Burrard Inlet	Downtown Vanc. and West End	Passenger flight (news reporter)
1918	Hoffar Brothers	Vancouver	Seaplane H-3 (2 seats)	Burrard Inlet	Local	Tests
Sept. 4 1918	Lieutenant V. Bishop	Vancouver	Flying boat H-3 (2 seats)	Burrard Inlet	Local North Shore West End	Tests

Source: Archival records and personal research files.

of commercial flying. The air mail services had three effects. First, it offered a revenue-generating commodity (air mail) which became a revenue base for the new commercial system. Secondly, it proved that the airline operators could generate sufficient demand to assure an economically viable air transportation service. For example, the air route between Vancouver and Seattle established in 1919 by the first international air mail service between the two major cities (Vancouver and Seattle) was shortly followed by the Vancouver-Victoria air route, thus forming a triangle air route (see Figure 3). By the end of 1920 the air mail route was extended to include Nanaimo. By 1922 there were already three airlines competing over these routes. They were not only carrying air mail but also passengers and freight. As early as 1920 some of the businessmen in Vancouver, Victoria and Seattle had realized the benefits of using aircraft in their business interests. In Vancouver the J.W. Kelly Piano Co. Ltd. was among the first companies to use the airlines in its business activity. Canadian Airways was already providing profitable services, operating a fleet of 6 aircraft (Glazebrook, 1964, pp. 260-261).

The third effect of the air mail experimental flights is that they laid the basis for the need of navigational facilities and for night and all-weather flight techniques. The intercity air mail operations in urban centres required regular deliveries and reliability calling for the all-weather day and night service. The early air mail operations were on a somewhat flexible schedule but by the mid-1920's relative regularity in air mail delivery was required and the government began to install rotating beacons and

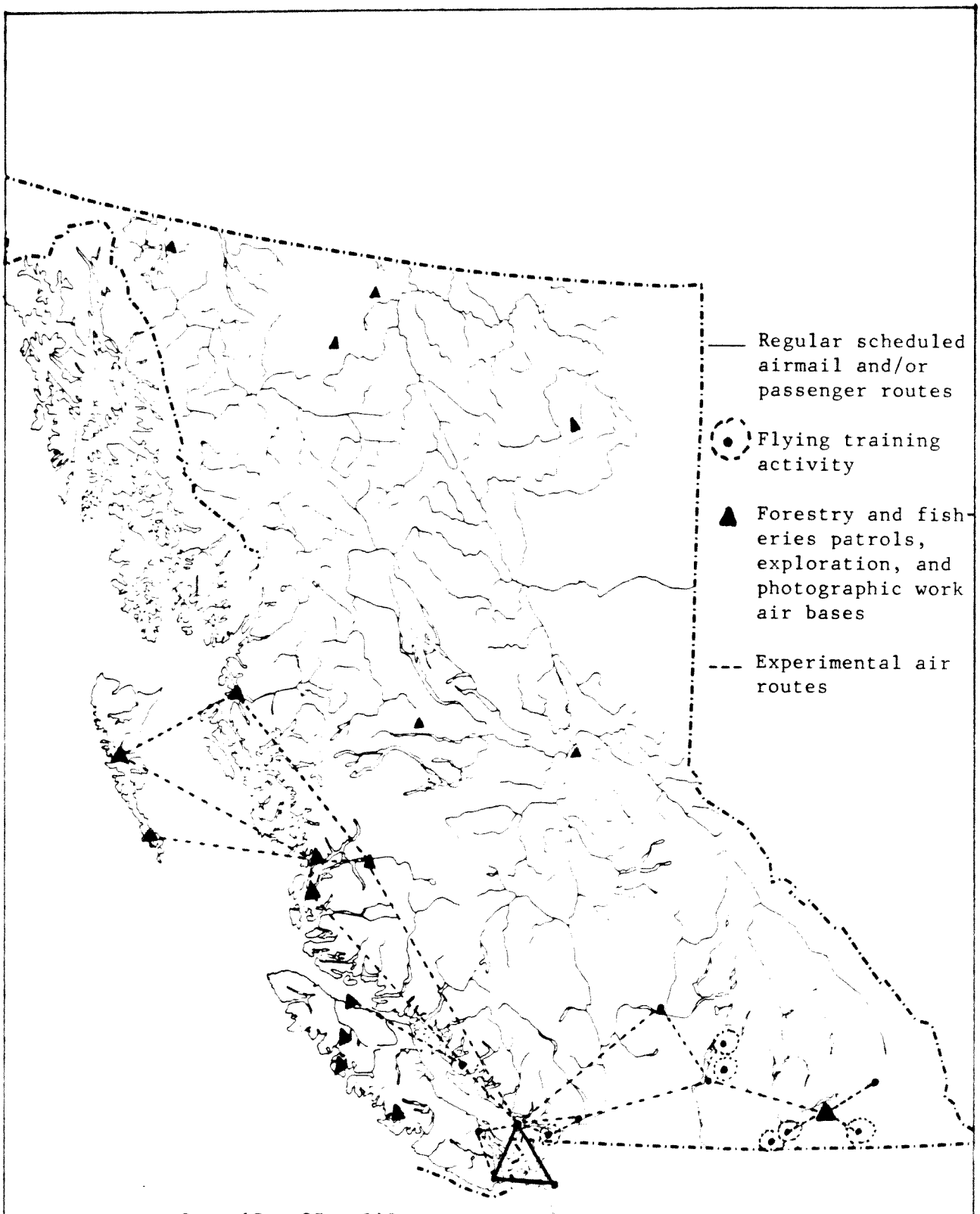


Figure 3: Geographical Distribution of Aviation: British Columbia, 1929

radios and other navigational aids in the bigger airports such as Vancouver, Victoria and the interior of British Columbia.

The main impetus for the growth of commercial air transportation during the mid-1920's was the development of natural resources in British Columbia. Gold mining and mineral exploration, in particular, provided a strong impetus to northern British Columbia and coastal aviation. Mining in these parts of the province paralleled the development of natural resources in the Canadian North. Mining in the North underwent a period of rapid growth in the mid-1920's. The underlying influences were the decline in price levels, currency devaluation, and the American revaluation of gold (Toombs and Stewart, 1966, pp. 154-156). Such actions encouraged the use of gold as a stable monetary system. Canada was in need of the U.S. dollar and it was therefore necessary for Canada to increase her supply of gold. The demand for gold lead to unrestrained mining expansion and mineral exploration which affected not only British Columbia but Canada as a whole. The search for mineral wealth and forest resources in northern British Columbia and on the coastal areas added a new dimension to the air transportation industry. The ability of the aircraft to penetrate areas inaccessible by other modes found an increasing use in mineral exploration and in opening up new mines in remote areas. Air transportation proved advantageous particularly in British Columbia because of the physical feature of the province, a mountainous terrain making the construction of roads and rail in many parts of British Columbia both difficult and costly. The construction cost of roads in British Columbia, as an example, was estimated to be more than $1,000,000 per mile. This included tunnels

but not bridges. A good example is the Cariboo Road which had to be cut through the rock wall of the Fraser Canyon in the 1860's. Air transportation in the 20th Century was seen as a better alternative mode in terms of its ability to reach the remote areas. Mining camps in remote areas and other isolated communities along the coast as well as in northern British Columbia needed to be connected to Vancouver, Victoria and other large cities in the interior of British Columbia. As the upsurge in mining and mineral exploration continued, flying operations expanded rapidly. Bush flying expanded considerably via charter services, however, regular scheduled services were established and by 1930 nearly all small communities were being served by air services (see Figures 3 and 4).

The demand for air services in the North, northern British Columbia and in the coastal areas changed the network pattern in southern British Columbia. The airlines providing air services in the interior of British Columbia abandoned their routes to take advantage of the air traffic in the mining areas. Low traffic density per carrier in the interior routes was due to intermodal competition. The airlines were in competition with surface modes, particularly the rail. Passenger and freight transportation in southern British Columbia was largely dominated by rail in the 1920's and 1930's. Rail was cheaper than airlines and therefore received a larger proportion of traffic than the airlines. Consequently, when the airlines were attracted by the market for mining activity they discontinued temporarily the interior British Columbia routes. By 1929 a number of airlines began providing air services to the mining communities on the coast. In 1929 the Ginger Coote Airways discontinued the

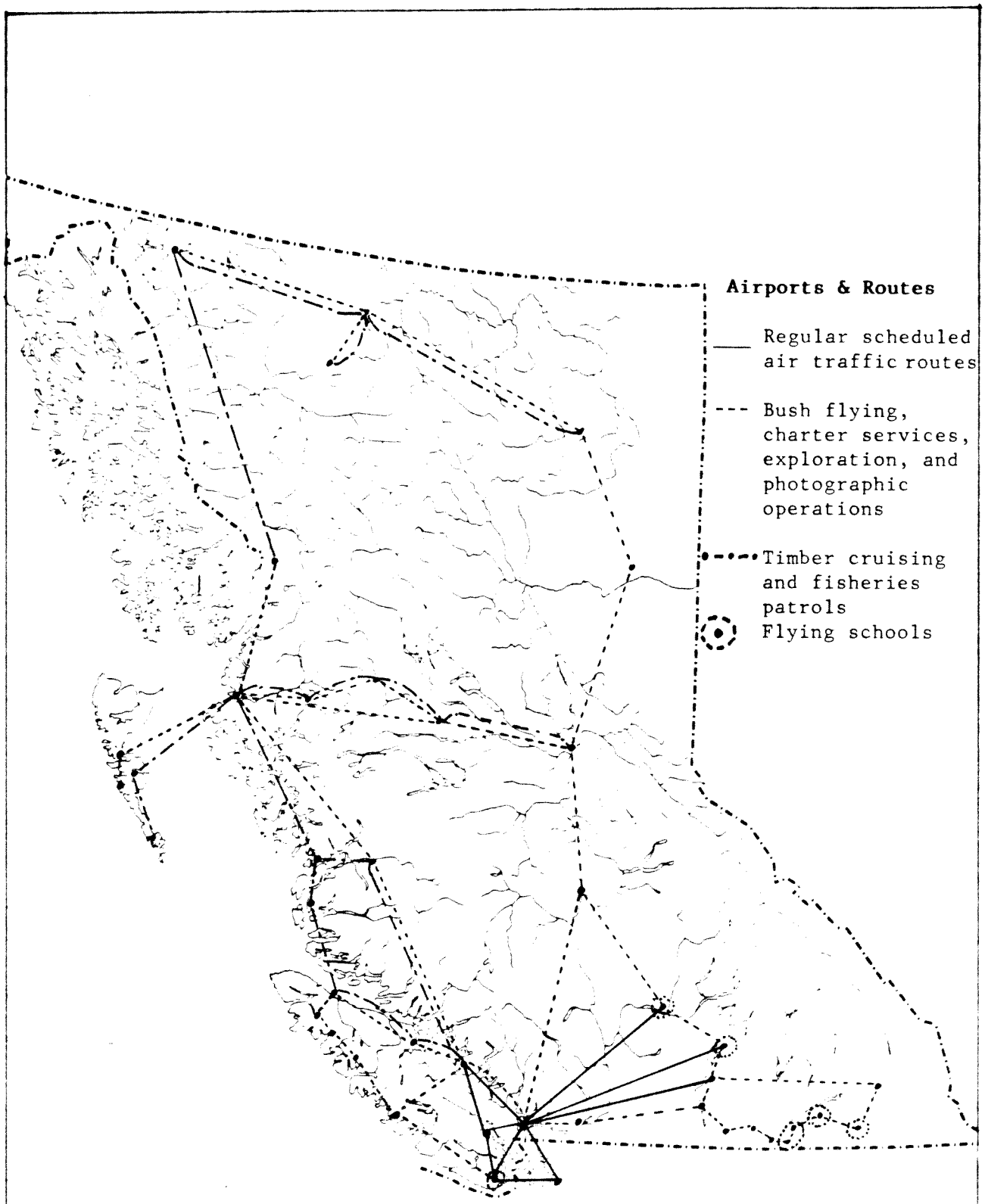


Figure 4: Commercial Airline Routes: British Columbia, 1939

Vancouver-Kelowna-Vernon routes when gold mining on Vancouver Island and Queen Charlotte Islands took place. The airline then began charter services between Vancouver, Zeballos, Tofino, Port Alberni and other small mining camps along the coast. United Air Transport began operating the north-south routes from Kelowna and Kamloops to Prince George, Fort St. John, Fort Nelson to the Northwest Territories and the Yukon. Alaska-Washington Airways, Air Land Manufacturing Company and Royal Airlines concentrated on the coastal routes to northern British Columbia and to the Yukon and Alaska. A new network pattern emerged as spatial interaction took place between mining communities in northern British Columbia, the coast and urban centres in the Lower Mainland. The network pattern was north-south and Vancouver, as a major commercial city, dominated air traffic. Air routes radiated from Vancouver to the North, northern British Columbia and coastal areas (see Figures 3 and 4).

The progress of the airlines is reflected in the records of the mail, freight and, to a small degree, passenger services. These were growing to serve both the developing and newly developed mining camps. There were still other services that continued simultaneously along with mining and exploration activity. Services such as aerial photography, surveys and observation were carried on. Reconnaissance flights, the main part of exploration, carried out flights to ascertain the nature of the geological structure of the area before making any advances in mining development. Reconnaissance flights were made along the Mackenzie River in the Northwest Territories, Atlin, British Columbia and near Stewart where the premier gold mine was found. By 1927 Canadian Airways, Western Canada Airways Ltd., Pacific

Airways, Yukon Airways and Exploration Company and Yukon Southern Airlines were making more profitable explorations than they had bargained for. These airline firms were not only engaged in reconnaissance flights but were also serving explorers and prospectors. They also helped in the development of mines, transportation of workers and freight. Gold in particular had to be transported by air to Vancouver.

The operations of the airlines are summarized in Table 2 which gives the trends in commercial air transportation in Canada between 1920 and 1940. Caution must be taken when reading this table for certain reasons. The figures given in Table 2 do not reflect the operations of the airlines in British Columbia alone but include the general trends of the air transportation industry in Canada as a whole. The figures are also distorted by inclusion of flying club operations and in a few cases the figures from the Canadian Air Force operations, the government agent engaged in forest and fisheries patrols and photographic work in 1920 to 1924. But for purposes of comparison, these figures are quite reliable though systems of classification vary. The important facts emerging from Table 2 are the changes in the industry. Four out of the five indicators used, specifically hours flown, number of firms, mail, and passengers, either fluctuate wildly or decline steadily, particularly in the first six years of the development of the commercial air transportation industry, 1920 - 1925. Only one indicator, freight and express, increases steadily. The number of airline firms and the number of hours flown give a somewhat clearer picture of the amount of work done and the direction of the industry. From 1920

The Operating Statistics of Commercial And Non-Commercial Airlines In Canada
1920 - 1940

Table 2

Year	Number of Firms	Hours Flown	Freight/ Express (lbs.)*1	Mail (lbs.)*1	Passengers (Number)*1
1920	30	6,505	6,740	n/a	15,265
1921	29	4,347	9,850	n/a	9,153
1922	23	2,541	14,700	62,000	4,300
1923	15	2,830	38,348	1,400	2,328
1924	9	1,893	77,400	1,200	5,300
1925	9	1,400	79,849	1,080	3,683
1926	15	2,321	380,433	4,960	6,800
1927	20	4,209	725,000	14,684	16,664
1928	53	28,719	1,641,250	316,631	73,700
1929	84	51,571	2,489,189	576,831	96,375
1930	104	92,993	1,759,259	474,199	124,875
1931	104	73,645	2,372,467	470,461	100,128
1932	77	56,170	3,129,974	413,687	76,800
1933	90	53,299	4,205,901	539,358	85,006
1934	128	75,871	14,441,179	625,040	105,306
1935	130	88,451	26,439,224	1,126,084	177,472
1936	138	101,953	22,947,105	1,161,060	118,660
1937	172	126,896	14,056,433	1,450,473	141,158
1938	142	133,168	19,623,133	1,901,711	136,806
1939	n/a	145,638	19,379,347	1,900,347	145,638
1940	n/a	151,828	14,436,571	2,710,995	149,025

Notes: *(1) No clear distinction was observed between unit toll and bulk transportation (charter and contract carriers) traffic prior to 1946. Therefore from 1920 to 1940 bulk transportation revenues were reported under passenger, mail and freight traffic.

Source: Urquhart, M.C. and K.A. Buckley. Historical Statistics of Canada. Toronto: The MacMillan Company of Canada Ltd., 1965, p. 551.

to 1923 the number of airline firms declined steadily and the curve flattened out between 1924 and 1925. The experimental nature of the industry was dying out. The influx of airline operators which took place immediately after the War was declining due to considerable technical difficulties that had to be overcome. The warplanes used proved uneconomical in their new functions as passenger and freight carriers. They had been inexpensive to buy but were expensive to operate. Depreciation of aircraft, broken parts and their replacements, and the need for appropriate engines for cold and warm weather proved to be very expensive for most operators. Furthermore, by the mid-1920's the warplanes became scarce and had to be replaced by new models which were expensive. The effect of the technical difficulties on airline operators was that some of them went out of business. Others survived either through the amalgamation process or by being efficient competitors. Additional problems for the operators were mainly the result of the lack of operational skills, inadequate knowledge of meteorology, weather forecasts and a lack of understanding of the environment, namely, the ground facilities, particularly sea bases used. The seaplanes (floats) which were practical for serving small mining and logging camps because of their ability to land and take off on the lakes and sea bases were constantly being damaged by contact with floating or half submerged logs or hidden rocks. A large number of crashes were due to landings in water bases before better techniques were discovered in the late 1920's for dealing with this problem. These factors, combined with the seasonal nature of operations, discouraged some of the airline operators as well as investors (private enterprises e.g. forest

and oil companies) from financing some of the airlines. Consequently the number of airline operators declined between 1920 and 1925.

Table 2 reflects another remarkable fact in the industry, that is, changes in the performance of airline firms. By 1925 the remaining eight airline firms were showing an increase in flying volume per firm. The average duration of a flight increased from 21 minutes in 1920 to 44 minutes in 1925 (Main, 1967, p. 27). In 1920 there must have been a large percentage of short hops (short stage lengths) for the average duration of flight for 30 firms was only 21 minutes. By 1925 the industry promoted itself into the commercial level of operation making a clear cut from the experimental phase. The increase in duration of an average flight can be credited to the increased use of aircraft in photographic and reconnaissance works, air passenger and freight operations. Such flying operations required long hours of flight over longer distances. For example, in British Columbia between 1926 and 1929 regular scheduled air services were established from Vancouver to Vernon, Kelowna, Kamloops, and Prince George. Similarly, in Alberta a year round route between Edmonton and Yellowknife was established in 1926 and in Ontario between Red Lake district and Toronto (Main 1967, p. 64).

In 1926 commercial operations began to increase. The number of airline firms increased which correlated with the increase in the volume of freight, mail and passengers which continued steadily until 1929. The increase in the number of airline firms gives an indication of what was happening in the industry. In 1927 there were 20 operators but by 1928 the number had more than doubled to 53 and increased sharply to 84 in 1929. In 1930-1931 the curve

flattened out at 104 in each year and then suddenly dropped in 1932 - 1933. The proliferation of the airline firms from 1926 to 1931 was the product of the upsurge in mining development and mineral exploration. The economic depression in 1932 and 1933 affected the airline operators while freight on the other hand increased sharply. Toombs and Stewart (1966, p. 154) state that the economic depression lead to a substantial decrease in the volume and value of mineral production while the gold mining industry remained relatively active. In 1933 the price of gold increased from $22 to $35 U.S. an ounce while the price of other base metals decreased (Toombs and Stewart, 1966, p. 154). The increased demand for gold during the depression years lead to greater mineral exploration and more mines in British Columbia, Ontario, Quebec and Manitoba were brought to production. While the number of airlines and hours flown dropped in 1932-1933, gold mining kept the weight of freight carried on a gradual increase. A triumphant breakthrough came in 1935 when the weight of 26,439,224 pounds of freight and 1,126,084 pounds of mail were carried. A slight decline began to occur in 1936 and continued until 1940.

Tables 3 and 4 which summarize selected air traffic statistics for 1934 and 1935, the first years when these data were available, give a slightly different view of the industry in terms of each province in Canada. For example, in British Columbia changes in the industry are apparent between the indicators used in these tables. The number of non-paying passengers (surveyors, or government personnel) declined from 1,748 in 1934 to 1,404 in 1935. The flying clubs decreased from 1,500 in 1934 to 1,050 in 1935. Against this, revenue

Table 3

Air Traffic Statistics By Province - 1934

Province	Passengers Carried				Goods Carried		
	Paying	Non-Paying	Clubs Including Dual Instruction	Total Passenger Carried	Mail (lbs)	Freight and Express (lbs)	Total Freight Express and Mail (lbs)
N.W.T.& Yukon	1,447	462	-	1,909	57,605	523,239	580,844
British Columbia	4,350	1,748	1,500	7,398	450	543,759	544,209
Alberta	2,624	234	2,000	4,852	69,400	225,603	296,003
Saskatchewan	4,435	699	2,000	7,134	30,678	398,450	429,128
Manitoba	9,662	730	2,000	12,412	65,094	2,962,811	3,047,905
Ontario	27,189	3,445	10,000	40,634	146,201	7,831,328	7,977,529
Quebec	20,681	1,358	2,500	24,539	173,918	1,954,526	2,128,444
N. Brunswick	857	26	1,000	1,913	82,985	398	83,383
Nova Scotia	221	-	3,500	3,721	-	86	86
P.E.I.	569	19	-	588	51,179	-	51,179
Totals	72,085	8,721	24,500	105,306	697,510	14,441,179	15,138,689

Source: Civil Aviation in Canada: Historical File Copy, Dominion Bureau of Statistics 51 202.

Air Traffic Statistics By Province - 1935

Table 4

Province	Passengers Carried				Goods Carried		
	Paying	Non-Paying	Clubs Including Dual Instruction	Total Passenger Carried	Mail (lbs)	Freight and Express (lbs)	Total Freight Express and Mail (lbs)
N.W.T.& Yukon	1,884	624	-	2,508	119,089	485,762	604,851
British Columbia	7,821	1,404	1,050	10,275	5,952	718,122	724,074
Alberta	5,697	239	1,000	6,936	12,077	367,907	379,984
Saskatchewan	7,018	2,018	1,000	10,036	12,066	961,411	973,477
Manitoba	12,736	748	1,000	14,484	261,791	4,134,339	4,396,130
Ontario	72,543	9,470	8,450	90,463	182,344	19,370,905	19,553,249
Quebec	24,159	2,493	8,000	34,652	494,988	4,593,731	5,088,719
N. Brunswick	1,335	64	1,000	2,399	125,642	1,870	127,512
Nova Scotia	852	41	3,600	4,493	218	---	218
P.E.I.	634	44	-	678	103,788	990	104,778
Totals	134,679	17,145	25,100	176,924	1,317,955	30,635,037	30,772,992

Source: Civil Aviation in Canada: Historical File Copy, Dominion Bureau of Statistics 51 202.

passengers increased from 4,350 in 1934 to 7,821 in 1935. The commercial operation was gaining stronger ground while non-commercial flying was declining. The volume of air mail doubled in 1935. It jumped from 450 pounds in 1934 to 5,952 pounds in 1935. This increase in the volume of air mail was the result of the air mail contracts granted to the airlines by the post office. During the late 1920's and early 1930's the post office offered mail contracts on a permanent basis for north-south air routes. This offer provided an incentive to increase air services both in the North and Northern British Columbia. Regular air mail services were established between the urban centres in southern British Columbia and nearly all of the isolated communities in northern British Columbia. For example, routes were established between Whitehorse in the Yukon, Atlin, Yellowknife in the Northwest Territories and Fort Nelson and also between Kamloops and Prince George, (Main 1967, pp. 91-104).

There was a substantial increase in the volume of freight handled in British Columbia in the years 1934 - 1935. In 1934, 543,759 pounds of freight were carried and in 1935 the volume amounted to 718,122 pounds. The increase in air traffic in British Columbia during 1934 and 1935 is reflected by aircraft mileage (see Table 5).

The impact of the increase in commercial airline operations from 1926 to 1939 is reflected in the expansion of the air transportation network in Figure 4. The number of nodes rose from 31 in 1929 to 42 in 1939, the routes from 21 to 56 in 1939. The network was less connected in 1929. Out of 30 nodes (mainly air bases for forest and fisheries patrols) only 21 nodes were connected by a minimum

Aircraft Operations by Province, 1934 and 1935 - Table 5

Province	Aircraft Mileage (Wheels & Skis)	Sea Plane Mileage	Total Aircraft Mileage	Aircraft Mileage (Wheels & Skis)	Sea Plane Mileage	Total Aircraft Mileage
N.W.T. & Yukon	177,832	210,178	388,010	173,480	188,772	362,253
British Columbia	253,188	242,883	496,069	409,266	334,831	744,097
Alberta	151,958	259,928	411,886	347,853	174,319	522,172
Saskatchewan	269,319	107,966	377,274	304,313	291,862	596,175
Manitoba	421,840	450,240	822,080	490,751	402,333	893,084
Ontario	1,181,145	1,386,278	2,502,417	1,445,076	1,057,889	2,502,265
Quebec	680,152	469,706	1,149,858	864,598	746,754	1,611,352
New Brunswick	111,254	-	111,254	95,614	2,150	102,764
Nova Scotia	126,904	-	126,904	135,396	4,000	139,396
Prince Edward Is.	86,885	-	56,885	47,845	-	47,845
Totals	3,430,475	3,067,162	6,442,637	4,134,192	3,207,910	7,522,102

Source: Civil Aviation: Historical File Copy Dominion Bureau of Statistics, 51-202.

number of 23 routes. By 1939 the number of nodes had increased from 31 to 42, connected by 56 routes. Out of 42 nodes, 9 were connected directly to Vancouver, the main hub, those being the ones closest to Vancouver. In this regard, it might be noted that the aircraft used in the 1930's were predominantly short range and not capable of long distance hauls. As a result, many small towns in northern British Columbia and in the interior of British Columbia are connected because they form stops along a chain route. There are two main chain routes obvious in Figure 4. The one in northern British Columbia leads to Prince George and then to Vancouver while the other route runs along small towns in the west Kootenays leading to Pentiction and Vancouver.

Changes in the network structure of the air transportation industry from the mid-1920's to 1939 were influenced by two main events. First, the increase in mining industry and mineral exploration as discussed earlier influenced the rise of north-south and coastal routes. The second event which influenced the increase in the network pattern was the unemployment relief projects during 1932 to 1936. In 1932, the federal government began a number of construction projects to combat unemployment in Canada. These prc jects included construction of airports, radio range and road works; the latter being carried out where a road was necessary for access to the airport sites.

More financial assistance was granted by the federal government to provinces which showed the greatest need for aviation and where unemployment was most acute. Ontario and British Columbia had the highest rates of unemployment. It was estimated that there were

170,000 men unemployed in these provinces during the Depression years. Ontario employed 52,000 men to work on 26 projects while British Columbia employed 62,000 men in nine fields (Main, 1967, p. 108). The largest project in British Columbia was the construction of lighted airports with runways, radio range, hangars and communication systems. Emergency landing fields at 30 mile intervals were built at intermediate locations. Between 1934 and 1936 a number of airports and landing fields were built in the interior of British Columbia. The airports built in the early 1930's included Kelowna, Penticton, Kamloops, Cranbrook, Prince George, Fort St. John, and Fort Nelson. Some of the existing airports such as Rossland, Trail and Vernon were improved.

The improvements of existing airports and the construction of new ones had a twofold influence on the network pattern. First, business firms began to increase their use of air transportation. Second, the new airport facilities attracted the airlines. With the increase of air traffic, particularly in the air routes to the interior of British Columbia, the airlines began to revive the air routes which they had abandoned in the late 1920's. Thus, the expansion of the air transportation network took place (see Figure ' .

2.3 Selected Characteristics of the Network Structure Between 1919 and 1936

The selected characteristics of the commercial airline operations in terms of technology, airline operators, the nature of demand or function and route structure have been tabulated (Table 1b). During the mid-1920's and early 1930's there was a progressive adoption of new aircraft in British Columbia. From 1927 aircraft such

as Ford Tri-Motor, De Haviland, Lockheed Vega, Boeing 247, and Fokker, powered with 3 to 4 air-cooled radial piston engines, were gradually introduced in British Columbia (see Table 1b and Appendix 4a). The potential value of these aircraft was in their economic performance and reliability. The passenger capacity increased from 4 to 12 passengers, and so were more economical than the Jennies and the HS-2L and HS-1 flying boats used in the early 1920's (see Table 1b). Although these new aircraft had improved economic value in their capacity, the economic value of stage lengths was restricted by the fact that they were short range aircraft. The effect of the operations of short range aircraft between 1920 and 1936 is reflected in the network structure that evolved during this time. The network is characterized by short-link and spinal patterns or a tree-like type of network (see Figures 3 and 4). In Figure 4 only 10 nodes out of 42 are connected directly to Vancouver forming a hub-and-spoke structure. The pattern of the network in the interior and in northern British Columbia tends to be linear and is formed by airline stops along a chain of towns and small camps.

Apart from the limitations of short range aircraft, the geographical features of British Columbia, its mountainous terrain, hindered medium and long distance operations. In addition, the distribution pattern of the small settlements along coastal areas and northern British Columbia influenced the short-link network. Many of these settlements were located close to each other but separated by natural barriers (water or mountains). Their locations were influenced by the availability of minerals and logging sites. Flying boats (short-range HS-2L, HS-1, Boeing C-3 and Lockheed Vega) were advan-

Selected Characteristics Of Airline Operations Between 1919 - 1935 Table 1b

Time of Operation	Owner/ Operator	Head Office	Aircraft Type	Airstrip	Route	Function
March 3, 1919 - 1920	E. Hubbard	Seattle (2 seats)	Boeing C-3	Coal Harbor Seattle	Vancouver air mail	Inauguration of
May 12, 1919 19--?	A. Eckley & E. Hall	Victoria	Jenny JN-4 (2 seats)	Victoria, Minoru Park	Victoria - Vancouver	Inauguration of air mail services
Aug. 8, 1919	Capt. E. Hoy	Vancouver	Jenny JN-4 (2 seats)	Minoru Park	Vancouver - Revelstoke - Lethbridge - Calgary	Inauguration of interprovincial air mail routes
1919	Capt. Trimm	Vancouver	Jenny JN-4 (2 seats)	Minoru Park	Vancouver, Chilliwack, Kelowna, Vernon, Rutland (regional routes)	Inauguration of air mail services
1920 - 1936	E. Hubbard	Seattle	Boeing C-3 (2 seats) Boeing C1-45	Coal Harbor Victoria Harbor	Vancouver, Victoria, Seattle	Scheduled passenger and air mail services
Oct. 7, 1920	Leckie & Hobbs	Ottawa	Military Aircraft (2 seats)	Halifax, Minoru Park	Halifax Vancouver (national)	Inauguration of a trans-continental air mail flight

Selected Characteristics Of Airline Operations Between 1919 - 1935 Table 1b - cont'd

Period of Operation	Owner/ Operator	Head Office	Aircraft Type	Airstrip	Route	Function
Feb. 20, 1920 April 1, 1924	Canadian Air Force	Ottawa	Jennies, JN-4 HS2L & HS1 flying boats (2 seats)	Jericho Beach Swanson Bay & Minoru Park	Coastal routes P. Rupert, Q. Charlotte Bella Coola Namu	Photographic operations, mapping, fisheries & forest patrols and surveys
Feb. 1925 - May 1928	Don McLaren (Pacific Airways)	Vancouver	HS2L's, Boeing flying boats & a Vedette (4-5 seats)	Jericho Beach Swanson Bay Bella Bella & Alert Bay	Coastal routes (local)	Aerial photography, mapping, surveys, forest & fisheries patrols
1927 - 1933	Dobbin Brothers (Dominion Airways)	Vancouver Nelson	Jennies JN-4 & Wooden Moth (2 seats)	Minoru Park Nelson	Local	Forest patrols & a flying school
1928 - 1942	Eves Bros. (B.C. Airways)	Victoria	2 OX5 Eagle Rocks, Driggs Dart Ford Tri-Motor (14-16 seats)	Lansdowne Victoria Minoru Park	Vancouver Victoria & Seattle	Regular scheduled passenger and air mail air services
1928 - 19--?	Eves Bros. (Sprott-Shaw)	Victoria	Jennies JN-4 (2 seats)	Lansdowne, Victoria	Local	Flying schools
1928 - 1930's	William Archibald	Trail Creston	De Havilland Moth, Puss Moth (2-3 seats)	Trail Creston	Local Local	Private Flying school

Selected Characteristics of Airline Operations Between 1919 - 1935 Table 1b - cont'd

Period of Operation	Owner/ Operator	Head Office	Aircraft Type	Airstrip	Route	function
1928 - 1930	Canadian Airways	Vancouver	Boeing flying boats	Jericho Beach Sea Island	Local	Fisheries & forest patrols and photography
1928 - 1930's	United Airlines	Seattle	Boeing C1-45	Sea Island Airport	Vancouver Victoria Seattle	Express parcel air services
1929 - 1934	Yarrows Aircraft Limited	Victoria	Jennies JN-4 & 2 Moths (2 seats)	Victoria Minoru Park	Victoria to Vancouver (local)	Passenger and freight
1929 - 1930's	Alaska Washington Airways	Washington	Fairchild 71 and Boeing boats	Sea Island Victoria Airport	Yukon, Alaska Northern B.C. & Interior B.C.	Charter services & scheduled air passenger and freight
1929 - 1935	Ginger Coote Airways	Chilliwack relocated to Vancouver (1930-1934)	Jennies JN-4 and Gipsy Moth (2-3 seats)	Chilliwack, Langley,Sea Island	Interior B.C. & Vancouver Island	Air Passenger and air freight
1929 - 1930's	Air Land Manufacturing Company	Vancouver	2 Junkers L6 1 Junior	Sea Island Victoria Harbor, Prince Rupert	Nanaimo Victoria Vancouver Powell River, Bella Coola Prince Rupert	Air passenger traffic and freight

Selected Characteristics Of Airline Operations Between 1919 - 1935- Table 1b - cont'd

Period of Operation	Owner/ Operator	Head Office	Aircraft Type	Airstrip	Route	Function
1929 - 1931	Barney Jones-Evans	Victoria relocated to Rutland (1930-1931) relocated to England	Gipsy Moth (3 seats)	Victoria Boyce Field	Local Local	Flying school
1928 - 1931	John Blakeley	Vernon	D-H Gipsy Moth (3 seats)	Rutland	Vernon, Rutland	Flying school
1930 - late 1930's	Royal Airlines	Vancouver	Bellanca	Sea Island & respective community airstrips	Atlin - Liard Post, Northern B.C. towns	Bush flying, supplies & passengers
1930 - 1939	Frank Gilbert (Pacific Coast Ltd.)	Chilliwack	Alronca CF-AQK (2 seats)	Chilliwack	Local	Flying school
1930 - 1936	H.O. Madden	Kamloops and Trail	CF-AKC's fleet	Kamloops and Trail	Local Local	Flying schools, bush flying
1931 - 1933	Eric De Pencier	Vernon	Travelaire biplane	Vernon	Local	Flying school, bush flying
1931 - mid 1930's	Ed Elderton	Vancouver	Boeing, Vickers flying boats (4-5 seats)	Local air-strips	Short distance hauls	Air traffic
1932 - 19--?	Shell Oil Company	Vancouver	Lockheed Vegas	Sea Island	Local	Explorations air shows

Selected Characteristics Of Airline Operations Between 1919 - 1935 - Table 1b - cont'd

Period of Operation	Owner/ Operator	Head Office	Aircraft Type	Airstrip	Route	Function
1932 19--?	Capt. F.L. Clarke	Vancouver	Vickers Viking	Jericho Beach	Local	Bush flying
1933 - 1942	Yukon Southern Airways	Vancouver	Waco Cabin biplane	Local air-strips	Oliver Rut-land, North-ern B.C., Yukon	Bush flying air traffic
1933 - 1942	United Airlines	U.S.A.	Boeing 247	Sea Island	Vancouver Victoria Seattle	Passenger air services
1933 19--?	Len Foggin	Vancouver	Gipsy Moth (3 seats)	Sea Island	Local	Flying school
1930 - 1942	Canadian Airways Limited	Vancouver	Boeing BIE's and Fairchild 71	Sea Island Airport	Vancouver Victoria Seattle	Passengers, air mail & freight
1933 Aug. 25 - 26	Lt. Comm. Hawks	-----	Texaco monoplane	Sea Island Airport	Vancouver Quebec	Air mail and promotion of long distance hauls
1933 - 1941	Duddle - Seymour Airline	Vernon	Private air-craft CF-ACM (2 seats)	Local air-strips	Vernon, Kelowna, Cranbrook Creston, Castlegar Grand Forks	Aerial photo-graphy, rescue service, timber cruising and passenger air service

tageous in northern British Columbia and coastal communities because they did not need landing fields. They could operate from lakes, rivers, and inlets which were numerous in these areas. Although the physical features of British Columbia and the spatial distribution of mining and logging communities influenced the network structure, aircraft technology played a significant part in the evolution of a short-link network in British Columbia (see Figures 3 and 4).

Table 1b shows another striking feature of the air industry between 1919 and 1936. It was overwhelmingly local. Men invested in flying businesses from either family connections or in partnerships with friends and relatives or individually (see Table 1b and Appendix 2 for detailed information). Almost all investments were small compared to those of later years and post-World War II, owing to the predominance of single owners or partnerships. Those who invested usually managed the flying business. There was nothing like the wide gap which was to spring up later between the investor on one hand and the manager and director of the airline company on the other, as in the joint-stock investment. The small airline operators tended to develop local air services rather than trying to venture into regional or interprovincial operations. The trend of the local service operations of the airline operators between 1920 and 1936 is reflected in the location of their head offices (see Table 1b). Most of the head offices were located locally with the exception of those operators who were mobile. They relocated their head offices several times hunting for better markets for their services.

Among other factors, operators were limited from expanding their operations beyond the local market due to a lack of financial

support and excessive intra-modal competition which was taking place across Canada. Any progress in the commercial air transportation tended to be a venture of individual operators, paid for out of their own pockets. Neither the federal government nor financial institutions took part, particularly between 1920 and 1930. Neither had the confidence that airlines would ever achieve profitable performances. This was based on the hosts of technical difficulties they were experiencing and the constant aircraft crashes. Furthermore, in the early 1920's air transportation did not seem to have a competitive advantage over the surface modes in terms of freight and passenger traffic. Even mail was carried profitably only at above surface rates because of higher costs which were justified by speed and time saving. However, mail by itself proved incapable of supporting a viable commercial air transportation paid for at rates which could be covered by acceptable postal charges.

Private enterprises such as oil companies and forest product companies had tried occasionally to support individual airline operators in the development of forest patrols, aerial photography and charter services. However, they were hesitant in financing new ervices because they were discouraged by technical difficulties experienced by airline firms combined with the seasonal nature of demand and bitter competition among airline operators.

The attitudes of the government officials towards the importance of the air transportation after World War I were quite obvious. Their opinion was that aircraft had little practical value during peaceful times. The War was over and therefore there was no need for the development of air transportation. This attitude is clearly

expressed in the words spoken by the Minister of Reconstruction in the Canadian Cabinet in 1918 after listening to an enthusiastic description of the role air transportation could play in the development of the Canadian North. His response was that he "did not think Canada would ever have need for an air service" (Main, 1967, p. 28). The reluctant attitude of the federal government towards financing and promoting the commercial air transportation industry is reflected in the aviation policy drafted in 1920. It stated that "there would be no government subsidies for commercial aviation, however, agencies such as the post office department would cooperate in any reasonable scheme" (Pendaker, 1974, p. 10). Underlying the reluctancy of the government to subsidize the airline operators was the effect of the financial conditions of the railways.

Two transcontinental railway companies and several short ones had been pulled out from the brink of bankruptcy and small railway systems had been consolidated to the Canadian National Railway system in 1918. Consequently, the government did not want to finance another competitive system to share the already inadequate source of revenue.

The excessively unregulated intra-modal competition which impeded the economic conditions within which the airlines operated restricted most of them from expanding their services beyond the local market. There was too much rate cutting among the airline operators which resulted in unprofitable conditions. This uncontrolled competition appeared not only in British Columbia but across Canada.

The impact of the competition on private firms, such as mining companies, took the advantage of the competition and began bidding for lower prices which further influenced an unprofitable environment.

The attitude of some of the private companies towards competition is clearly expressed by Main (1967, p. 103).

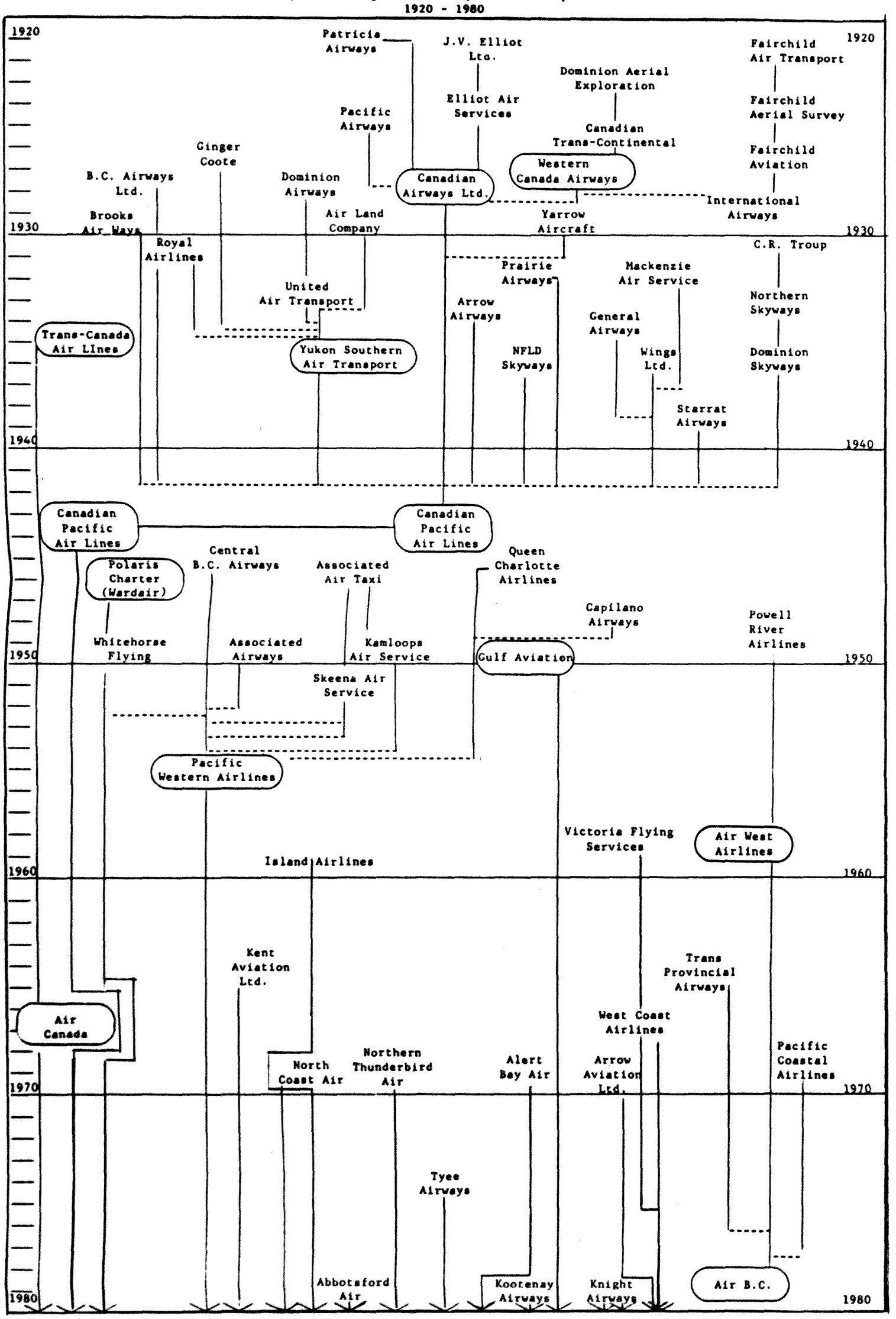
> "Some mining companies caught the spirit of the game and offered ridiculous prizes such as a goldheaded cane or silk hat to the last pilot out on floats or the first one in on skis. A lost aircraft not infrequently became the price of a high-hat or gold cane."

It is quite evident that the mining companies prospered while the airlines operated at a great loss. Due to competition and its component unhealthy economic condition, a number of small airlines went out of business. Some as early as 1924 and 1925 were already in the financial doldrums. The airlines such as Pacific Aviation of Vancouver, Vancouver Island Aerial Transport, Commercial Airways, Commercial Aviation School of Victoria, to name a few, went out of business between 1925 and 1926.

A few of the survivors solved the problem of competition through amalgamation. Between 1928 and 1934 a number of acquisitions involving several operators were consumated. In 1928 Pacific Airways Ltd. merged with the Canadian Airways Ltd. In 1931 Canadian Trans - Continental Airways Ltd. was acquired by Canadian Airways Ltd. and between 1932 and 1934 some airlines merged with Canadian Airways Ltd. (see Chart 1). Similarly, between 1934 and 1935 United Air Transport acquired four airlines in rapid succession and amalgamated them to form the Yukon Southern Air Transport (see Chart 1).

The primary benefits for amalgamated airlines were on the revenue side. Amalgamated airlines achieved relative rate stability which had previously been too low due to competition. In some cases,

Chart 1 - The Development of Major Air Transportation Companies in British Columbia 1920 - 1980



Source: Archival Records and Personal Files. Aviation Statistics Centre, Fleet Report. 1968-1970, 1970-1977. Aviation in Canada, Catalogue 51-501, p.21. Canadian Transport Commission, Report No. 40-80-13, Oct. 1980 p. 51-57, 67-70.

——— = Approximate lifespan of airlines

( ) = Approximate founding date of main airlines.

Note: Some of the airlines using class 3 licence are not included.

however, economies of scale did not materialize as the airlines had anticipated. In fact, none of the amalgamated airlines could really be regarded as financially successful. Even Canadian Airways Limited which became the largest airline operating in British Columbia in 1935 was still experiencing financial difficulties. One reason for the lack of expected economies of scale was blamed in part on the company's lost air mail contracts in 1932. Another reason was that through acquisition of a number of airlines it found itself possessing a very large number of aircraft within a short time. The result was that losses soared. Maintenance of the aircraft and an increased number of pilots caused the costs to rise. However, the Air Transport Board came just in time to rescue the company from its financial difficulty. The Air Board was interested in a transcontinental air mail and passenger service from Vancouver to Halifax. The American airlines were threatening to gain control of the Canadian domestic market and the Air Board realized that if they were permitted to form a transcontinental line Canada would never have a major airline. To alleviate the financial difficulties of Canadian Airways Limited, the Air Board encouraged Canadian Pacific Railways and Canadian National Railways to each acquire 10,000 shares out of a total of some 127,000 issued by Canadian Airways Company.

Amalgamation of the airlines had one main function. It laid the basis for the emergence of larger airlines in British Columbia. Around 1934, a number of larger airline firms, including Canadian Airways Limited, Yukon Southern Air Transport and British Columbia Airways Limited (see Chart 1). Canadian Airways Limited was the largest and its route structure extended from Vancouver to as far

as Winnipeg by 1936. Table 6 shows the operating and financial statistics of the airline reflecting its dominance from 1930 to 1940.

2.4 The Transition Period, 1937 - 1945

The period between 1937 and 1945 has been considered as a transition period for two reasons. With the outbreak of World War II in 1939 the commercial air transportation industry declined. The airline operations were reduced considerably by the Federal Government's restrictive regulations which curtailed commercial air transportation activities. The government placed a tight control over the airline industry. Aircraft purchases were banned and replacement parts for non-military aircraft were no longer available. All non - essential flying such as bush flying, charter services and training schools were reduced and had to be done under special permission. Licences were no longer issued for private lessons unless the trainees were in the Royal Canadian Air Force. Gasoline and oil was reserved for military activity and for commercial airlines and was restricted to a limited amount. It was only the larger airlines such as Trans - Canada Airlines and CP Air which were allowed a minimal supply as they were engaged in military activity carrying government supplies, cargo, and mail. A gasoline shortage was created by the War and it was not easy to import gas and oil from oil-producing countries.

In addition to the constraints imposed by the government restrictions mining and mineral exploration activities declined considerably. There was a shortage of labour because men were needed for the War and airline pilots had to go the Air Force. All the restrictive

Table 6

Canadian Airways Ltd. Operating and Financial Statistics, 1930 - 1940

Year	Revenue Miles	Revenue Passengers	Revenue Passenger Miles	Revenue Freight (lbs)	Freight Ton Miles	Mail (lbs)	Mail Ton Miles	Operating Revenue (dollars)
1930	---	36,372	---	2,060,695	---	333,886	---	1,817,544
1931	1,646,639	8,047	796,653	764,449	31,169	459,459	39,922	1,412,797
1932	1,123,968	8,963	998,619	1,870,136	81,046	299,066	25,985	676,880
1933	1,067,213	16,942	1,094,600	2,522,234	109,306	328,618	28,553	615,467
1934	1,501,183	16,594	1,468,434	5,766,691	253,584	472,308	42,383	881,536
1935	1,564,307	14,540	1,514,681	5,275,745	250,754	817,678	72,903	865,972
1936	1,854,700	19,870	2,123,300	7,681,000	307,580	845,920	70,300	964,495
1937	1,852,563	16,612	2,237,894	7,233,672	330,140	889,763	67,489	1,056,293
1938	1,660,184	14,612	2,556,399	4,814,349	232,372	567,667	39,400	900,701
1939	1,731,476	14,370	2,750,218	3,560,400	210,793	494,606	35,702	852,450
1940	2,040,250	26,334	3,231,530	5,627,734	345,236	458,160	40,078	1,054,548

Source: Poor's, Moody's, and Financial Post Surveys, compiled by the Dept. of Reconstruction, Commercial Air Services in Canada, 1919-1944.

regulations, combined with the decline in mining, affected the financial conditions of the airlines causing many of them to go out of business.

The transition period was characterized by the transition of small airline operators to major national airlines. It must be noted, however, that in British Columbia larger airlines, of which Canadian Airways was by far the largest and the strongest of the air transportation companies, began to emerge by 1935. Prior to 1935 there was no national airline.

Between 1937 and 1945 two major national airlines emerged, Trans-Canada Air Lines (now Air Canada) and Canadian Pacific Air Lines (now CP Air). The Trans-Canada Air Lines (TCA - AC) was formed in 1937 as a crown corporation airline, under the control of the Canadian National Railway Company. The airline began its operations with a passenger and air mail service between Vancouver and Seattle on September 1, 1937 (Ashley, 1963, p. 11). By 1938 it had extended its operations as far as Winnipeg. Its route structure was from Vancouver, Lethbridge, Calgary, Edmonton, Regina to Winnipeg. Figure 7 shows the network structure and the routes operated by the Trans-Canada Air Lines in British Columbia.

Canadian Pacific Air Lines (CPAL - CP Air) was formed in 1942 as a subsidiary of Canadian Pacific Railway (CPR) through the acquisition of ten small airlines (Currie, 1967, pp. 543-544). Just prior to 1939, bush flyers operating across the Canadian North were experiencing financial difficulties due to declining business. The number of airline companies was still large while mining industry as a whole was rapidly ceasing to expand its operations. By 1940 traffic

had declined even more than previous years. Prospecting and mineral exploration shrank as a result of the shortage of labour and the impossibility of raising venture capital. In addition to these problems the airlines were experiencing the chronic problem of bitter competition and rate cutting.

The timing of the purchase was just right. Canadian Pacific Railways had seen the opportunity of forming a profitable enterprise through the amalgamation of some of the companies that were experiencing financial difficulties. The railway company was in a good position to absorb the competitors and form a mainline airline. The Canadian Airways Limited, which Canadian Pacific Railways had supported financially for almost ten years became the nucleus of Canadian Pacific Airways Limited. The newly formed airline was built around Canadian Airways (see Chart 1).

Of the ten airlines acquired by Canadian Pacific Railways, four were from British Columbia. Canadian Pacific Air Lines took over their routes in Northern British Columbia, the Yukon, and the Northwest Territories. Generally, Canadian Pacific Air Lines operated the north-south routes taken over from the Yukon Sourthern Air Transport. The coastal routes taken over from British Columbia Airways Limited included the Vancouver - Victoria - Seattle and the Powell River - Prince Rupert routes. However, due to the effects of War the routes on the coastal areas had to be temporarily discontinued.

Even though air transportation found many new applications between 1939 and 1945 they were purely of military concern. All commercial air transportation activities were reduced to a minimum as mentioned before. By 1943 there were only two airlines in opera-

tion in British Columbia and across the country, namely, Trans-Canada Air Lines and Canadian Pacific Air Lines. The effect of the reduction of commercial airlines is reflected in the spatial network of the airlines which evolved between 1940 and 1945. Only a few routes were being operated, those being the north-south route operated by Canadian Pacific Air Lines and the Seattle - Vancouver - Calgary route operated by Trans-Canada Air Lines. The network structure between 1943 and 1945 was reduced to a spinal pattern, a tree-like pattern which reflects a minimally connected network (see Figure 5).

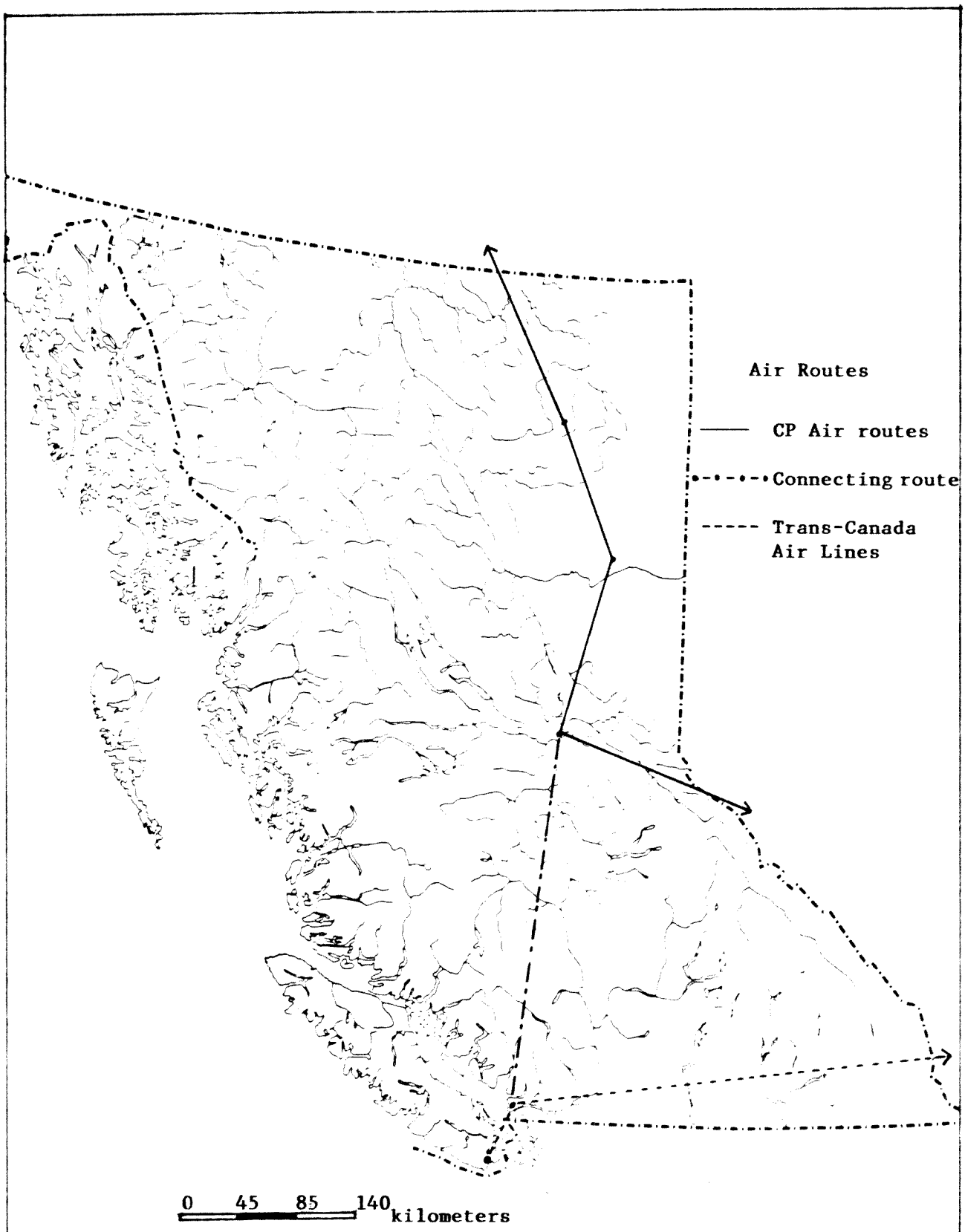


Figure 5: Airline Routes: British Columbia, 1943

III. POST WORLD WAR II EXPANSION IN THE AIR TRANSPORTATION INDUSTRY, 1946 - 1980

3.1 The Growth of the Air Transportation Network, 1946 - 1960

The immediate cause of growth and expansion of the commercial air transportation industry after World War II was the resumption of natural resource development on a large scale. There were also important large scale construction projects coupled with the federal government defence programs. Large and reliable aircraft were a necessity for without these the anticipated profit and growth in the industry would have been far less.

Immediately after the War, natural resource development, particularly mining, mineral, oil and natural gas exploration was revived and took place on a large scale. Rapid changes were made in all phases of mineral exploration, notable among them the adoption of the airborne magnetometer. This was a device developed during the War for mineral exploration. It had the capability of detecting the geological structure and mineral contents within the rocks. The use of this magnetometer combined with advanced mining equipment developed during the War period, had remarkable impact on both exploration companies and the airlines. Unrestrained mineral exploration and development programs by all sectors of the mining industry took place, not only in British Columbia but across Canada and the North. The major mining and industrial mineral exploration areas in British Columbia included central British Columbia, Cassiar and Liard regions, the Kootenays and the areas along the coast. The airlines were required for several functions. First they were needed

for aerial photography, an activity required prior to mining. Aerial photographs made it possible to develop and prepare maps showing topographical details to mark out potential sites for further detailed investigation on the ground. Secondly, airlines had to take photographs of the geological structure of potential sites using the magnetometer. And third, airlines had to fly the crews, including photographers, interpretors, industrial engineers, explorers along with all their equipment. These activities increased the demand for airline operations.

The air transportation operations also owed much of its growth and profitability in the late 1940's and 1950's to the mining activity itself. In places where discoveries had been made, mining development followed which required airlines for the transportation of workers, equipment and supplies. In addition, old mines were revived as new ones and logging camps sprung up. Airline operations were needed more in areas where surface modes were too expensive to construct or where the locations of the mining towns were more easily accessible by air. Mining towns and logging camps on the coastal areas and northern British Columbia were primarily serviced by air. These communities ranged from small and somewhat permanent logging camps to larger communities associated with fish canneries, mining, and pulp and paper operations. These communities gave rise to heavy bulk movement of commodities from the northern points of the province to the Lower Mainland. The reverse was also true, a variety of manufactured commodities, labour force, personnel, equipment, medical and food supplies moved from Greater Vancouver and metropolitan Victoria to all these coastal communities. Small communities in

northern British Columbia and on the coast were dependent on supply centres such as Vancouver and Victoria as evidenced by government records. These activities between the coastal communities and the Lower Mainland increased the demand for air transportation.

Parallel to natural resource development were the major construction projects taking place in northern British Columbia between 1948 and 1953. In 1948 the Aluminum Company of Canada planned a large scale construction project. It built a large hydro-electric power plant at Kemano and an aluminum smelter development at Kitimat in central British Columbia (Main, 1967, p. 237). The project was an attempt to develop a connection between the port of Kemano and the town of Kitimat. The construction began in 1949 and required a heavy airlift service. Workers, equipment, personnel and supplies were to be transported by air to and from the construction site. Contracts were granted several airlines including Central British Columbia Airways, Queen Charlotte Airlines, Okanagan Helicopter Company and to several bush flyers. Among the airlines with contracts, Central British Columbia Airways held the largest contract. It had to do 75% of the hauling.

The impact of this project on the structure of the airline companies can be seen through the rapid growth and expansion experienced by Central British Columbia Airways in the early 1950's. With the resources derived from the operations in the Alcan projects, Central British Columbia Airways purchased six of its competitors between 1953 and 1955 (see Chart 1). After the company had absorbed the six carriers it changed its name to Pacific Western Airlines in 1955. The acquisition of the six airlines between 1953 and 1955

offered Pacific Western Airlines (PWA) two signficant advantages. The acquisition of other airlines changed PWA's network structure and its structural conditions. The addition of new routes from acquired airlines provided increased opportunities for more traffic flow and new markets in which the airline believed it could compete effectively. For example, with the acquisition of Queen Charlotte Airlines (QCA) in 1955 PWA gained scheduled Class 1, 2 and 3 services which expanded its coastal and interior British Columbia operations. The expansion of PWA's network structure and its market enabled the airline to gain a regional status. It became a chief competitor of the trunk lines, CP Air and Air Canada.

The main advantage of the acquisition of the six airlines was that PWA gained more aircraft and labour force as each acquired airline brought with it a fully trained labour force and aircraft consistent in size with PWA's new scale of operation. For instance, in December 31, 1954 PWA had a total of 106 employees, 22 owned aircraft and 6 leased aircraft (PWA annual report 1955). By the end of 1955 there was a remarkable increase in the labour force, aircraft and utilization of aircraft. By December 31, 1955 PWA had a total of 56' employees, 69 owned aircraft and 10 leased aircraft (PWA annual report). The growth in the structure and operations of PWA was also influenced by additional contracts such as forest and fisheries patrol contracts and the DEW line contract obtained from acquired airlines. The significance of these contracts, additional equipment and routes gained can be gauged from the remarkable increase in operational statistics (passengers, hours flown, weight of goods carried, etc., gross revenue and net profit between 1953

and 1956 (see Table 7).

In the mid-1950's the project that really boosted the growth of the air transportation industry was the National Defence Program. The federal government had three defence lines that were built in the North; the Distant Early Warning Line (Dew Line), the Mid-Canada Line, and the Pinetree Line. Radar stations were installed along these three lines to detect aircraft approaching North America from Russia and possibly Japan. Among the three lines, the Dew Line was the greatest stimulant to the expansion of airline operations, thus influencing growth in the industry. The nature and scope of the Dew Line was enormous. The project was a great challenge as almost all of the sites for stations were accessible only by air and the project had to be carried out within a short period of time. The Dew Line was built along roughly the 68th parallel north and stretched from the Alaska - Yukon border in the west coast to Cape Dyer on the east coast of Baffin Island. Approximately 150 miles of the coastline west of the Mackenzie delta is mountainous while east of the delta is a stretch of about 200 miles of reindeer moss. From there the terrain is rough and toward Baffin Island it is mountainous again. Along this line, 41 surveillance stations, 18 auxilliary and 19 imtermediate bases were to be built at approximate 50 mile intervals (Milberry, 1979, pp. 73-74).

The Dew Line project induced a great demand for air transportation services. Survey crews, with their supplies and equipment, had to be flown in to the sites or as close as they could get to them. Construction materials for both the stations and airstrips, equipment (tractors, generators, heavy machinery, engines, fuel,

Table 7

Pacific Western Airlines
Consolidated Statement of Earnings
(Profit and Loss)

Four (4) Year Comparison Ending
December 31, 1956

	1953	1954	1955	1956
Operating Revenues:				
Passengers	30,574	32,306	110,775	188,434
Goods (lbs.)	526,054	1,523,523	14,417,040	18,715,580
Revenue hours	18,189	15,820	38,466	64,047
Revenue miles	1,843,520	1,610,906	4,895,017	8,173,573
Gross Revenue ($000's)				
Distant Early Warning Airlift			3,453,486	6,949,181
Other	1,500,000	N/A *	2,053,035	4,150,192
Total	1,500,000	N/A	5,506,521	11,099,373
Operating Expenses			4,676,231	10,128,792
			830,290	970,581
Gain on disposal of equipment			11,596	84,862
			841,886	1,055,443
Interest on borrowings			72,808	143,974
			769,078	911,469
Less non-cash items:				
Depreciation			174,185	451,253
Amortization of deferred charges			185,025	241,370
Amortization of financing costs			2,146	10,344
Total			361,356	702,967
Profit before taxes			407,722	208,501
Legal fees			28,287	
Taxes on income			20,992	11,000
Net Profit			358,643	197,501

N/A*: Information not available.

Notes: Prior to 1955 Pacific Western Airlines did not publish official annual reports. Thus the break-down of gross revenue and operating expenses are not available for 1953 and 1954.

Source: Pacific Western Airlines Ltd. Annual Reports for 1955 and 1956.

etc.) and food supplies were transported to the sites by air. Moreover, before any construction took place, aircraft were needed for aerial photographs of the sites necessary for topographical details of potential sites. Such activities induced an increase in the number of airlines and airline operations. Some of the local service carriers in British Columbia began as bush flyers in the 1950's as a spillover of the Dew line demand (see Table 1c and Appendix 3). The airlines which were the larger contract holders in British Columbia included PWA, Wardair, and Powell River Airways (Air West). A number of bush flyers obtained contracts for providing air services.

The effect of the Dew Line on airline operations is reflected in the expansion and growth of the airline companies. Not all of them, but a few gained financial power which enabled them to expand their services. The impact of the Dew Line on the airline industry can be seen from the operating and financial statistics of PWA. The company's (PWA) gross operating revenues increased almost tenfold between 1953 and 1956 (see Table 7).

The economic changes in British Columbia and across Canada not only influenced the air industry but also socio-economic characteristics of traffic generating nodes. Personal disposable income increased as both national and provincial incomes rose with the increase of new capital invested largely in natural resource development. These factors showed a long term growth over the air industry and produced economies of scale which enabled major airlines such as PWA, CP Air, and Wardair, to purchase larger aircraft. Although CP Air was a transcontinental airline it had a large share of routes in British Columbia and as early as 1953 began to use long range

Selected Characteristics of Airline Operations Between 1945 - 1980 - Table 1c

Period of Operation	Owner/ Operator	Head Office	Aircraft Type	Airstrip	Routes	Function
1946 - 1953	Russell Baker and Walter Gilbert (Central B.C. Airways) PWA	Ft. St. James Later relocated to Alberta	T-50 Cranes 2 Junkers Beaver	Vancouver Prince Rupert Prince George Kitimat Smithers Ft. St.James	Local. By 1949 regional	Charter services and contracts
1946 - 1955	Jim Spilsbury (Queen Charlotte Airways)	Vancouver	DC-4, Rapide, Anson, Canso Stranraer	Vancouver Queen Charlotte Is. Prince Rupert P. George Powell River	Regional	Scheduled air passenger and freight services
1946 - *	Polaris Charter (Wardair)	Yellowknife	Fox Moth, CF-DJB, Otter DC-6, 2 Bristol freighters	Vancouver and other national airports	Arctic, Northern Can. & international	Charter air services
1948 - 1953	Kamloops Air Services	Kamloops	Tiger Moth, Dragonfly, CF-BZA twin Otter	Kamloops Vernon Kelowna Penticton Cranbrook	Local	Non-scheduled services (class 2 and 3)
1949 - 1953	Skeena Air Services	P. Rupert		Local	Northern B.C. Yukon, N.W.T.	Scheduled & non-scheduled air traffic services (class 3)

Selected Characteristics of Airline Operations Between 1945 - 1980 - Table 1c cont'd

Period of Operation	Owner/ Operator	Head Office	Aircraft Type	Airstrip	Routes	Function
1948 - 1979	Powell River Airways renamed Air West	Vancouver	Twin Otter (DHC-6) Grumman G-21A	Local	Coastal air routes	Scheduled air services (class 2)
1950 - *	Gulf Aviation Ltd.	Campbell River	Otter (DHC2) Norseman, Beaver (DHC2) Cessna 172	Local	Coastal routes and northern B.C.	Scheduled and non-scheduled air services (class 2 and 3)
1953 - *	Central B.C. renamed Pacific Western Airlines	Ft. St. James Edmonton (1954) Vancouver (1957)	3 Junkers Beaver, Otter (DHC2)	Regional airports. Vancouver, interior B.C. and northern B.C.	Local and regional routes	Charter services and contracts
1958 - 1977	Victoria Flying Services	Victoria		Victoria Vancouver, local airports in coastal areas	Local air routes	Scheduled and non-scheduled air services (class 3)

Selected Characteristics of Airline Operations Between 1945 - 1980 - Table 1c cont'd

Period of Operation	Owner/ Operator	Head Office	Aircraft Type	Airstrip	Routes	Function
1959 ---	Island Airlines Ltd.	Campbell River and another office in Vancouver since (1977)	2 Grumman G-21A's, Twin Otter, Beech BE-18	Airports in Gulf Islands, Vancouver Is. & Lower Mainland	Local	Scheduled services licence (class 2 and 3)
1963 ---	Kent Aviation Ltd.	Chilliwack	3 Twin Otters Britten-Norman	Chilliwack Tippella, Stokke Creek, Bear Creek, P. Douglas, Twenty Mile Pt. Tretheway Creek, Horrison	Level III air carrier routes (local)	Charter and non-scheduled air services licence (class 3)
1963 - 1979	Trans Provincial Airways	Prince Rupert	Grumman G-21 Twin-Otter Beaver	Masset Sandspit Terrace, Edmonton, small local air bases	Local routes	Scheduled and charter services
1965 - 1979	West Coast Airlines	Vancouver	Grumman G-73 Grumman G-21 Otter	Local airports on coastal areas	Vancouver Ocean Falls intermediate points, Vancouver Is.	Scheduled and non-scheduled air services (feeder lines) (class 2&3)

Selected Characteristics of Airline Operations Between 1945 - 1980 - Table 1c cont'd

Period of Operation	Owner/ Operator	Head Office	Aircraft Type	Airstrip	Routes	Function
1966 - 1979	Pacific Coastal Airlines	Vancouver	Twin Otter (DHC-6) Beech BE-99 Piper PA-31 Britten-Norman BN-2A	Vancouver Nanaimo Qualicum P. Alberni Vancouver Is.	Level III air carrier local routes	Scheduled and non-scheduled air services (feeder lines) (class 2&3)
1969	Northern Thunderbird Air Ltd.	Prince Rupert	3 Twin Otters (DHC-6's)	Prince Rupert, Terrace, Smithers P. George	Level III air carriers routes (local)	Scheduled services class 2
1969	Arrow Aviation Ltd.	Revelstoke	Piper PA-31 Beech BE-99 Beech BE-18	Airports in the interior of B.C.	Level III air carrier routes (local)	Scheduled and charter services class 3
1969	North-Coast Air Services	Prince Rupert	Beaver Fairchild F-27 Twin Otter	P. Rupert P. George Terrace Smithers and other local airports	Operates on level III air Masset (local)	Scheduled and charter services carrier routes class 2 and 3
1970*	Alert Bay Air Services	Campbell River	Piper PA-23 Beaver Beech BE-18	Campbell R. Nanaimo, Alert Bay, P. Hardy, Bella Bella Bella Coola & small community airports	Level III air carrier routes	Scheduled and non-scheduled & charter air services (class 2&3)

Selected Characteristics of Airline Operations Between 1945 - 1980 - Table 1 c cont'd

Period of Operation	Owner/ Operator	Head Office	Aircraft Type	Airstrip	Routes	Function
1973 - *	Tyee Airways	Powell R.	Seaplane BE-18 Beech BE-99	Powell R. Nanaimo & local airports	Local	Scheduled charter (class 2 and 3)
1979 - *	Abbotsford Air Services	Abbotsford	Cessnas C-207 Cessna 186	Abbotsford Victoria	Local	Charter air services (class 3)
1979 - *	Air B.C. Ltd. (Acquisition of Air West, Trans-Provincial Airway and Pacific Coastal Airlines)	Richmond	3 DHC-7 12 DHC-6 BN-Islander	Vancouver Harbour, Victoria Harbour Powell R. Comox, Nanaimo and other small air bases on the coast	Local routes served by Level III air air carriers	Scheduled air services (class 2)
1980 - *	Kootenay Airways Ltd.	Cranbrook		Cranbrook Invermere Golden and local small air bases	Local routes	Scheduled and charter services licence class 3
1980 - *	Knight Air Ltd.	Ft.St. John		Ft.St. John Dawson Creek small local airports and Edmonton	Local air routes	Scheduled and non-scheduled services (class 3)

Source: Aviation Statistics Ce tre, Fleet Report - Inventory of Commercial Aircraft in Canada, 1970 - 1977 Canadian Transport Commission, Local Service Air Carriers Providing Unit Toll Services in Southern Canada 1972 - 1978, Research Report No. 40-80-13, October, 1980.

* Airlines still in operation.

aircraft. The Dew Line helped CP Air improve its economic operations so that in 1957 the company purchased 2 turbo-propeller jets (Milberry, 1979, p. 80, also see Appendix 4a for principal aircraft used by airlines.

The use of large aircraft in the 1950's increased flight capacity which in turn produced lower unit fares. The reduction of fares stimulated an increase in air passenger traffic, particularly in the routes of southern British Columbia. Northern routes were self--supporting because of the traffic volume generated by the mining and forestry industries.

Table 8 summarizes airline operations and the growth of the commercial air industry in Canada between 1946 and 1960. The table gives global or national information rather than presenting the operations of the airlines in British Columbia. One remarkable fact that emerges from Table 8 is that on the basis of all six indicators used there is a big increase. Moreover, it was in this period that commercial passenger services became important.

In contrast to Table 8 is the information on contract and charter services expressed in Table 9. A different picture in the trends of the industry emerges. In all three criteria used there is fluctuation. For instance, in 1949, 1954, 1957 and 1958 there is a decline across all three indicators. The decline in 1949 reflects the general pattern of air transportation in mining and mineral exploration areas. During the early stage of exploration small aircraft (with payloads of approximately 1,100 pounds) were used for transportation of exploration crews and material supplies. When construction projects began after discoveries were made, larger aircraft such as

Table 8

The Growth of Domestic Scheduled Air Carriers
1946 - 1960
(Trans-Canada Airlines not included)

Year	Passengers Carried Thousands	Passenger Miles Thousands	Mail Carried Thousands of Ton Miles	Goods Carried Thousands of Pounds	Goods Thousands of Ton Miles	Miles Flown Thousands
1946	445.8	156,389	1,428.4	9,270	1,108.0	16,520
1947	462.3	179,383	1,527.4	10,035	1,607.5	17,122
1948	600.8	253,721	2,603.3	12,244	2,357.3	18,429
1949	709.3	313,265	3,783.4	13,322	3,021.0	20,090
1950	864.8	374,781	4,043.6	16,520	4,122.0	22,674
1951	1,053.7	451,051	4,369.3	19,278	4,547.9	30,933
1952	1,248.8	542,162	4,689.0	22,396	5,393.4	28,838
1953	1,419.6	628,098	5,265.3	23,889	6,373.4	31,146
1954	1,559.6	707,404	6,604.3	27,454	8,358.4	32,394
1955	1,797.2	794,797	7,293.3	35,603	11,071.5	36,384
1956	2,115.6	946,463	7,950.3	47,977	13,102.4	39,795
1957	2,393.9	1,073,192	8,770.9	46,457	15,091.4	44,689
1958	2,651.1	1,224,057	9,186.4	48,453	17,775.1	46,335
1959	3,098.3	1,449,151	9,844.1	59,392	19,393.1	52,234
1960	3,098.7	1,649,894	10,418.5	65,687	23,295.5	54,704

Notes: Domestic revenue traffic only. International traffic not included.
Domestic scheduled carriers: 1946: CP Air, Maritime Central Airways, Queen Charlotte Airlines
1947 -1960: CP Air, Maritime Central Airways, Queen Charlotte Airlines, Rimouski Air Lines (Quebecair), Central Northern Airways

Source: Urquhart, M.C. and K.A. Buckley. Historical Statistics of Canada. Toronto: The Macmillan Company of Canada Ltd., 1965.

Table 9

The Growth of Contract and Charter Traffic
1946 - 1960

Year	Passengers Carried Thousands	Goods Carried Thousands of Pounds	Revenue Miles Flown Thousands
1946	83	13,046	5,399
1947	109	19,384	6,616
1948	143	18,169	7,905
1949	137	15,565	7,166
1950	165	19,813	8,286
1951	193	26,269	9,986
1952	295	94,694	17,447
1953	379	132,730	19,532
1954	320	63,141	15,450
1955	406	175,789	32,266
1956	524	246,886	42,370
1957	509	194,456	36,743
1958	424	128,006	26,372
1959	505	126,524	28,702
1960	509	123,200	23,939

Notes: Contract and Charter refer to the hiring of the whole of the aircraft capacity.

Source: Urquhart, M.C. and K.A. Buckley. Historical Statistics of Canada. Toronto: The Macmillan Company of Canada Ltd., 1965.

Beavers and Otters, Lockheed 10, and Beachcraft B-18 were used (see Appendix 4c). At the completion of construction projects and when production began, charter services were usually replaced by regular scheduled services for passengers, mail and cargo, thus reducing charter operations. The decline between 1957 and 1958 is partly due to a decline in business following completion of the Dew Line by 1957. Consequently the demand for air transportation began to decline. The scheduled air carriers did not experience the decline because their air traffic was supplemented by air traffic in southern Canada, mainly the east - west routes along populated urban centres.

The decline in output of the charter industry in 1954 was affected by the completion of construction projects in other provinces. For example, the completion of mining and railway construction projects in northern Quebec at Knob Lake coincided with this decline in charter industry. The sharp increase between 1955 and 1956 was due to the defence construction airlifts combined with other factors. This growth is illustrated by the statistics compiled from Contract and Charters' Reports to the Air Transport Board by Statistics Section. The statistics show the geographical distribution of charters licenced to operate from fixed bases.

3.2 Selected Characteristics of the Network Between 1946 and 1960

Table 1c tabulates in summary form selected features of the commercial airline companies in terms of the airline firms, location of head offices, route structure, aircraft types, and demand. A number of these features such as demand, aircraft types and route structures have been discussed in previous paragraphs.

The nature of the airlines that emerged in 1946 differed slightly from pre-War airlines. They did not start as individual investors but instead started in partnership or as small shareholders. Partnerships were still small compared to joint-stock investments of the two trunk lines, CP Air and Air Canada. However, they were no longer owner/operator types of airlines. Large capital and overhead were the prerequisites for large operations. This was expected because of the anticipated traffic growth as a result of the War. Larger aircraft available in the market were necessary to accommodate traffic and this required large investments which individual investors could not afford. As a result the airline firms were larger than the ones between 1920 and 1936 because of the need of joint shares investments.

Head offices and main operating bases were no longer restricted to local locations, particularly for the airlines which were operating as regional carriers. Central British Columbia Airways provides a good example. When the airline began its operations in 1946 its head office and main operating base was located at Fort St. James. With the expansion of its services in the early 1950's it divided its operations into two parts and so were its head offices. One division was responsible for operations in the Northwest Territories while the head office for the northern operations was moved to Edmonton. All business operations for the North were performed from Edmonton. Operations in the North required day contact or Visual Flight Rules flying. For this function the airline used light and medium weight aircraft. The main head office and operating base was relocated from Fort St. James in 1957 to Vancouver International

Airport. It was from this main operating base that several types of domestic operations (regional) were conducted using about eight aircraft ranging from DC-3, DC-4, DC-6 and DC-7.

The regional routes of Central British Columbia Airways which by the 1950's had changed its name to Pacific Western Airlines, extended from Vancouver to Edmonton and to Inuvik, Yellowknife, Fort McMurray and Fort Smith. Local services extended from Vancouver, Powell River, Campbell River, Comox, Port Hardy, Prince Rupert to Alice Arm and Stewart. The general picture of the route structure of the main airline firms operating in British Columbia between 1946 and 1960 is given in Figures 6, 7 and 8.

3.3 Air Transportation Moves Towards Maturity, 1960 - 1980

Perhaps 1960 to 1980 was the most significant phase in the evolution of the air transportation industry in terms of network expansion. The expansion of the network during this phase was a continuation of the growth of the air industry in the 1950's. However, between 1960 and 1980 it can also be said that the air transportation industry was moving towards maturity. During this phase (1960 - 1980) the industry was well organized, well regulated and had become more sophisticated than previous periods. Sophisticated navigation and communication equipment and techniques were adopted in the 1960's; air traffic control facilities were installed and a swing to modern jets and wide-bodied aircraft took place.

These trends were the most significant in the development of the air transportation industry during the period from 1960 to 1980. The swing to large aircraft by large airline firms (PWA and CPA)

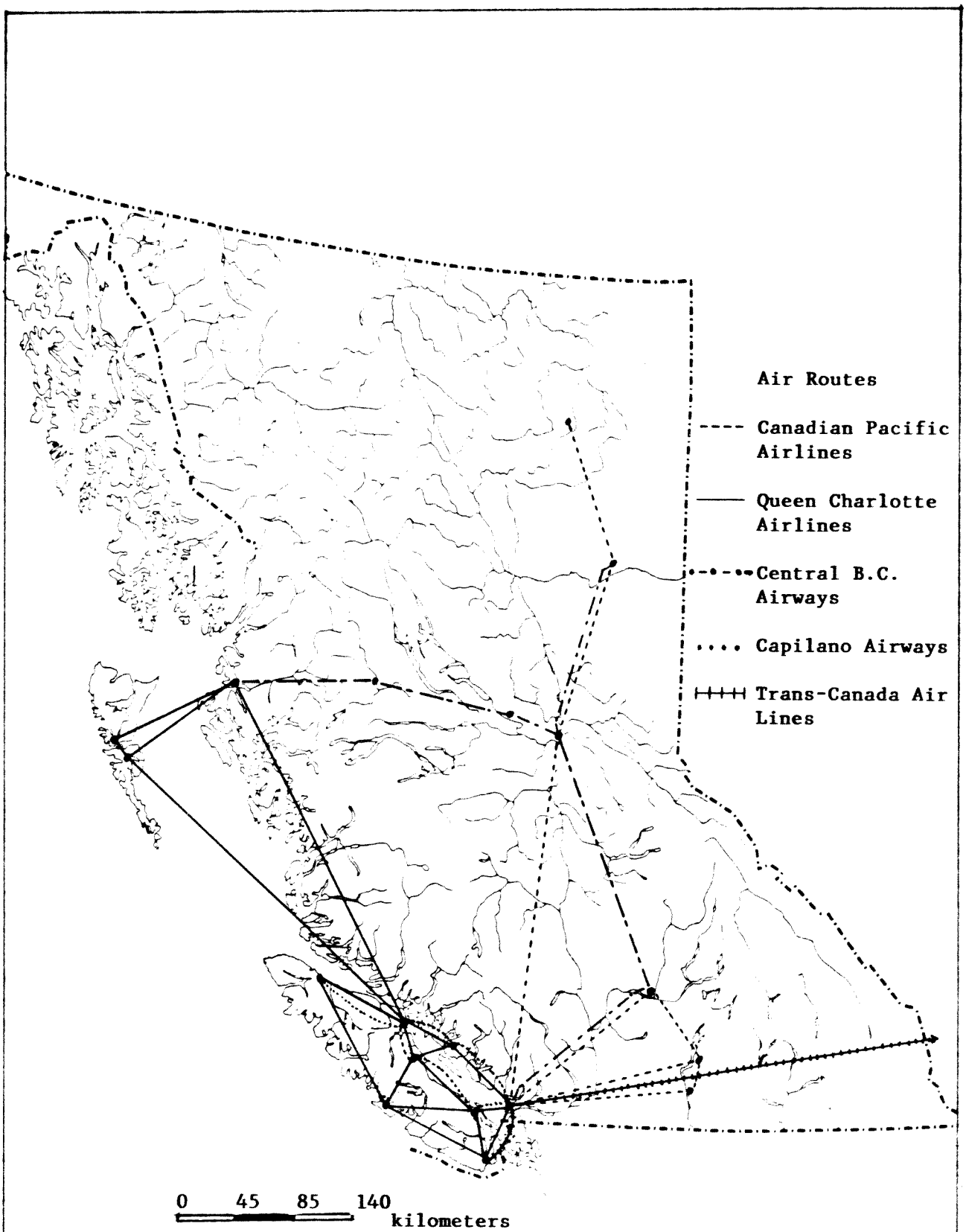


Figure 6: Airline Routes: British Columbia, 1946

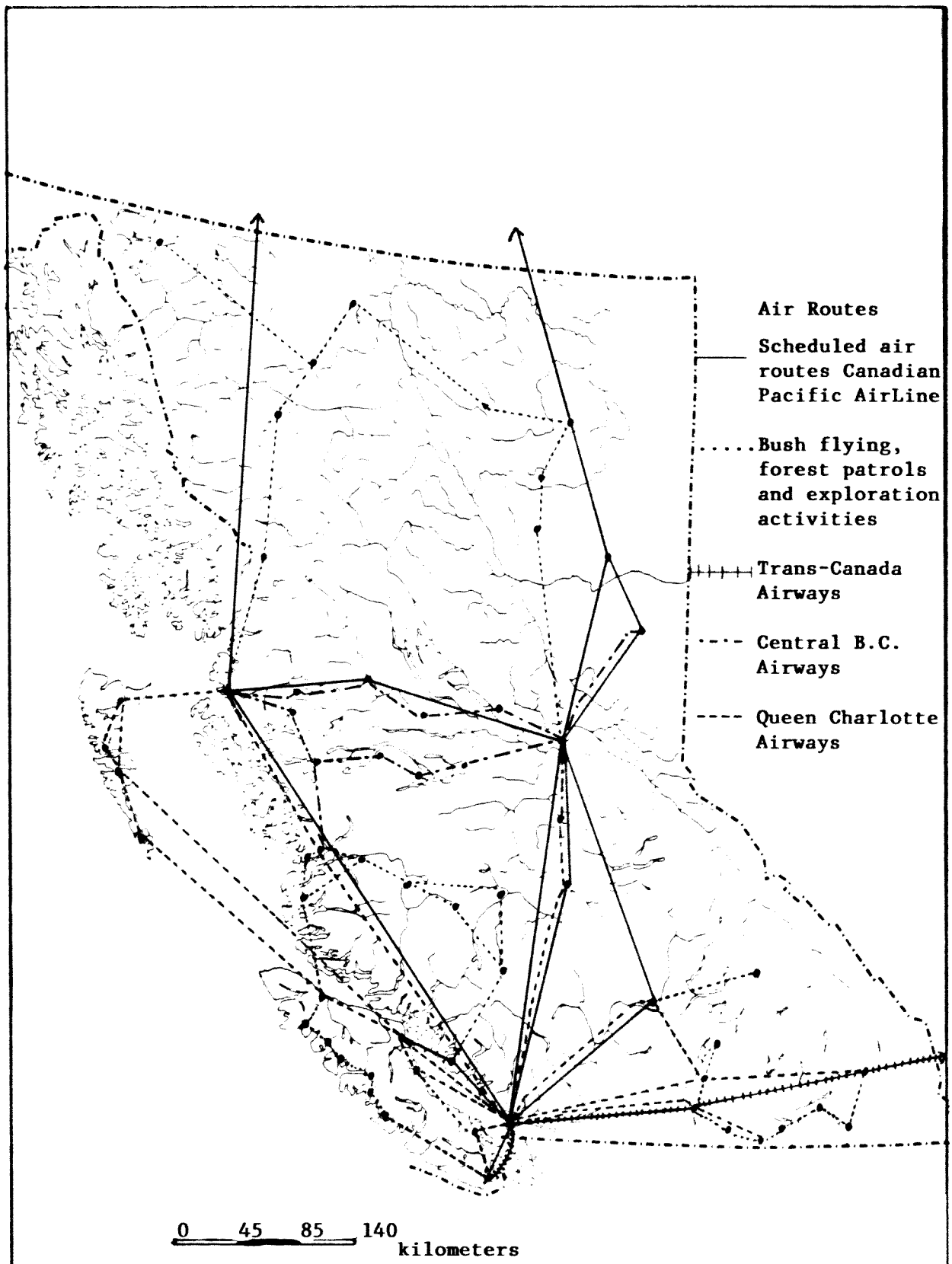


Figure 7: Airports and Airline Routes: British Columbia, 1949

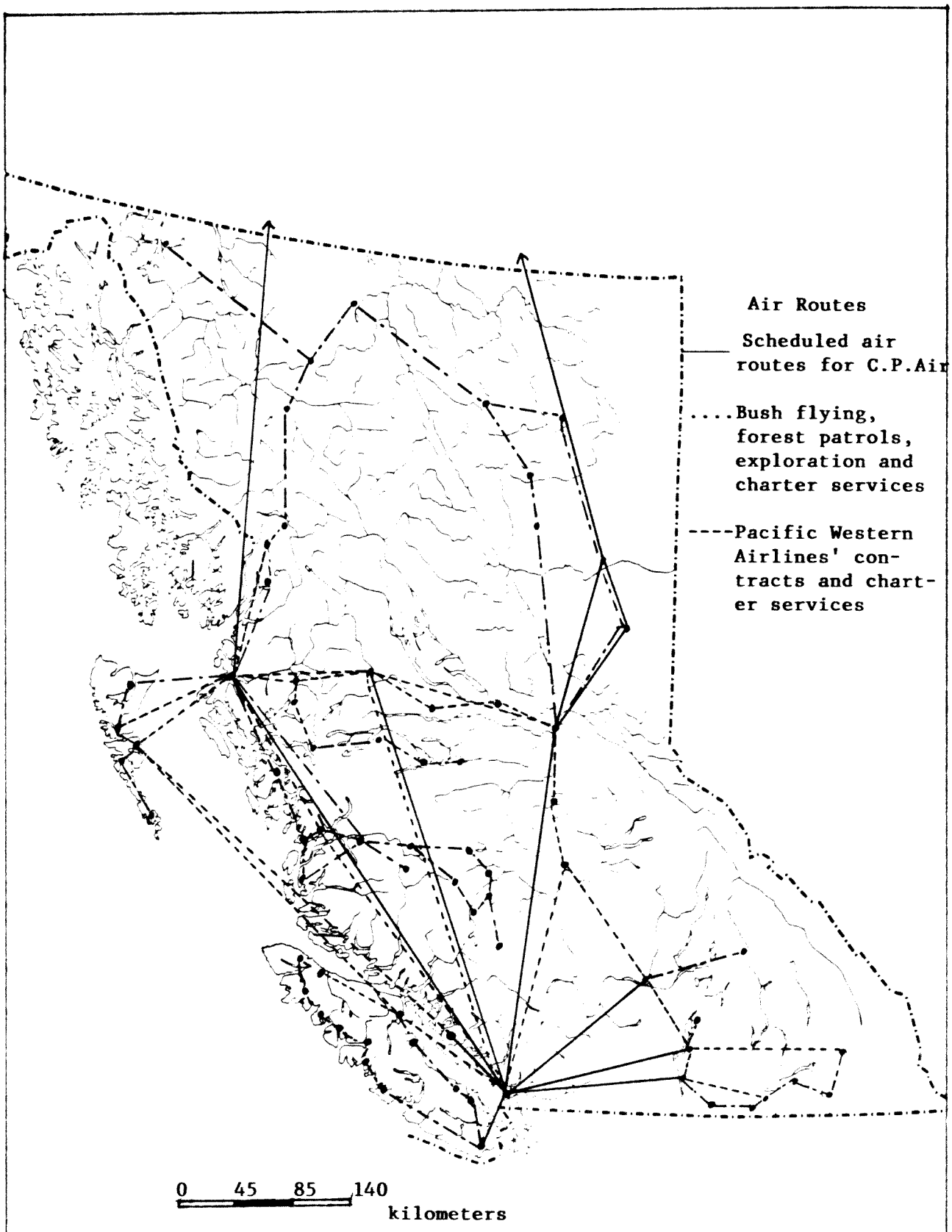
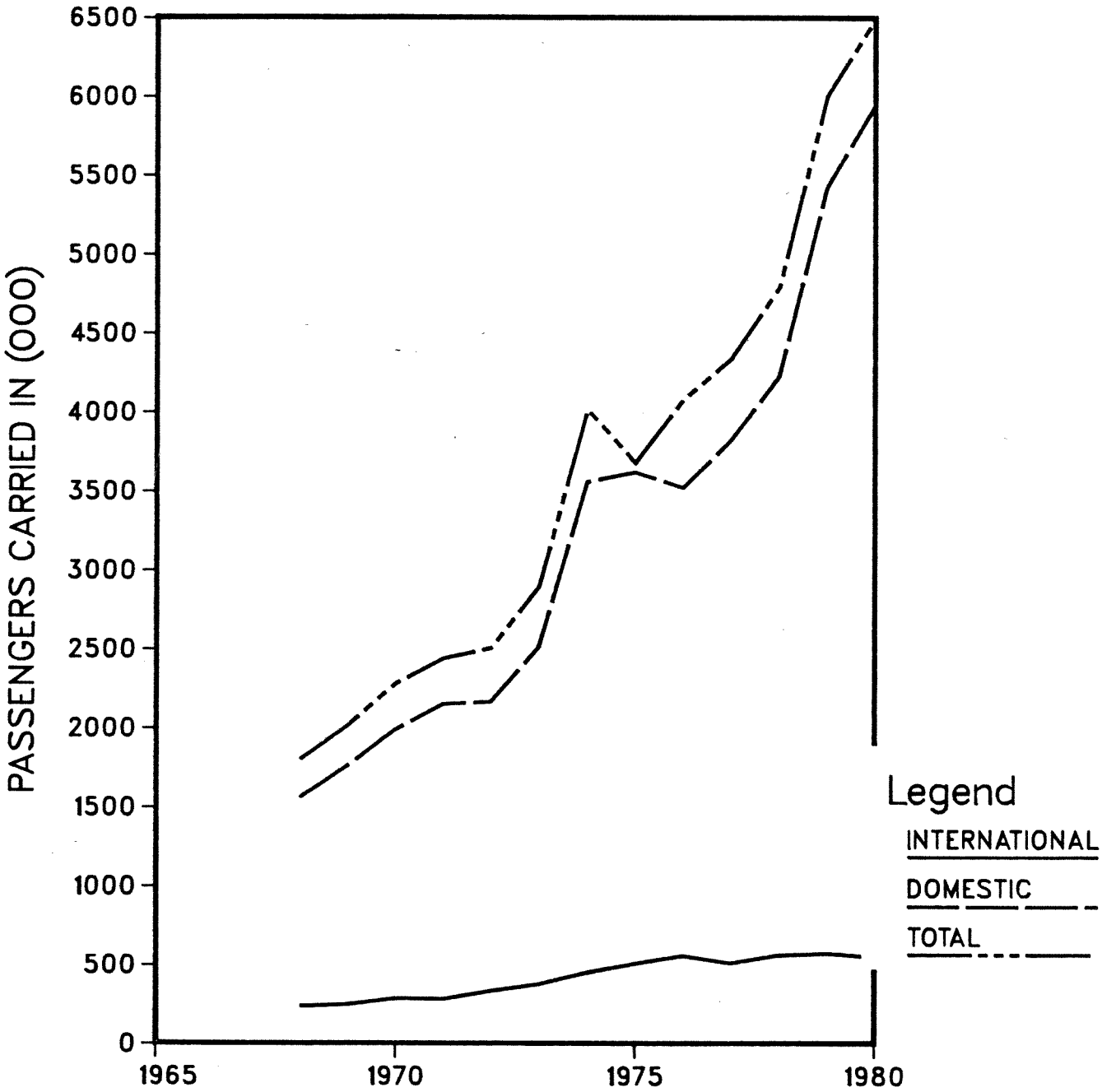


Figure 8 : Airline Route Structure: British Columbia, 1959

and to modern aircraft for short haul routes by small local air carriers coincided with the economic growth in British Columbia as well as in Canada as a whole. An increase in personal disposable income does not necessarily give rise to air passenger traffic but it has a potential influence on personal travel (recreational trips, visits, etc.) On the other hand, the GNP reflects the fact that there was a substantial progress in industrial and commercial development in British Columbia and in Canada between 1960 and 1980. Business traffic depends on the development of industry and commerce and the degree of trade, that is, trade between British Columbia and other provinces in Canada and international trade. An increase in traffic between 1960 and 1980 can be attributed in part to an increase in trade because business travel and freight are influenced by trade while personal travel is influenced by an increase in per capita income.

Figure 9 shows the growth in air passenger traffic between 1968 and 1980. One remarkable fact in this graph (Figure 9) is the existence of a gradual growth of air travel. In the 1960's the increase in passenger traffic was affected by a gradual increase in personal disposable income and the spread between the fares. That is, the average fare for passengers and rates for cargo dropped in the 1960's while the consumer price index rose (Glenn, 1979, p. 3). The reduction of rates and fares lead to penetration into the lower income travel market and into the lower dollar per pound of air freight. The airlines were able to keep the rate structure down during the 1960's because of the new aircraft technology (large wide-bodied aircraft) which were economically efficient in terms

FIGURE 9: AIR PASSENGERS CARRIED FROM 1968 TO 1980



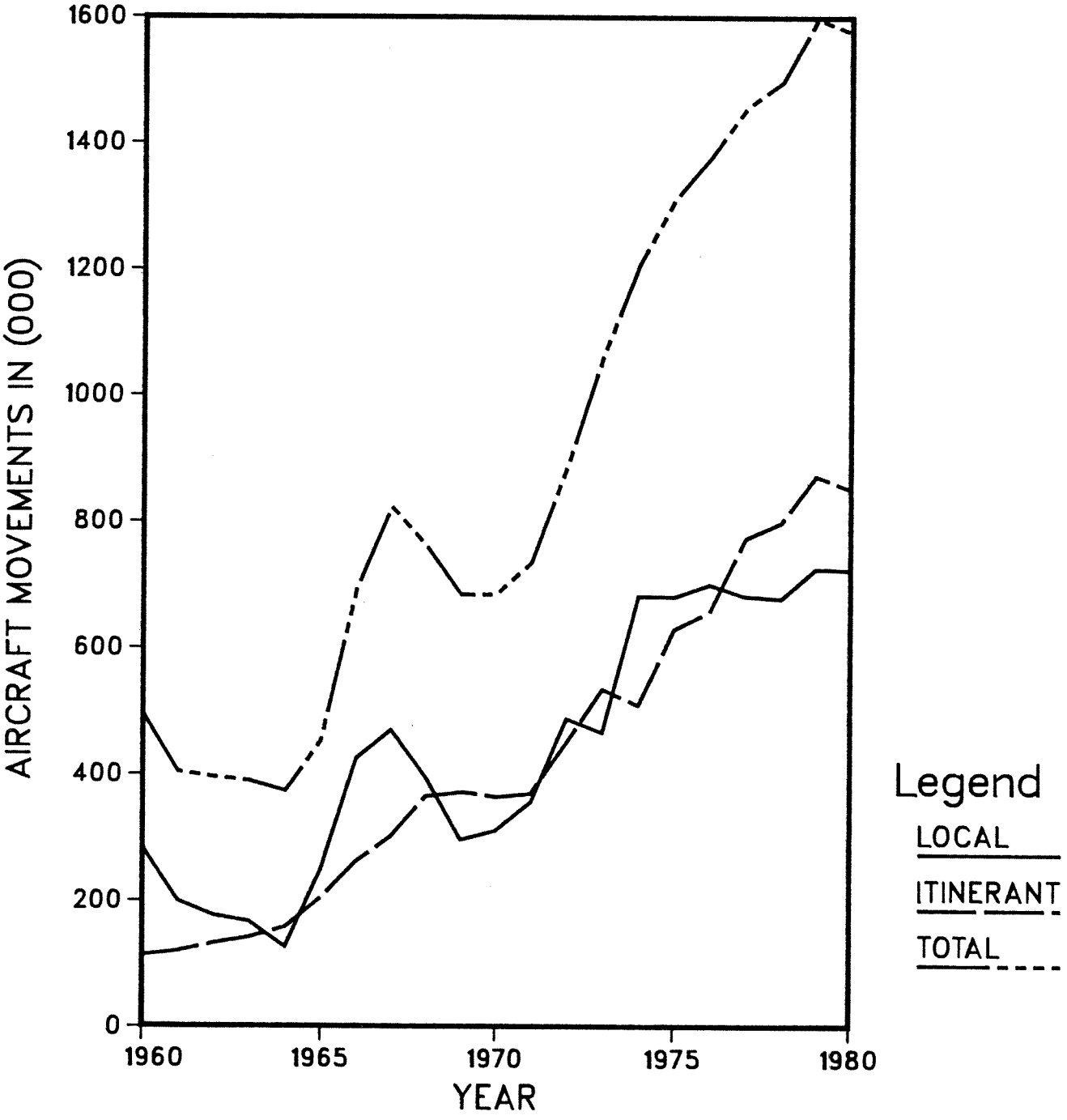
of operating costs, capacity and productivity. A change occurred between 1970 and 1971 in that there was a slight decline in passenger traffic (see Figure 9). This decline corresponded with the change in operating costs in 1970 for almost all of the world airlines. Transportation unit costs began to rise in 1970 because of the rapid increase in labour and material and the lack of more efficient aircraft coming into service. The situation was accentuated by the increase in the fuel prices in the early 1970's until 1973. Operating costs and fuel costs increased between 1970 and 1972 affecting air passenger traffic (see Figure 9).

The decline in domestic air passenger traffic in 1976 was partly due to the economic difficulties of the mid-1970's experienced by the local service airlines those being the largest group of commercial airlines serving the local market in British Columbia. A study done in 1977 by students at the University of British Columbia of local service airlines operating on the coastal routes between Powell River and Prince Rupert found that a number of these airlines had financial problems. For instance, Victoria Flying Services in 1977 ceased its operations after losing money for four years (CTC, 1980, Report No. 40-80-13, p. 51). Other local service airlines had a combination of losses and profits. The only financially successful local service airline was Airwest. Its profits were significant enough between 1972 and 1978 to show that the British Columbia local service airlines were the only ones with a net income or profit in a study done by the Canadian Transport Commission in 1979. Airwest had an outstanding financial record in the 1970's because of its route patterns. It was servicing heavily populated centres between

Vancouver, Victoria, Nanaimo, Comox, Powell River, Campbell River and Port Hardy. In some of the routes it was not even competing against larger carriers, as others did, but provided interlining passengers for larger carriers such as PWA, CP Air and Air Canada. For example, in 1977, five percent of Airwest's passengers on the Vancouver - Victoria, Vancouver - Nanaimo and Vancouver - Powell River routes connected with either PWA, Air Canada or CP Air.

In spite of the financial position of local service airlines general trends in air traffic movement between 1960 and 1980 showed a gradual growth. Such growth in air traffic was affected in part by the use of sophisticated navigation and communication systems and air traffic control facilities. Air traffic control towers increased utilization of airports which in turn increased frequency of flights. That is, the number of aircraft using airports increased remarkably per hour. Pilots were no longer dependent on visibility and clear daylight for operations but relied on instrument flight rules and direct - controller - to - pilot communication systems. This system is composed of radio transmitters and receivers connected to control centres within air traffic control zones. As the number of air traffic control facilities increased and the use of modern navigation aids increased, traffic handled in airports in British Columbia increased. Figure 10 shows the total movement of aircraft at the airports with air control towers in British Columbia between 1960 and 1980. Although there is a substantial fluctuation in the movement of aircraft between 1960 and 1970, the number of aircraft began to increase gradually between 1971 and 1979. The decline from 1961 - 1964 was partly the result of the changes in aircraft

FIGURE 10:AIRCRAFT MOVEMENTS BY CLASS OF OPERATION WITH AIR TRAFFIC CONTROL TOWERS IN BRITISH COLUMBIA FROM 1960 TO 1980



types used by airlines. Between 1960 and 1970 turbo-prop aircraft were gradually replaced by pure jets. By 1970 trunk lines and regional airlines were using turbo jets more than the former. Turbo jets were making over fifty percent more of the flights at airports in British Columbia than were the turbo props. The use of larger aircraft by major carriers decreased the frequency of flights because they could carry more people in one aircraft and have only one flight or two per day depending on the density of traffic over the route served. On the other hand, while the major carriers reduced their frequency of flights the number of light aircraft utilizing the airports increased. The sharp increase in total movement between 1964 and 1967 was due largely to an increase in local flights (generally recreational and training flights) and to a lesser degree due to an increase in itinerant flights (primarily commercial and business flights which may include some recreational flights). The gradual increase experienced between 1971 and 1979 was also influenced by the increase in private commercial activity by private companies. In British Columbia private companies engaged in forest products, petroleum industries, charter services and some of the flying training schools (e.g. Abbotsford and Langley airports) made use of the airports with air traffic control towers. Hence the volume of flights increased between 1971 and 1979. This increase in the density of flights is reflected in the mean local degree which shows that as the number of aircraft utilizing the airport per hour increases so does the frequency of flights increase (see Table 10).

A comparison of Figures 9 and 10 reveals one remarkable fact

and that is that between 1960 and 1980 there has been a gradual increase in the growth of both passenger traffic and the movement of aircraft. Air passenger traffic increased from 1,809,175 in 1968 to 6,500,760 in 1980 while total aircraft movement increased from 494,622 in 1960 to 3,945,124 in 1980. However, the increase in aircraft movement does not really indicate whether the aircraft were carrying passengers or freight. They are not even classified by size or type but the important fact is that aircraft operations increased in British Columbia as the number of air traffic control towers increased between 1960 and 1980.

Another factor which played an important role in the growth and intensification of the air network between 1960 and 1980 was the specialization of the air industry. The air transportation industry became highly specialized in terms of route lengths, traffic scale, types of air carriers for specific markets and in terms of route systems predicted to contain some economically desirable links. To achieve a well organized and coordinated air transportation system it was necessary to classify the airlines into certain categories. The classification of airlines and designation of their markets were aimed at improving their economic efficiency. In 1966 the Canadian Transport Commission, a regulatory agent of the Air Transport Board, divided the airlines into 9 groups defined as levels I to IX. The commercial air carriers consisted of levels I, II and III. The classification system was based on the level of economic performance, fleet size, aircraft types and types of services offered by the respective air carriers.

Level I refers to the two national carriers (trunk lines),

Air Canada and Canadian Pacific Airlines (CP Air). The trunk lines operate long and medium distance hauls connecting the major urban centres across Canada. They operate over high density traffic routes. Both CP Air and Air Canada have routes in British Columbia. However, CP Air has a larger share than Air Canada of the British Columbia travel market (see Figures 11 and 12).

Level II defines the regional air carriers serving the medium haul market. These carriers use medium range aircraft which are smaller than those of the trunk lines. The regional carriers operate the routes which because of the traffic volume or size of airports and related facilities were not suitable for the trunk lines. In British Columbia there is only one regional carrier, Pacific Western Airlines (PWA) which has its routes extending from British Columbia, to the Northwest Territories and Alberta.

Level III carriers (third levels) are local service air carriers serving routes between larger urban centres and small cities. They are generally short distance haul air carriers serving low traffic routes using light aircraft with 56 to 60 seats and a payload capacity of no more than 18,000 pounds (see Appendix 4c). The third levels use both class 2 and class 3 licences (in some cases class 4) for scheduled and non-scheduled passenger and cargo services.

The third level carriers played an important role in the growth and expansion of the network structure of the air transportation industry in British Columbia between 1960 and 1980. They form the largest group of the commercial airline industry in British Columbia (see Table 1c, appendix 3, and Chart 1). Generally, the third level carriers provide services including scheduled, non-scheduled, daily

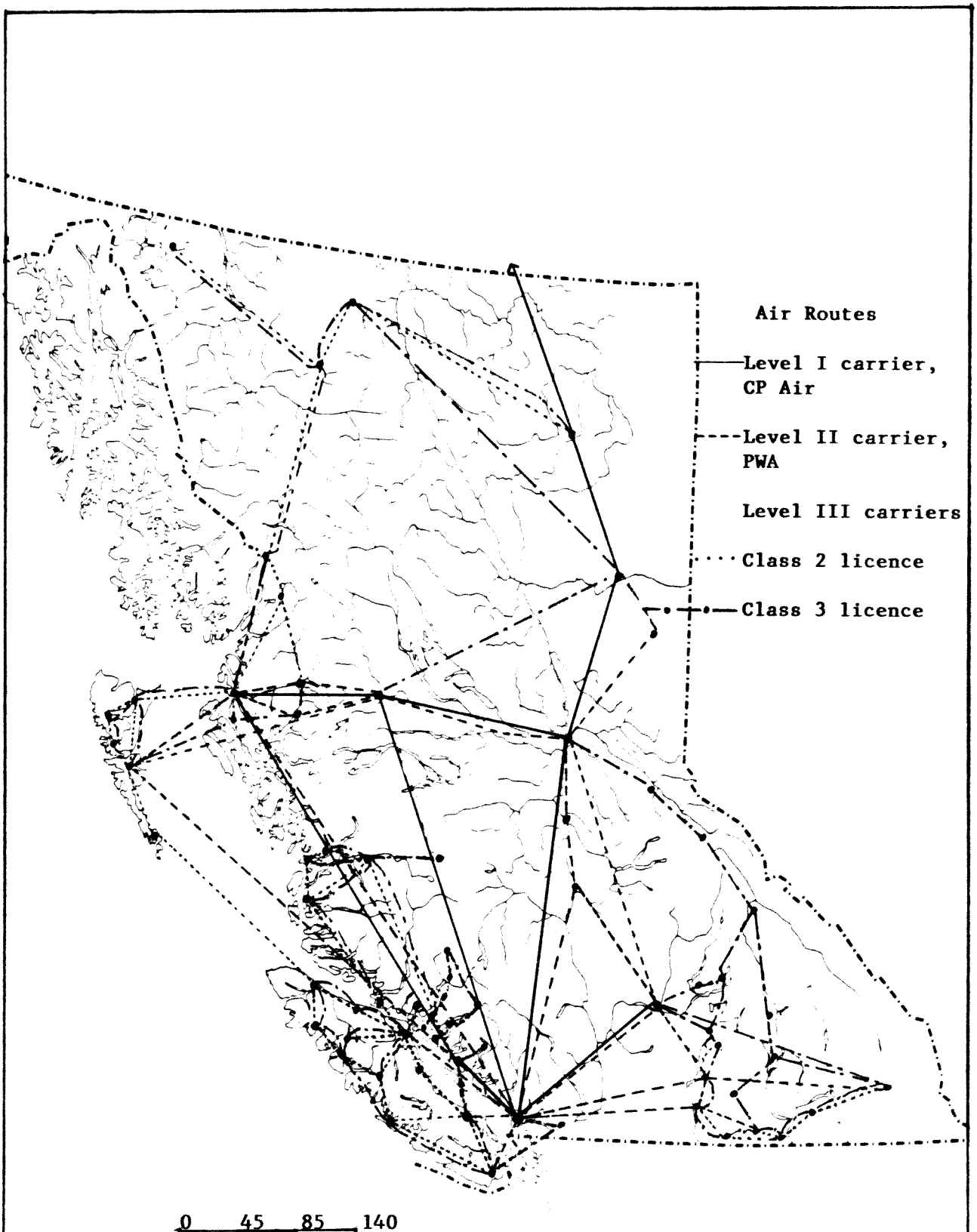


Figure 11: The Routes of Air Carriers by Class: British Columbia, 1969

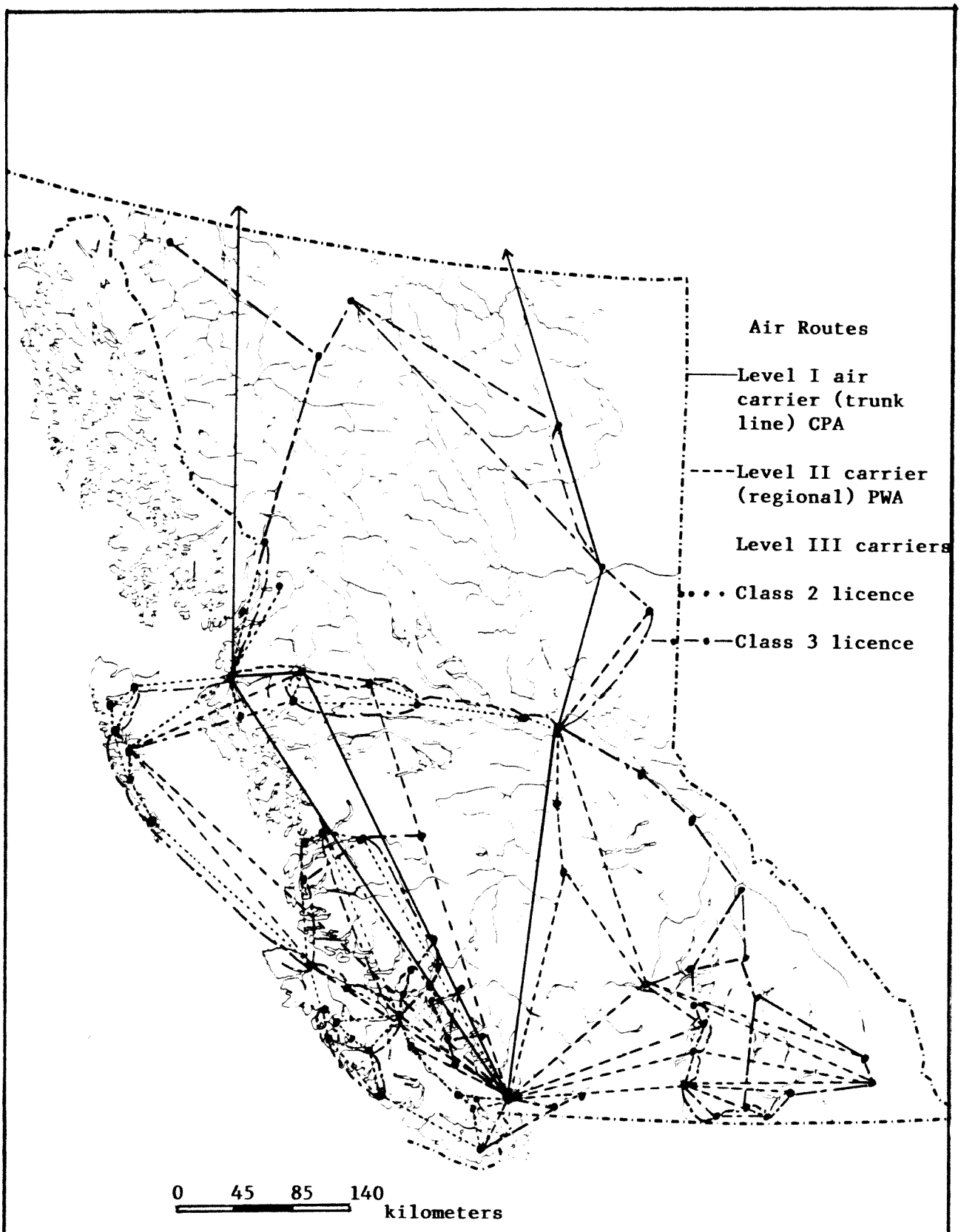


Figure 12: The Routes of Air Carriers by Class: British Columbia, 1979

commuter services and "flag stops" (CTS, 1977, p. 145). Flag stops mean that passengers can make flight arrangements by phone for a pick-up or discharge of passengers. Daily commuter airlines such as Air B.C., one of the largest British Columbia local service carriers operates mainly between large urban centres.

The main function of the local air carriers is to provide feeder lines for PWA and CP Air on the routes that are not economical for the operation of larger aircraft. The local air carriers also provide interlining and under agreement services. The interlining services are similar to feeders but a given local airline has a certain percentage of passengers which it connects with either PWA or CP Air. For example, Airwest Airlines in the mid-1970's operated an interlining route between Nanaimo and Vancouver where it connected its flights with either PWA or CP Air (CTC 1980, p. 19). In the service agreement arrangement a given local air carrier operates on behalf of the major air carrier. For example, Arrow Aviation in the east Kootenays operates on behalf of Pacific Western Airlines. That means, Arrow Aviation provides services in place of PWA.

The network pattern that has resulted from the operations, particularly of the local service carriers reflect the manner in which certain nodes have organized themselves into functional regions or hub and sub-hub-spoke types of networks. The sub-network structures are the result of feeder and interlining air services described above. These sub-networks occur at collecting points where larger aircraft are made available to larger urban centres, mainly Vancouver. Most of the local service air carriers, particularly those operating class 3 licences conduct their operations from the central points

(collecting centres) such as Prince George, Prince Rupert, Kamloops, Cranbrook, Campbell River, Sandspit and Ocean Falls. Each of these urban centres commands a hinterland of influence from small towns and logging camps in their surrounding areas. For example, Prince George attracts the air traffic from Dawson Creek, Fort St. John, Fort Nelson, Fort St. James, Burns Lake and Quesnel (Statistics Canada, Cats. 51-004, 51-203 and 51-204). Prince George then channels the air traffic to Vancouver which serves as a dominant nodal point within the air transportation network. The small communities generate very low traffic and as a result they cannot have direct flights to Vancouver. They are connected to Vancouver through intermediate nodal points (the collecting points).

One of the factors which has also influenced the sub-network structures is the geographical feature of the province. Mountainous terrain in British Columbia has played an important part in shaping the structure of the network. The effects of the physical barriers in British Columbia on the network structure are reflected by the average passenger flight length or trip length and the average flight time (see Table 10). The average flight time shows that the distances flown in British Columbia are very short which indicates that some of the urban centres are very close to each other. However, because of the physical barriers (water and mountains) they are connected by air transportation. Hence, the short link network and sub-hub network structures resulting from short distance hauls. A study done in 1979 by the Canadian Transport Commission on local service air carriers across Canada showed that the average passenger flight

Table 10

A Comparison of the Average Trip Length and Average Flight Time in British Columbia, the Prairies and Ontario/Quebec, 1972 - 1978 (third level carriers)

Province		1972	1973	1974	1975	1976	1977	1978
British Columbia	Passengers	61,830	98,584	128,257	161,473	207,566	258,948	234,077
	Average Passenger Trip Length (km.)	76	82	83	82	96	121	126
	Average flight Time (mins.)	20	21	27	27	25	27	27
Prairies	Passengers	74,017	106,922	155,655	193,995	202,933	222,373	218,468
	Average Passenger Trip Length (km.)	242	242	237	245	242	253	270
	Average Flight Time (mins.)	39	37	35	35	36	40	42
Ontario and Quebec	Passengers	43,500	82,116	97,387	112,808	224,769	305,846	341,944
	Average Passenger Trip Length (km.)	266	246	207	245	210	195	202
	Average Flight Time (mins.)	55	44	40	43	40	42	43

Source: Canadian Transport Commission, Local Service Air Carriers Providing Unit Toll Services in Southern Canada. Ottawa: CTC, Research Report No. 40-80-13, 1980. p. 29.

length and the average flight time in British Columbia were by far the shortest when compared with other provinces in Canada (see Table 10). Although Table 10 shows that the average passenger flight length was increasing between 1975 and 1978 this increase was due to the additional services provided by West Coast Air Services and Pacific Coastal Airlines. These two airlines expanded their operations into the Queen Charlotte Islands.

In summary, the air services offered by local service air carriers coupled with the route structures of Pacific Western Airlines and CP Air have resulted in a highly connected short-link network system in British Columbia. The physical nature of the province has contributed to the existing short distance network pattern.

IV. CHANGES IN THE NETWORK STRUCTURE, 1929 - 1979

To provide summary descriptive statistics of changes in the network structure between 1929 and 1979 some well known measures of network connectivity have been calculated (Table 11). Comparing this table with Figures 3, 4, 6, 7, 8, 11 and 12 the measures of network connectivity indicate a number of characteristics of the air transportation networks betwen 1929 and 1979. The indices show the sequence of changes in the degree of connectivity of the air networks. For example, the air transportation networks between 1929 and 1979 vary in the number of loops or circuits and in the number of routes required to link every node (airport) directly with every other node. The number of actual routes increased remarkably from 12 in 1929 to 270 in 1979. The networks between 1929 and 1979 also vary in the degree of redundancy and the degree of connectivity.

Civil aviation (or the air transportation industry) in 1929 and 1939 was less developed in British Columbia than the air transportation industry after World War II. The air network in 1929 with 12 nodes (air landing fields) and 21 connecting routes, was .32 or 32% connected and .18 or 18% redundant. The level of connectedness and of redundancy or circuitry was low thus reflecting a low level of the development of air transportation industry. The cyclomatic number also shows the connectivity of the network in 1929 to be low at 10.0 indicating a minimally connected network which is characteristic of a spinal network structure (see Figure 3). This spinal pattern was still dominant in 1939 even though

Table 11

Summary of the Measures of the Changes in Network Structure 1929 - 1979

	1929	1939	1946	1949	1959	1969	1979
Nodes	12	28	19	55	64	66	70
Routes	21	56	42	93	113	182	270
Alpha Index	.18	.08	.16	.03	.03	.06	.08
Gamma Index	.32	.15	.25	.06	.06	.08	.11
Cyclomatic Number	10.0	29.0	24.0	39.0	50.0	117.0	201.0
Mean Local Degree	2.15	2.53	2.47	3.38	3.53	5.53	7.73
Redundancy Ratio	.1581	.2774	.2035	.2506	.2597	.3068	.3610

Source: Computer Program, Nodac

Notes: Nodac was originally programmed by D.F. Marble of Northwestern University. The program was modified by J.D. Radke and R. Steiner of Wilfred Laurier University in 1975 to run on a Xerox Sigma 7 computer. Further modifications had been made by J.D. Radke of U.B.C. in 1978.

the number of nodes and routes had increased (see Table 11). The expansion of the air transportation pattern was restricted, among other things, by aircraft technology. The limitation of route lengths, speed and capacity of the aircraft available during the 1920's and the 1930's determined the pattern of the network. The aircraft used during that time (1920's - 1930's) were short range and practically suitable for the market of that period and for short distance hauls.

The effect of the short range aircraft is reflected in the type of network structure which evolved in British Columbia during 1929 and 1939. The network is characteristically short-link, with few cities connected to the major hub, Vancouver (see Figure 4). The nodes connected directly to Vancouver are those with denser traffic volume than small towns and villages. The resultant network tends to be a hub-and-spoke or radial network structure. Along the small towns in the interior of British Columbia and northern British Columbia the spatial pattern of the network tends to form a chain-like route structure leading to bigger centres and then to Vancouver.

The chain-like network structure between 1929 and 1939 (Figures 3 and 4) also reflect the nature of air traffic demand between city pairs. The small towns and mining camps did not generate enough traffic to justify direct flights from remote locations of mining towns to urban centres in the Lower Mainland. In order to increase the load factor, airline operators had to make several stops along small communities. In addition, there was a problem of intermodal competition on the routes where surface transportation existed,

as in the interior British Columbia routes. The problem was that wherever surface alternatives were present they were superior. As a result surface alternatives attracted a large proportion of traffic leaving the airlines with minimum volume.

The chain-like pattern of the network in the interior of British Columbia was influenced by the type of flying operations. For example, flying schools and forest patrols, particularly in the Kootenays e.g. Nelson, were the dominant activities. Such aviation activities did not develop connectivity between the nodes because they were local activities doing very little or no commercial flying. Similarly, in the coastal areas the dominant flying activities in the early 1920's were those of industrial operations providing services which did not require transportation of traffic. As a result they did not form a connected network of air transportation (see Figure 3).

By 1939 the value of the cyclomatic number was almost triple, however, a slight decline occurred in 1946 (see Table 11). During World War II, roughly between 1939 and 1944 the massive restrictive measures taken by the federal government against all commercial air transportation operations reduced the number of nodes and routes. Hence the reduction of the netowrk structure of the air transportation industry (see Figures 5 and 6). The values of gamma and alpha indices were lower in 1946 than those of the network in 1929 but higher than those of 1939. The air transportation network was .25 or 25% connected with a .16 or 16% degree of circuitry which was higher than those of the network in 1939.

After 1946 the numerical values of the measures of connectivity, particularly the cyclomatic number and the redundancy ratio, reflected

a substantial increase and intensification of the network structure of the airlines (Table 11). The high values of these indices indicate that the network structure was highly connected. The existence of a high level of connectivity of the air network is indicative of a relatively high level of economic development in British Columbia after World War II. Moreover, the expansion or intensification of routes between nodes is directly related to an increased demand for air transportation services and facilities. Therefore, the high level of connectivity indicates that there were increases in the travel demand at the traffic-generating nodes between 1959 and 1979. The values of the mean local degree (the average number of routes leading to each node) between 1959 and 1979 confirm the fact that there was an increase in the demand for air services which in turn influenced the increase in the density of routes. The high density of routes reflects the high frequency of flights which from 1960 to 1980 was influenced by the utilization of modern navigation aids, direct-controller-to pilot communication system, the air traffic control towers combined with modern jet aircraft and short-range aircraft as was mentioned earlier. The expansion of routes is apparent in the network structures in Figures 8, 11 and 12.

While the cyclomatic number provides an index of the air transportation network that is invariant under isomorphic transformation, it does not provide a readily intelligible measure of the network structure since its upper level depends on some number which is a function of the number of nodes in the network system. thus, one cannot depend on the cyclomatic number alone to measure the expansion of the network. However, one can transform the cyclomatic

number in such a manner that it has a common upper and lower bounds for all networks. Such transformation can be achieved because alpha and gamma indices have this property of common upper and lower bounds. Therefore they have the ability to provide more meaningful information about the expansion and connectivity of the network. However, the values of alpha and gamma indices in Table 11 do not reflect the expansion and connectivity of the air network structure as could be expected. These values (of gamma and alpha) are in contrast to the substantial increase of the cyclomatic number and redundancy ratio between 1949 and 1979. They are very low and reflect loosely integrated network structures. When these values are compared with the three configurations - the spinal, grid and delta - the development of the air transportation network between 1949 and 1979 corresponds to a spinal configuration. According to the cyclomatic number and the redundancy ratio the air transportation networks during the same time period (1949 - 1979) were approaching a delta network configuration. The low values of alpha and gamma indices were unexpected.

The suggested reason for the unexpected results relates in the non-planar case. (In fact if the network is treated as a planar network, the alpha and gamma indices behave as would be expected). Theoretically alpha and gamma indices should remain invariant under isomorphic transformation, however, the transformation of the formulae for alpha and gamma indices from planar to non-planar networks resulted in some difficiencies. As a result no meaningful information concerning the connectivity and the circuitry or redundancy of the network structure can be extrapolated from these indices. They

do not express an adequate picture of the network connectivity and expansion between 1949 and 1979.

The preceding section has attempted to summarize the development of the air transportation network from 1929 to 1979 through the application of simple graph theoretic measures of network structure. The graph theoretic indices are not adequate methods for measuring intensification and connectivity of the network. However, they give us a clue of the growth, expansion and the spatial pattern of the network developed by the air transportation industry in British Columbia between 1949 and 1979.

V. SUMMARY AND CONCLUDING REMARKS

The current complex network structure of the air transportation system in British Columbia is the result of the interplay of various factors. Initially the air transportation industry in British Columbia evolved without a travel market, suitable aircraft, supporting ground facilities, and even pilots capable of operating the proposed mode of transportation. These constraints were overcome in the context of economic changes in British Columbia and the two world wars.

The development of natural resources in the North and in British Columbia, large scale government defence expenditure on the Dew Line, contracts issued to airline operators for construction projects at Kemano and Kitimat, and the contracts for the Dew Line construction laid the foundation for the present air transportation industry. These factors lead to the rise of airline entrepreneurs in the early

1940's and post World War II saw the emergence of a few large airline corporations. Their work, combined with economic changes after the War and the acceptance of air transportation by the public as a mode of travel produced the existing medium and short haul network structure in British Columbia.

It is quite clear that aircraft technology, economic changes, wars, and the physical features of the province played a very important role in the evolution of the air transportation industry and its network structure in British Columbia. Due to the geographic nature of British Columbia, small aircraft seem to be preferable because of the short haul travel market and low density routes. Small aircraft increase the chances for small communities, particularly in the coastal areas and in northern British Columbia to receive frequent air service. Air fares may be higher than the larger air carriers but high fares have to be expected because this is one way the small carriers can achieve low break-even load factors.

The short distance, low traffic density network produced by the third level carriers tend to be a hub-and-spoke type of structure. This is because traffic generated from small communities is destined to collecting points from which point the traffic is connected to major hubs.

Appendix 1

Comments On Entrepreneurs
In The Air Transportation Industry In British Columbia
1908 - 1920

Owner/Operator (Birthplace)*	Comments
William Wallace Gibson (Saskatchewan)	In 1908 Gibson designed and built the first successful Canadian aircraft engine.
W.W. Gibson (Saskatchewan)	Between 1909 and 1910 Gibson constructed the twin plane powered by his 6 cylinder engine. His twin plane made a successful flight on September 8, 1910, flying at a distance of 200 feet at a height of 20 feet.
C. Hamilton (New York)	Hamilton recognized that a market for flying machines was in big cities. He flew at all Pacific Coast cities, crating his aircraft and shipping it from one city to another. In Vancouver he flew from Minoru Racetrack to New Westminster, March 25, 1910. On March 28, 1910 Hamilton set up a race against a racehorse from Minoru to New Westminster. Hamilton lost the race. His aircraft speed was comparatively lower than that of the racehorse.
McMullen-Templeton Brothers (Vancouver)	Designed and built a tractor-type of aircraft based on the information obtained from American periodicals. Several experimental flights were made in 1911. The aircraft was destroyed by fire in 1912 at Coal Harbor.
Bill Stark (Vancouver)	Stark was the first person to possess a pilot's licence in British Columbia. He was also the first pilot to fly with a passenger. Stark modified his Curtiss pusher, a single seater, to add a second seat to accommodate a passenger seat. On April 24, 1912 Stark took Daily Province sports editor Jim Hewitt for a flight. Later the same day Stark took his wife Olive for a flight and she became the first woman airplane passenger in Canada.

Appendix 1

Owner/Operator (Birthplace)*	Comments
Billy Stark (Vancouver)	Organized the Aero Club of British Columbia with the purpose of promoting aviation in British Columbia. The Aero Club operated flying schools in British Columbia at Minoru Park and Pitt Meadows.
Alys and John Bryant (United States)	This was a husband and wife flying team which visited British Columbia in 1913 from the United States. Alys was the first woman to fly an aircraft in Canada. John was killed on August 6, 1913 in Victoria when his aircraft crashed and thus became Canada's first aviation fatality.
Phil Parmalee (United States)	Parmalee performed exhibition flights at Hastings Park (PNE). Professor Saunders accompanied Parmalee and did the first parachute jump in British Columbia.
Lieut. V. Bishop (Resident of Vancouver)	On September 4, 1918 Lt. V. Bishop flew a flying boat H-3 built by Hoffar Brothers of Georgia Street. At a height of 1,500 feet the engine failed. The aircraft crashed onto Dr. J.C. Farish's house on Bute and Alberni Streets. Lt. Bishop landed in the bathtub.
Hoffar Brothers (Vancouver)	Between 1919 and late twenties began aircraft manufacturing company which produced hydroplanes. Be the early thirties the company began manufacturing Boeing aircraft.
E. Hubbard (Seattle)	Hubbard began the first international airmail service between Vancouver, Victoria and Seattle. The airmail service laid the foundation for regular schedule air passenger and freight routes between these big urban centres (Vancouver, Victoria and Seattle).

Appendix 1

Owner/Operator (Birthplace)*	Comments
Capt. Ernest Hoy (Canada)	Hoy was the first pilot to attempt to cross the Rockies with a Jenny (JN-4) aircraft. He began the interprovincial air traffic movement. He flew from Vancouver to Calgary May 12, 1919. The trip took 16 hours and 42 minutes.
Capt. Trimm (Canada)	Trimm established a new regional route between Vancouver and the interior of British Columbia. He flew a Jenny (JN-4) aircraft from Vancouver, Chiliwack, Kelowna, Vernon, Rtuland.

* Birthplace given in brackets

Source: Archival records and personal research files.

Appendix 2

Comments On Firms Operating
In The Air Transporation Industry In British Columbia
1920 - 1946

Airline/Operator	Comments
Lt. Col. Leckie and Major Hobbs	This was a trans-Canada flight project which laid the foundation of the transcontinental airmail, air passenger and freight movement. The total flight from Halifax to Vancouver took approximately 45 hours and covered a distance of 3,265 miles.
Canadian Air Force (1920-1924)	The Canadian Air Force operated patrol duties (forest, fisheries patrols), mapping and aerial photography and explorations. Its operations were on the coastal areas in British Columbia, e.g. Queen Charlotte Islands. There was no communication system along the coastal areas at that time. The pilots began a pigeon system of communication between the aircraft and Jericho Beach (airport at that time). Pigeons were carried along in a wicker basket. In case of bad weather, engine failure or crash, the message would be written on a thin and light paper, inserted into a tube and tied to a pigeon's leg and the bird would be released, directed toward Jericho Beach, the base station.
Pacific Airways	Pacific Airways took over the operations of the Canadian Air Force in 1925 after the newly formed Royal Canadian Air Force withdrew from patrol activities.
Dominion Airways	This airline was established by the three Dobben Brothers to operate forest patrol in the Nelson area. The airline also provided training lessons in flying.
Sprott-Shaw Ltd.	This airline established flying schools, one in Victoria and another one in Vancouver.

Appendix 2

Airline/Operator	Comments
The Hoffar Brothers and Mr. Ed Elderton	Mr. H. Hoffar and Ed Elderton established the Canadian Boeing firm in Vancouver. The firm produced Canadian versions of the Boeing BIE flying boats as well as trainer gliders. Mr. Ed Elderton also designed the Vickers of Vancouver.
Truck Manufacturing Company in Vancouver	The Truck Manufacturing Company diversified its operations by forming the Air Land Manufacturing Company which produced aircraft (the type of aircraft built are not specified in the sources of information). The Air Land Manufacturing Company operated aircraft which were either purchased from firms going out of business or purchased in crashed conditions and repaired.
Jimmy Duddle (16 years old) and Eldon Seymour (15 years old)	Paper boys from Vernon, British Columbia designed and built a two-seater high wing monoplane. From 1935 until the end of 1941 the aircraft was in service in search and rescue work, timber cruising and passenger service.
Trans-Canada Air Lines (Air Canada)	The Trans-Canada Air Lines came into existence April 10, 1937 as a subsidiary of the Canadian National Railways. The Canadian Airways (new) serving Vancouver, Victoria and Seattle was purchased by CNR and all its routes and fleet became Trans-Canada Air Lines now known as Air Canada.
Canadian Pacific Air Lines (C.P. Air)	Between 1939 and 1942 the Canadian Pacific Railway Company purchased ten small airlines operating in northern Canada across Canada and amalgamated them to form the Canadian Pacific Air Lines Ltd. (C.P. Air).

Appendix 2

Airline/Operator	Comments
Central B.C. Airways (PWA)	This airline was formed by Russell Baker in partnership with Walter Gilbert. From 1946 to early 1948 the company secured a forestry patrol contract from the British Columbia government. In 1949 the company obtained a contract with the Alcan development project in Kitimat and Kamino. With the resources and prestige derived from these operations the airline bought up six of its competitors and was renamed Pacific Western Airlines in 1953.
Queen Charlotte Airways	This airline was formed by Jim Spilsbury of Vancouver. In 1955 Queen Charlotte Airways was acquired by PWA.
Polaris Charter (Wardair)	This airline established air charter services in the Arctic, Canadian north and on the international routes.

Source: Archival records and personal research files.

Appendix 3

The Local Service Air Carriers in British Columbia 1948 - 1980

Air Carrier (approximate founding date)*	Comments
Air West Airlines began as Powell River Airways in 1948 and was renamed in 1958	This airline used both land and sea planes. Direct competition with PWA is restricted on Vancouver - Powell River route. Air West has to make mandatory stops either in Nanaimo or Gillies Bay. It operates both class 2 and 3.
Gulf-Air Aviation Ltd. (1950)	This firm is based in Campbell River. In 1970 the Gulf Air Aviation took over the operations of Trans-Mountain Air Services Limited.
Victoria Flying Services Ltd. (1958)	The airline operated class 3 points. Its operation ceased in 1978. It transferred its licences to West Coast Air Services and other companies.
Island Airlines (1959)	This airline has two main offices, one in Powell River and another in Vancouver near the Second Narrows Bridge.
Trans-Provincial Airlines (1963)	This airline provides both scheduled and charter services using both conventional and amphibious aircraft.
Kent Aviation Ltd. (1963)	This airline operates class 3 points.
West Coast Airlines (1965)	Provides daily services from Vancouver to Ocean Falls and at intermediate stops.
Pacific Coastal Airlines (1966)	This airline operates both land and sea plane aircraft.

Appendix 3

Air Carrier (approximate founding date)*	Comments
North-Coast Air Services (1968)	This airline provides both scheduled and charter services.
Northern Thunderbird Air Ltd. (1969)	Provides daily scheduled and non-scheduled air services. The airline operates class 2 points for PWA.
Arrow Aviation Ltd. (1969)	This air carrier possesses both class 2 and 3 licences between Kamloops, Vernon, Kelowna, Penticton, Castlegar, Cranbrook and Grand Forks. It operates class 2 under service agreement for PWA.
Alert Bay Air Services (1970)	This firm's head office is in Campbell River. It provides scheduled and flag services. In 1978 Gulf Air Aviation gained control of this air carrier.
Tyee Airways (1973)	Operates class 3 air routes between Powell River and Nanaimo and at small points around Powell River.
Abbotsford Air Services (197__)	This company operated class 2 and 3. In 1979 the airline transferred its charter and class 2 licences to Eastern Pacific Aviation Ltd.
Gateway Aviation (1979)	This air carrier operates between Vancouver and Edmonton three times a week. It stops at intermediate points such as Jasper and Hinton.
Air B.C. (1979)	Jim Pattison, a Vancouver businessman acquired three air carriers in succession in 1979. He acquired Air West Airlines, then gained control of the Pacific Coastal Airlines Ltd. and by the end of 1979, the Trans-Provincial Airlines Ltd.
Knight Air Limited (1979)	Operates class 2 and class 3 licence aircraft.

Appendix 3

Air Carrier (approximate founding date)*	Comments
Kootenay Airways Ltd. (1980)	Operates class 2 and 3 licence aircraft.

* Approximate founding date of the airlines.

Sources: Canadian Transport Commission, Local Service Air Carriers Providing Unit Toll Services in Southern Canada, 1972-1978.

Ottawa: Research Report No. 40-80-13, 1980.

The Federal Provincial Committee on Western Transportation, Western Region Intermodal Passenger Study, Working Paper No. 6, January 1979.

Appendix 4a

Selected Principal Commercial Aircraft Flown In Canada
1922 - 1970

Aircraft Type	Aircraft Make	Year of Entry Into Service	Direct Characteristics: Maximum Passenger Capacity *	Direct Characteristics: Cruising Speed (m.p.h.) **
Piston	DH-4A	1922	2	110
	Fokker	1926	8	95
	Lockheed Vega	1927	4	---
	Ford-Tri-Motor	1928	12	145
	Northrop A	1930	6	145
	Boeing 247	1933	10	---
	Douglas DC-3	1936	32	185
	Douglas DC-4	1939	86	228
	Curtiss C-46	1941	65	195
	Lockheed Lodestar	1942	99	170
	Lockheed Constellation	1945	64	313
	Douglas DC-6	1947	107	311
	North Star	1947	86	267
	Convair 240	1948	40	270
	Convair 440	1952	44	285
	Lockheed Super-Con	1952	94	304
	Douglas DC-7	1953	95	349
Turboprop	Vickers Viscount	1953	70	330
	Bristol Brittannia	1956	139	355
	Fairchild F-27	1958	53	258
	Lockheed 188	1958	99	400
	Vickers Vanguard	1960	139	420
	Hawker-Siddeley 748	1962	62	273
Jet	Boeing 707	1958	189	525
	Comet 4	1958	102	460
	Douglas DC-8	1959	189	521
	Boeing 727	1963	189	605
	Hawker-Siddeley 121	1963	179	600
	B.A.C. 111	1965	79	507
	Douglas DC-9	1965	105	561
	Boeing 737	1967	125	573
	Douglas DC-8-60	1967	259	525
	Boeing 747	1969	490	640
	Fairchild F-28	1969	65	519
	Lockheed 1011	1970	330	625
	Douglas DC10-10	1970	345	545

* Maximum Economy Seating ** Maximum Cruising Speed

Source: Aviation Statistics Centre, Fleet Report - Inventory of Commercial Aircraft in Canada, 1970, 1978. Statistics Canada, Catalogue 51-004.

Appendix 4b

Aircraft In Operation In Canada
1970 - 1980
(By Level I and Level II Carriers)

Aircraft Type	Aircraft Type	Capacity (passenger)	Cruising Speed (mph)
Fixed wing	Boeing 747	490	640
4 engine jet	Boeing 747B	442	550
	Douglas DC-8-43/53	156	532
	Douglas DC-8-40	189	521
	Douglas DC-8-50	114	579
	Douglas DC-8-60	250	579
	Douglas DC-80-60F	189	600
	Douglas DC-8-63	213	527
	Boeing 707	181-189	525
	Boeing 767-200	278	540
3 engine jet	Douglas DC10-10	345	545
	Douglas DC10-30	278	540
	Lockheed L1011	330	625
	Lockheed L1011-500		
	Lockheed	94	304
	Boeing 727	189	605
	Boeing 727F	144	545
2 engine jet	Boeing 737	107	493
	Boeing 737-200	115	475
	Boeing 737-ADV	112	480
	Douglas DC-9-15	90	572
	Douglas DC-9-32	115	496
	Douglas DC-9	105	561
	BAC 111	79	541
	Fokker F-28	65	519

Source: Statistics Canada, Catalogue 51-004.

Appendix 4c

Summary Of The Principal Aircraft Operated By Third Level Air Carriers (Suitable For Low Density Routes) 1959 - 1980

Aircraft Type	Cap. seating/weight
Bristol Freighter Canso DC-3, DC-4, DC-6 Fairchild Hiller F-27 De Havilland (DHC-7)	Aircraft with disposable load of 6,000 lbs. and over.
Series of Beachcraft types e.g. Beachcraft B-18 Beach BE-99 Britten Norman BN-2A and series of DHC e.g. De Havilland Otter (DHC-3) De Havilland Beaver (DHC-2) De Havilland Twin Otter (DHC-6) Lockheed 10 Grumman G-21 Grumman G-21A Grumman G-73	Aircraft with disposable load of 1,100 lbs. and over.
Series of piper types e.g. Piper PA-23 Piper PA-31 Cessna 176 to 180 Cessna 310 Short SD3-30	Aircraft with disposable load of 1,100 lbs. and under.

Source: Aviation Statistics Centre, Fleet Report - Inventory of Commercial Aircraft in Canada, 1970-1978.

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HAGERSTRAND'S TIME-SPACE MODEL IN HUMAN GEOGRAPHY:

AN ASSESSMENT

by

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ABSTRACT

This essay critically reviews the time-space model as developed in Sweden by Torsten Hagerstrand and his co-workers. This critique is in six sections. Following the introduction, objective and scope of the paper, section two provides a description of Hagerstrand's original time-space model. Section three reviews applications of Hagerstrand's model in teaching and research within human geography and comments on variables which have relevance to the model. Section four discusses the innovative qualities of the model. Section five discusses the limitations inherent in the model and is followed by the summary and concluding remarks.

The time-space model is a conceptual framework which seeks insights into the interplay or relationship between the effects of time and space on human activities and social organization. The primary objective of the model is to determine how the quality of life of individuals can be improved. The central feature of Hagerstrand's model is a time-space prism. The prism is a static graphical representation of an individual's action space showing the location and duration of activities (including those spent in movement) for a particular time period. The shape of the prism is affected by the three types of constraints: capability, coupling and authority constraints. A wide variety of factors affect these constraints while changes can occur over time.

The time-space model has generated much excitement in human geography since the 1970's, however, its potential as a research tool in human geography and for evaluating social opportunities has not been fully realized. The main problem with the time-space model is

the lack of a clearly defined theory of action which specifies goals and objectives and the nature of search, evaluation and choice processes.

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I. INTRODUCTION

This essay critically reviews the time-space model as developed by the so-called Swedish school of geography. This critique focuses on:

a) a description of Hagerstrand's original time-space model;

b) the value of the model in terms of its applicability in teaching and in empirical research in human geography;

c) the innovativeness of the model;

d) the problems and limitations inherent in the model.

The critique concludes with a brief overall evaluation of the model in terms of its possible contribution to human geographical research.

The reason for this critique derives from its innovative departure from traditional research approaches which typically work from theory to practice. In contrast, Hagerstrand's model presents a unique humanistic and more pragmatic approach based on physical realism in human geography. In comparison with other models in human geography, Hagerstrand's time-space model highlights the integration and interdependency between the occurrence of events and situations and the utilization of time and space. Hagerstrand's model shows explicitly how human activities and man himself (mankind) depend on time and space, while on the other hand time and space obtain their definition because of the activities of man.

The essay is divided into six sections. Section one presents the introduction and objectives. Section two gives a brief description of Hagerstrand's original time-space model. Section three reviews the

application of the model in teaching and research in human geography. Section four presents a discussion of the factors that can change time-space constraints and prisms. Section five gives a brief discussion of the problems and limitation inherent in the model. Finally is the summary and concluding remarks.

A background and a brief description of Hagerstrand's model is presented in the following section.

II. HAGERSTRAND'S TIME-SPACE MODEL

2.1 Background

The time-space model is an approach to the studies of both the daily or lifetime path of individuals through temporal and spatial events and the ways in which a society makes use of its resources. This framework attempts to understand the complex relationship between time and space in the contexts of human activities. The focus of this framework is on the quality of life, that is, the freedom which individuals have in a society to take advantage of the opportunities within their reach. The time-space model has been pioneered over the past twenty years by a Swedish human geographer, Torsten Hagerstrand and his colleagues at Lund University in Sweden. The time-space model emerged as a product of Hagerstrand's studies of population migration in Sweden where the availability of detailed population statistics kept since 1749 allowed Hagerstrand to trace the movement of specific individuals over a given period of time (Thrift, 1977). Furthermore, Hagerstrand had also been interested in the problems of diffusion of

innovations within an historic time-geography during the 1950's. By the early 1960's his attention began to focus on the interrelation between social constraints (expressed in time-space terms), social organization and human activities. As thrift (1977, 5) puts it, Hagerstrand's intention was:

> ...to find concepts which might give geography the integration and degree of physical realism it had heretofore lacked. The decision was taken to go right back to the basic dimensions, to space and time, to start from the beginning.[1]

Since 1966 Hagerstrand and his research team and colleagues at Lund University, Sweden, including Carlstein, Lenntorp and Martensson have been progressively developing the time-space approach. The concept of time-geography was publicized outside Sweden in the early 1970's in various studies, such as Hagerstrand's seminal paper entitled, "What About People in Regional Science?" (Hagerstrand 1970). Subsequently, the work of Hagerstrand (1973, 1974, 1975, and 1976) and his associates has become widely known to other human geographers. Outside Sweden, information on time-space geography was disseminated through publications by Pred, Parkes and Thrift (see Pred, 1973, 1977, 1978, 1979 and 1981; Parkes and Thrift 1978, 1979 and 1980). The most comprehensive treatment of time-space geography can be found in the works of Carlstein, Parkes and Thrift (1978, Volumes 1 and 2), Carlstein (1981) and Martensson (1979) which publicized further the concept of time-space geography outside Sweden.

Human geographers outside Sweden have found the concept of time-space geography to be an appropriate tool for studying social constraints to human behaviour. The main elements of this framework are time and space which are viewed as scarce resources. Like most

resources they have to be put to alternative uses. All human activities take time and use space. Human activities are geographically variable and access to them is a function of both time and space. The two factors, time and space, impinge on or constrain activities. Any movement over space to a given opportunity requires a certain amount of time to cover a given distance in order to obtain access to a particular activity or event. In some cases access to a given activity or opportunity is easily surmounted. However, the consumation of such opportunities can be impeded by other constraints such as protocol, rules of entry, customs, dress codes, etc. A number of such constraints as articulated by Hagerstrand will be discussed later in this essay.

The important factor of the time-space model is that the opportunities and resources from which the individuals satisfy their needs and wants must be accessible in both space and time. The time-space approach attempts to capture this complexity of interaction between man (or individuals) and the environmental elements (time and space) by using a smallest unit of human population, an individual's action space, paths and projects. These terms are defined in the next section.

2.2 A Description of Hagerstrand's Time-Space Model

The time-space model as interpreted by Carlstein (1978 and 1981) is a framework through which societal constraints on human behaviour can be identified and analyzed. The central aspect of the model is a concept of a time-space prism. A prism is a static graphical representation of an individual's action space showing the distances

travelled by an individual in a given time period and the duration of each activity within the specified time period. A prism shows the maximum spatial extent that could be covered in the time available. An action space shows simply the physically accessible parts of the environment (opportunities) which form a connected and continuous set of positions in time-space. The prism, therefore, is the maximum time-space range over which an individual is able to operate. The shape of the prism is circumscribed by three sets of constraints, namely, the capability, coupling and authority constraints. The prism is measured on a 24 hour scale of observation. But it can also be measured on a weekly, monthly, annual or seasonal basis or any meaningful period of observation, depending on how much time is spent continuously away from home base. The main element is that there must be a fixed point or home base from which an individual can return.

An important distinction in the concept of the prism is that the prism is based on actual or possible movement of individuals within a given set of constraints. Figure 1, for example, reflects hypothetically the maximum potential daily spatial range of an individual (within a set of constraints) and therefore reflects potential movement. Alternatively, prisms can be used to express the actual movements of individuals over time (see figure 4). In figure 1 the horizontal axis indicates the movement or the individual's spatial traverses across the day while the vertical axis marks the passage of time. In this diagram space is treated as a single dimension. According to Hagerstrand (1973, 1974) any lifeline or journey involves movement along both axes simultaneously. In figure 1, attention is

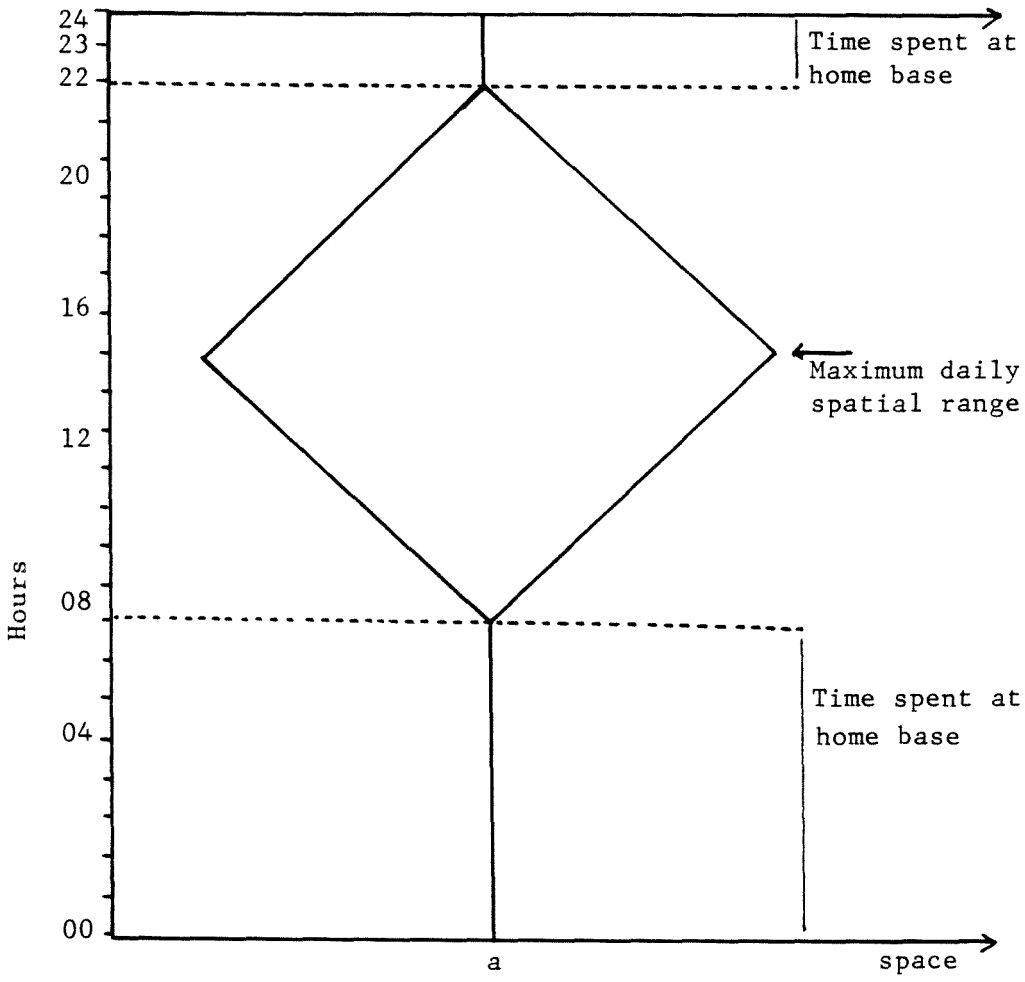

Figure 1: A daily time-space prism.

In this example a person starts at point 'a' at 8:00 a.m. and must return to it by 10:00 p.m. The prism between 8:00 a.m. and 10:00 p.m. indicates his maximum available space range.

focused on a 24 hour daily prism for an average person in western society.

The basic terms and concepts which play an important role in the model are presented below:

Time and Space - Time and space are the main elements of Hagerstrand's model. They are defined in terms of their relativeness, that is, the relative space which is inseparably fused to relative time forming the time-space process. Movement is a key word because it is change in space through time. Any behaviour which requies movement involves the individual or group traversing a path through space and time, as shown in figure 1. Time and space are viewed as resources which constrain human activity.

Paths or Life Paths - These are actions of the individual which are used to describe the movement of individuals graphically at daily, weekly, monthly, annual or life-long scales of observation. They form an unbroken, continuous path through time and space (Carlstein 1981, 46-48). The actions are composed of discrete units of events or behavioural choices which accumulate along individuals' biographies. The sequence of events forming an individual's biography is termed a path. In Hagerstrand's time-space model, all living organisms belonging to the animal and vegetable worlds and all man-made objects, including buildings, tools and machines are also thought of as having biographies and describing continuous paths in time and space. Each event that occurs in the individual's path is viewed in its sequential and interdependent context.

Life-Span - Each individual's path has a life span which is visualized on a continuous line (according to the events taken place)

starting at a fixed home base and returning to that point. A life span can be a continuous line starting at the point of birth and ending at death. The scale of observation for a life span depends on the period of observation.

Action Space - It is an area throughout which an individual functions, usually on a daily route of going to work, school, etc. and returning to home base.

Stations - They are the locations of the projects or bundles where an individual can join others to carry out their projects such as production, consumption and carrying out transactions.

Projects - Hagerstrand's starting point is that human beings are always seeking to reach goals. Some are immediate and others more distant, some of the goals are individualistic while others are collective in nature (Hagerstrand 1974b; Thrift, 1977, 7 and Gregory, 1978, 139). To attain these goals both individuals and social groups must combine their projects. Projects are sequences of future activities of individuals and groups designed to materialize in certain forms of products or output for survival. Projects range from simple tasks such as cooking a meal, cultivating a crop, church services to larger scale activities such as setting up an airli e service, production factories, space shuttle, setting up medical facilities, etc. Projects are vehicles for attaining the goals of individuals, social groups and social organization (Hagerstrand 1974b). Time and space, upon which individuals and groups have to draw to achieve a set of goals, are considered as finite resources that must be allocated among different uses. Consequently, projects have to be packed or

formed into nested hierarchies in time-space constraints which may interfere with their performance and completion (Thrift, 1977, 7).

The paths, action spaces and projects are all limited by time-space constraints, capability, coupling and authority constraints (Hagerstrand 1969b, 1970a).

Capability Constraints - These include both biological needs and the tools and technology an individual can command. Every person requires a certain amount of hours to sleep, rest, eat at regular intervals and take care of personal matters. As a result, the number of places or activities an individual can interact wtihin a day is limited because certain hours have to be spent at "home", or at a "home base". In addition, the extent of movement in space during a given time is limited by the means of transportation at his command. The radius of the area which can be included within an individual's daily path is increased if an automobile is available or if one is close to public transportation. The radius of the daily path is reduced if one has to walk, or ride a bicycle. The major impact of capability constraints is the indivisibility of an individual and of tools. An individual cannot be in two places or more at the same time. an individual is faced with the constant process of m·ting choices between where to be and at what time.

Coupling Constraints - These are the time and space requirements which limit the "where, when and for how long an individual can join other individuals, tools, machines or materials in order to produce, consume or transact" (Hagerstrand 1970). These constraints require that individuals, to effectively participate in an activity, must be in particular places at certain periods of time with other individuals.

For example, teachers and pupils should be at school on certain days at specific times, workers at a factory during regular shift hours, etc. Consequently, if an individual wants to interact with others or participate in given activities he must fit his life paths into those of others to form bundles. The bundles of activities in which people join together to fulfil some common purpose are coordinated in both space and time. Hagerstrand calls this set of constraints coupling constraints which are the time-space expression of the social nature of most human activities. Coupling constraints are envisaged spatially as creating bundles of activities at particular locations. These bundles of activities, for example, work, recreation activity, etc. take place at a predefined time period and reflect the deliberate organizing of different activities in time and space.

Authority constraints - Where and when joint activities or bundles of activities occur and who can participate in such activities is constrained further by what Hagerstrand terms authority constraints. The locations of the bundles of activities and the time they are available to individuals are the function of who controls that particular piece of time-space. Even if an individual can overcome both capability and coupling constraints, ar entrance to a given social activity may be blocked or impossible because someone exercises control over a particular time-space domain. Authority constraints are also regarded as domains or control devices (Hagerstrand 1973, 1975b, Carlstein 1977). A domain is an entity within which things and events are under the control of a given individual or group. Domains are physical manifestations of norms or laws which regulate access to different time-space locations (or stations). Authority constraints,

therefore, restrict access to certain resources or activities by means of rules, laws, customs, policies or expectations. Some places, for example, are accessible by invitation, payment, membership, reservation, negotiation or struggle. Authority constraints determine who may or may not have access to specific facilities at specific times. They occur at different levels to produce hierarchies of accessibility to different activities and they vary in both spatial extent and temporal duration. Authority constraints range from small domains protected only through immediate power or personal control over a favourite chair, a room, or a parking spot. Other domains vary from legal status such as a property, neighbourhood, state, country and nation. Authority constraints with national overtones are almost permanent in duration such as universities, social institutions, banks or large national companies, e.g. Canadian Pacific Rail. Others are only temporary such as a seat in a car, church or at the table (Hagerstrand 1970, p.16).

The three constraints, capability, coupling and authority, form the central concepts of Hagerstrand's model. According to this model it is the capability, coupling and authority constraints which are fundamental bases for describing, classifying and understanding human behaviour. From this point of view the prism is simply the illustrative, summary device which graphically reflects the effects of these constraints. Given these constraints - capability, coupling and authority - facing each individual an important social problem is how to "bundle" activities in which individuals, groups and organizations need to join together to fulfil some common purpose. In the light of capability, coupling and authority constraints a society can be seen as

being made up of individuals, groups, organization and institutions which are locked into a series of interconnecting activity systems or bundles. Such bundles have to be coordinated both in time and space.

Bundles - These are the activities in which individuals within a society have to join with others in order to fulfil their needs and wants and to perform their roles in society. Bundles of activities are created at particular locations because they have to be coordinated or organized in space. For instance, individuals (people) leave their home bases to form a work bundle at a factory, office, school, hospital, etc. either at the central business districts, in the suburbs or wherever the work place is located. Bundles are not only coordinated in space but also in time. There are predefined time schedules in terms of relative time, that is, clocks, calendar or seasons which regulate the time sequence of the operation of bundles. The main function of the bundles is to ensure the production and distribution of goods and services to meet the needs and wants of a society.

III. APPLICATION OF TIME-SPACE MODEL WITHIN HUMAN GEOGRAPHY

Hagerstrand's concepts of time-space constraints in human geography have been used both for teaching and analytical purposes. In textbooks for example, time-space constraints are used to introduce students to various concepts associated with problems of accessibility to social facilities, economic activities, etc. In research studies time-space ideas have been used in issues involving public policies in an attempt to determine how the quality of life for individuals can be

improved. The following section discusses the application of the time-space model in human geography.

In introductory geography books time-space ideas have been utilized to provide a provocative basis for the discussion of the spatial patterns of human landscape, the processes of human interaction, the influence of changing technologies on people's lives, the dominance of giant business organizations and the changing urban form. The textbooks draw the attention of the students to the ways these dimensions set the constraints within which individuals make choices which affect their daily lives or well-being (Dicken and Lloyd, 1981, Moseley, 1979 and Haggett, 1979).

In empirical studies various applications of time-space concepts have been applied in various contexts which are closely related to public policy. Among the topics which have been studied are how relocation of work places affects employees, the members of their household and opportunities for contact with relatives and social facilities; the conflicts that arise when employers require certain employees to move their families to another city and other members of the family do not want to move; and how the staggering of work hours and altering of [illegible]ations affect the choices and lifeline paths of individuals. Among the authors who have done a fair amount of work in empirical studies utilizing time-space geography are Martensson (1975, 1978 and 1979); Carlstein (1975, 1977, 1978 and 1981); Lenntorp (1976); Pred (1977, 1978, 1981); Parkes and Thrift (1975, 1977 and 1978); Pred and Palmer (1974 and 1978) and Moseley (1979).

3.1 Time-Space Model in Textbooks

Haggett (1979) applied the concept of time-space constraints to explain the processes generating spatial organization of human activity and spatial interaction. He used the example of the distribution of people on a beach to illustrate that time and space are important explanatory variables of spatial behaviour and variation in the spatial structure of social facilities.

The trends and cycles of spatial distribution of individuals were observed both in space (i.e. primary or grid pattern and relative locations) and over a period of time (day, week, month or seasons). The trends, cycles or stability in the arrangement of people on a beach appeared to be a function of the period of observation. The location of the individuals was related to the time of their arrival. On a daily basis it was observed that the early arrivals occupied the best sites with later arrivals gaining the less attractive areas or forced into crowding the already occupied areas. In this trivial case the observation of even simple spatial processes over time provides a clue to the time-space constraints which have a crucial influence on the availability of opportunities which must be accessible both in time and space.

In their book, "Modern Western Society: A Geographical Perspective on Work, Home and Well-Being", Dicken and Lloyd (1981) cover a variety of topics using the idea of time-space constraints ideas to introduce students to the problems and issues in the geography of post-industrial society. They deal with the problems of nature and location of employment, choices and constraints in the labour markets, the effects of time-space constraints on accessing goods as well as their influence or proximity to noxious facilities on housing

opportunities. A principal theme of their book is that, the well-being of people and the problems frequently generated by rapidly changing technology and job opportunities in western societies, must be examined in geographical and time-space terms. This enables them to argue that social constraints such as the overall organization of a society and structure of authority, control and stratification, centralization and decentralization of economic activity, specialization and division of labour are expressed through time-space constraints. At the same time time-space constraints affect the operation of all these human activities.

In his book "Accessibility: the rural challenge" Moseley (1979) has also used Hagerstrand's time-space model to evaluate and measure transport opportunities for residents in rural areas in Great Britain. His aim is to introduce students in regional planning and transport policy-making to the issues concerned with serious problems of accessibility and inaccessibility in rural areas, inadequacy of employment opportunities, isolation and loneliness of certain social groups and selective depopulation and repopulation. These and other problems and their links to such pervading issues as insufficient accessibility are explored in detail.

Using the time-space model, Moseley established alternative ways in which different levels of accessibility can imporve the well-being of individuals in rural areas. He points out that the challenge or rural accessibility can improve the well-being of individuals in rural areas. He points out that the challenge of rural planning is to enlarge individuals' (mainly women) time-space prisms by improving public transportation facilities and schedules. Furthermore, the

dimensions of individual actions spaces could be expanded by planning more social services, recreational activities and economic activities within easy access in time and space to rural communities.

3.2 Time-Space Model In Research

Although the time-space model has been used by numerous authors in various contexts, relatively few empirical studies using real world examples have been completed. The major work in time-geography remains that of the Swedish human geographers at Lund University in Sweden. The authoritative works in time-geography are those of Hagerstrand, mentioned earlier, who was the first to introduce this concept in human geography. The main and recurring objective of Hagerstrand in all his works (in time-space geography) is to provide a focus on the quality of life implications of the packing of people in time and space (Johnston 1983, 134). His intention is to examine human situations by studying individuals' biographies (life paths) which he conceives as being part of time and space or co-existing within time and space. In fact, Hagerstrand pointed out that the central aspect of the individual's biography is corporealization which means territorial co-existence. With this concept Hagerstrand's intent is to look at a society or members of a society as integral parts of the environment living together as neighbours. The neighbours are both man and natural elements in a common milieu. Here Hagerstrand envisaged a society or members of a society as a geographical web of biographies. In this kind of milieu man and his artifacts (means of production, distribution, tools, economic activities, etc.) are incorporated and treated together as neighbours in time and space. Thus, the

establishment of a symbiotic (united life or partnership of organisms, etc.) relationship between man, tools, and environment (time and space). The concept of this symbiosis is underscored by Hagerstrand when he discusses indivisibility of man, man-made objects and environment (time and space). For Hagerstrand the understanding of this indivisibility is seen to be one of the most central contentions in his works. Other authors such as Pred (1973, 1977); Parkes and Thrift (1978, 1979) and Carlstein (1981) have also emphasized the close relationship between man and environment (time and space). For example, Pred (1977) uses the concept of togetherness to convey this idea of indivisibility of man, tools, economic activities and time and space. The ideas of this symbiotic relationship is explicitly expressed by Pred (1977, p.213):

> Time-geography is not a panacea for human geographers...It is, however, a great challenge...to cease taking distance itself so seriously...to accept that space and time are universally and inseparably wed to one another; to realize that questions pertaining to human organization of the earth's surface, human ecology, and landscape evolution cannot divorce the finitudes of space and time...It is a challenge to turn to the 'choreography' of individual and collective existence...[2]

The concept of corporealization or symbiotic relationship identifies a society (or individuals), artifacts, human activities and time and space existing together as neighbours. In this symbiotic partnership (or relationship) individuals, in order to succeed in their actions, transactions and social activities, should take on corporeality by filling space and time and by moving in time and space (Van Paassen 1981, 22-25).

Another prevailing theme in Hagerstrand's works was neighbourliness or togetherness within a society (mainly Swedish

society where his work was focused). Hagerstrand's intentions with this framework was to understand neighbourliness and to improve it. His search for it is clearly expressed by Van Paassen:

> To succeed as a neighbour implies being 'accepted' by the fellow elements of the environment and this applies equally to human individuals, to expressed ideas, to artifacts and to natural elements.
>
> To succeed as a neighbour at the same time requires that one should act as a neighbour. This permits a variety of action, sometimes in standard situations with well-known neighbours with recognizable, predictable behaviour, sometimes in critical and/or unexpected situations.[3]

Hagerstrand's time-space framework was further seen as an attempt to search for territorial co-existence which offers a new approach to the relationship between man and nature within the complex and rapidly changing urban-industrial and rural-urban society.

Hagerstrand's associates principally Martensson, Lenntorp and Carlstein, have done substantial research in rural areas in Sweden applying the time-space model to specific rural problems. For example, Martensson has carried out several empirical studies investigating various problems such as spatial distribution of job opportunities, relocation of workplace, spatial distribution of social services and recreational facilities and childhood interaction and temporal organization. The central theme in all these research projects is the importance of time. Time is conceived as a scarce resource which must be allocated among different activities. Complementary to this view of time is the concept that time is an integrating medium which is a

fundamental aspect of studying the possibilities of individuals' daily life paths.

The primary objective of Martensson's research was to increase individual opportunities for interaction with the environment and to reduce the time spent in movement between places. The established models, based on individual time-space prisms and biographies, allowed varying levels of accessibility to be enjoyed by different groups of people. These models essentially calculated the possibilities of bringing together in time and space the components that had to coincide in order to generate events (projects) such as journeys to work, meetings between people and the coming together of people in recreational facilities (Martensson 1979).

Lenntorp, Ellegard and Hagerstrand (1976) did a joint study of the generation of daily travel to work and to educational facilities. Their objective was to analyze and describe possible future travel patterns and transportation requirements to match daily travel schedules. The study took into consideration different modes of travel such as automobiles, buses, cycles and pedestrians. Time-space ideas provided the bases for the development of a long-run model of choices of transport facilities. While the time-space model by itself is generally inadequate to explain complicated problems such as travel patterns, trip generations and modal choices, in this study it was shown to have an important role by bringing into consideration equality of access to transportation facilities for all citizens. In particular, the ability of women to reach gainful employment was affected and the access of young and elderly people to services and

their ability to participate on the same terms as motorists was well implemented.

The authors attempted to bring about genuine equality in travel patterns by developing a model for a public transportation system which was closely tied to individual transportation. In this model the transportation system had to be flexible in terms of access times and routes. In order to achieve such flexibility the suggestion was that the location of economic activities, commercial centres and social services be within cycling and walking distances of all citizens.

Other human geographers outside Sweden have used the time-space model theoretically without concrete examples. They have used time-space ideas to address various current and controversial social issues such as the effects of negative externalities on property values, the impact of technological and institutional innovations on the life content of individuals (Pred 1978) and status of women in the labour market (Palmer and Pred 1981). In "Timing Space and Spacing Time", a book edited by Carlstein, Parkes and Thrift (1978) there are a number of studies by different authors (e.g. Carlstein's Innovation, "Time Allocation and Time-Space Packing") which use theoretical rather than empirical examples. Most of the studies utilizing time-space framework without real world examples tend to take a behavioural approach and view time and space as impediments to human behaviour rather than in terms of territorial co-existence in time and space.

As noted, theoretical references to, and empirical studies of the time-space model (Pred 1978); (Palmer and Pred 1981); Hagerstrand 1974; 1974, Martensson 1975; 1979 and Lenntorp, Ellegard and Hagerstrand 1976) have identified three major constraints which are seen to impinge

on an individual's daily time-space prism. These three constraints have been identified as capability, coupling and authority constraints. Besides determining the individuals daily, weekly, monthly or yearly lifepaths these constraints also produce variations in the individual's action space.

Hagerstrand's time-space model as just presented, has generated some limited research by his associates (Hagerstrand, Martensson, Carlstein and Lenntorp), while others have used the time-space as a theoretical base in textbooks (Dicken and Lloyd 1981), Moseley 1979 and Haggett 1979) in understanding human geography. The time-space model as developed by Hagerstrand presents an innovative approach to the study of man and his use of time and space. A discussion of the innovativeness or good qualities of this model in terms of its unique view of man and time and space is presented in the following section.

IV. INNOVATIVE QUALITIES OF THE TIME-SPACE MODEL

The time-space model, in contrast to traditional geographic investigations which examine parts of a structure of human activity, offers a contextual approach which views an individual's situation relative to other individuals and economic activities within their environments. In comparison o traditional models, be they behavioural, spatial or socio-economic models, which start by constructing conceptual theories or general statements and then try to test those theories on empirical reality, the time-space model takes an approach that works from observation to empirical generalization. For example, rather than hypothesizing that a relationship exists between the individual's paths, actions and time-space constraints and then testing this hypothesis, the time-space model is used to deduce the

existence of such a relationship from empirical observations. In contrast most traditional models would start by stating a hypothetical relationship between time-space constraints and then test for confirmation of such a relationship as theorized in the model.

The time-space model is also a fluid or flexible model in that it can accommodate theoretical changes to reflect changes in process and product since it works from groundwork up, that is, from practice to empirical generalization. It has the ability to predict that the theoretical construct will change as human interaction (processes) and decision-making of the individual change. Finally, the time-space model is innovative in that it focuses on the processes operating within an individual's action space, thus allowing the study to focus on the individuals through biographies or lifelines. In statistical aggregation of people and objects, common in quantitative methods, the identity of people being studied is usually lost.

The good qualities of the time-space model documented above do not mean that the model is perfect. Despite its innovativeness and physical realism, it exhibits some of the limitations inherent in working from practice (or observation) to empirical generalization. One such limitation relates to a tendency for overgeneralization. For example, this model makes the generalization that the relationship observed in southern Sweden (where most of Swedish research was done) holds in all places and all cases.

Despite the innovative approach of this model as outlined in the last section, there seems however to be a number of attending limitations. In the following section problems and limitations of the model are discussed and a critical evaluation of time-space constraints and the prism is presented.

V. THE LIMITATIONS OF THE TIME-SPACE MODEL

5.1 General Critique

The main problem with Hagerstrand's framework is that it lacks any clearly defined theory of action which specifies goals and objectives and the nature of search, evaluation and choice processes. The framework tends to lean on idiographic explanations for sequences of events and actions that produce the individual's paths and spaces without providing any theoretical background against which relationships between these variables can be measured.

Although the time-space prism is given as a method for measuring the relationship between an individual's action space, paths, project and time-space constraints, it has no theory by which to measure and thus support the validity of the relationship between these factors or conversely to falsify them. Consequently, the model has no ability to predict classes of events, for instance, spatial patterns of projects where the individual travels to transact, produce or join others for social activities.

The time-space prism and the three major constraints - capability, coupling and authority constraints - which define the prism (a graphical representation of individuals' action spaces) are all derived empirically. They clearly ought to be tied to logical assumptions or premises postulated from a properly constituted "social" theory, which would then permit a more rigorous incorporation of power or political factors into the problem of time and space and the effects of time-space constraints on people's projects. Practically, each project, between its beginning and its end, tries to accommodate its parts in the surrounding complex network of paths and open time-space

left over by other projects or it may gain accommodation through competition (Hagerstrand 1973, 78-9). Logical assumptions about power or political factors can be derived since power is partly influential of the disparities in the distribution of projects, that is, of jobs, goods, services, information as well as residential areas. Hagerstrand himself admits that there is a need for a way of 'dealing with power in space-time terms of considerable precision': power relations are of great importance for the understanding of how projects compete in the available space-time that their analysis could develop into the core of a new human geography (Hagerstrand, in Gregory 1978, 140).

Gregory states that the object of such a theory would be to uncover 'structural patterns and outcomes of processes which can seldom be derived from the laws of science as they are formulated today' (Hagerstrand, in Gregory 1978, 140). Hagerstrand argues that the failure of modern science is a result of its neglect of synchorization and synchronization: the inescapable necessity for space-time "packing" in the conduct of practical life (Pred 1977, 211; van Paassen 1981, 17-28). Hagerstrand attaches the structures of the social and the natural worlds to the organization of space-time through the identification of paths which, through coupling constraints define the where, when and for how long an individual can join other individuals, tools and materials in order to produce, consume and transact. (Hagerstrand, in Pred 1973, 39-42); Gregory 1978, 140). Further, Hagerstrand ties social and natural structures into the organization of space-time through identificaton of domains which define, via authority constraints, the systems of regulation governing the actions of the individual and social groups (Hager-

strand, in Pred 1973, 39-42). In Hagerstrand's model for analyzing relationships between social structures and natural elements there is no clearly defined and testable theory which specifies the nature of evaluation of such processes and how future patterns can be predicted.

The time-space model is more or less an axiomatic approach because each proposition in the model designates a specific relationship between two or more variables which by definition are true and need not be tested or proven true. But some of them are unmeasurable. For example, Hagerstrand starts out by saying that "all human beings have goals, some immediate and some more distant, some of an individualistic and some of a collective nature" (Thrift, 1977, 6-7). To achieve these goals the individuals must have projects or coherent clusters. These clusters represent necessary steps towards each goal. The projects must form bundles or packs into the limited resouces of time and space. Time and space are resources of particular interest because projects can often not be completed due to the existence of time-space constraints. All these statement are axiomatic in their nature. They are true and need not be tested but they have no predictive ability. They simply state what is obvious which leaves no room for v -fication or falsification. In fact, they leave a researcher without any means to predict future patterns of actions and spatial patterns of projects. These axiomatic statements are redundant and tautological because they have no direction but go in circles. Even the goals of the individuals stated by the model are vague and imprecise, thus cannot be directly tested, primarily because they cannot be measured satisfactorily.

Another problem of the time-space model is that of aggregation of the individual's daily prisms. It has been mentioned earlier that there is a considerable variation in the individual's daily prisms because they are influenced by a wide variety of variables. Thus, it becomes difficult to establish a stable daily prism which can be used comparatively when one is interested in a large scale of action of people rather than a micro-scale. The reason the aggregative problem occurs is because the time-space model is interested in observation of the ongoing processes and revealing changes in the individual's action space. The model is not interested in social products as opposed to the process by which those products are derived. Consequently, it does not show how the decisions (actions) are made which are the products of the ongoing processes, for example, time-space constraints. In the processes there is commonality...people generally tend to think about the same basic infrastructures, for example, transportation modes, getting a job, going to certain social and recreational activities, shopping centres and entertainment. However, the product or decisions made to "do/or not to do" certain activities are peculiar as they depend on the priorities and values placed on those activities because of their capacity to satisfy that individual's particular preference or need. Thus there is an interplay between human interaction or between the activities and preferences of the interacting individuals. These preferences and values of the individuals do not occur independently, rather they are the functions of the roles individuals play in a particular social group or peer group. As such, preferences also depend on the lifestyles of the individuals. Finally, the combination of such parameters influences

the product or decisions made by individuals which affect their action spaces. Thus, the time-space model does not account for how the preceding variables affect the product so that while it identifies the underlying processes it fails to predict how people will act or respond to a given situation.

The next subsection evaluates possible variations in time-space constraints which were not taken into account by Hagerstrand. These potential variations are seen to be capable of influencing decision-making of individuals, thus undermining any kind of predictability of action proposed by the model.

5.2. Possible Variations in Time-Space Constraints

Human beings have the capacity to interpret and perhaps alter their biological constitution (capability limitations) and to regulate their behaviour through the mediation of technological innovations and through the change of their habits under certain circumstances. Perhaps biological necessities such as sleep, rest and food may not be quite adjustable except on a temporal basis. Everybody needs to sleep or eat and if fundamental physiological needs are disturbed or disrupted the consequences in the long run may be seriously damaging to one's health. Thrift (1978) states that man has a system of internal clocks that control wide areas of his behaviour and bodily rhythms. Once put out of phase it takes a long time to fall into place again: social demands in the labour market can initiate changes in the individual's behaviour. For example, the physiological system of people who work in different shifts has to be adaptable to that condition of working daytime or nighttime according to the establish-

ment of the organization they serve. Students, whether in a college or university under certain pressures often stay up all or part of the night either studying for examinations or writing term papers. The anxiety occurs because of the deadline that has to be met - as a result a student will alter the biological need to sleep.

There are different non-mechanistic ways people use to alter their biological constraints. Under certain conditions an individual may go without eating in order to maximize his or her time. It depends on the priorities of a person and what seems to have more value to the individual at that particular time. Society has a lot of leeway or permissable actions, for example, eating lunch while in a hairdresser's chair waiting for hair to dry. People can eat and drink in a bus, or even while driving. Similarly, people sleep in the bus or while travelling by air or even in a car if a person is not driving.

For personal care people do not have to be confined to the home for such duties. They can carry out such activities even while driving. Women, most of the time, put their makeup on while driving to work. In some instances both men and women use their lunch hours to do personal matters such as going to the YWCA and YMCA. Instread of eating lunch they may go to a recreational centre for physical fitness classes or for jogging. There are a number of things that people do to alter their biological constraints.

Capability and coupling constraints are subject to change through the application of technology. In advanced nations technological progress in transportaton and communication has given a considerable

freedom to both organizations (firms) and, to a certain degree, to individuals through the shrinkage of space. (Abler, Adams and Gould (1971, 555-556) argue that much of technological change in industrial societies has been a deliberate effort to adjust geographical space. That is, reducing the friction of distance through transportation and communication to overcome the capability constraints imposed by limitation in mobility. Although reduced capability constraints seem to be the most obvious reflection of the effects of space - adjusting technologies, the coupling constrains are also modified by improvements in transportation and communication technologies which enhance the possibilities of coordinating social and business activities and enhance control of businesses and social activities (Dicken and Lloyd 1981, 45). In industrial societies the spatial extent of both individuals and business firms are larger compared to the developing nations. The daily time-space prisms of individuals in modern western societies are more intense compared to the recent past because of faster modes of travel such as rapid transits, subways and other fast modes found in metropolitan areas. It may be true that not all big cities have fast modes of transport but each industrial society tries to upgrade their modes of transportation by purchasing highly advanced technological innovations in transportation. For instance, Vancouver is on the verge of utilizing one of the fastest modes of surface transport, the Light Rapid Transit. It is anticipated that it will take less than twenty minutes from downtown New Westminster to downtown Vancouver. If the Light Rapid Transit can save five to seven minutes for every person per hour then per day it would save thousands

of minutes. It would be economically efficient and time-space constraints will be reduced.

In the business world capability and coupling constraints have been overcome, to some extent, through the use of telephones in cars, telecommunication, teleconferencing, dictaphones and by the use of tape recorders.

Technological changes in computing sciences during the 1980's in modern western societies have brought another mechanism through which capability and coupling constraints can be altered. The new trend of using small home computers by individuals (those who can both afford it and possess the necessary skills) and firms offers the convenience and freedom from restrictive locational influence of business offices in central business districts of the cities. The use of home computers can liberate office workers and business persons from driving to work places. But the possession and operation of small home computers depends on socio-economic status, the type of occupation and the possession of the skills that meet the demands of the new era computer technology which requires a high degree of skill and precision.

Some of the companies have discovered that it is cheaper to purchase small computers and have their office workers, especially computer operators, carry out the work at home. It is quite possible that within fifteen to twenty years most office workers and business-persons will be using home computers rather than working in downtown areas. The benefits of such a system of operation will be that companies will need less office space thus reducing office rent. Working mothers in managerial positions or secretarial jobs could have

the privelege, if they so choose, to be at home with their pre-schoolers if they use home computers to transact managerial business at home. That may mean reduction of the cost of living...elimination of costs for babysitters or nannies and also the cost of day care may be reduced. The cost for travelling to work and cost for buying new clothes for work may be also be decreased.

Businessmen such as stockbrokers may not need to be in their offices downtown in order to have access to information on the stock exchange. They may take a small computer and go to a resort area such as Whistler where they may enjoy skiing and entertainment and still carry out business operation. Through the computer they may also have access to information on the Stock Exchange from Toronto or even London or Europe. However, this decentralized future vision (Dekan, 1981) has been challenged by consultant John Naisbitt (1983) who argued that high technology demands high touch. That is, people want to go to the office for its social aspects (prestige) even though it is not necessary for work.

Cottage computers in western societies, particularly in the 1980's are no longer the luxuries of the few people within upper classes or the few secretaries for some of the outstanding companies. They are widespread. They have become so popular that students in high schools and universities can afford them. Even elementary pupils have become computerized and use computers at home and at school.

Many financial institutions have also adopted the new mechanisms of cashing money through computerized machines. Many banks have installed 24 hour instant banks, green machines, cash stops, and other forms of convenient methods of depositing and withdrawing money

without having to waste time waiting in line. Such a system of cashing money saves time and releases people from pressure and anxiety as a result of the concern about reaching a bank before closing time in order to withdraw or deposit money. Instant banks are spatially distributed at convenient locations and accessible 24 hours a day. Individuals can go to these machines whenever it is convenient for them. Hence, time constraint is virtually eliminated. However, other forms of constraints such as coupling constraints may prevent an individual from utilizing such innovations as instant banks. Examples of such coupling constraints are lack of transportaton, car out of gas, and/or gas stations closed.

It is quite obvious that the effect of capability and coupling constraints on accessibility to opportunities has been affected by space and time adjusting technologies. Similarly, the structure of the authority constraints which limits individuals from using specific facilities or differentiates them in the labour market because of certain entry requirements has also been affected within the last 30 years. Various screening and filtering devices used by social groups and organizations to restrict entry to certain jobs and facilities are being weakened. For example, women are now employed in traditionally male dominated jobs such as bus driving, engineering, business executives, top managerial jobs and other high level positions. Studies such as Finegan (1975) have shown clear and unequivocal evidence indicating a substantial increase of women in jobs which were once dominated by males. Social attitudes towards women in the labour market in performing tasks which were defined as 'for men only' have changed.

For a long time female participation in politics has been very minimal with the exception of a few queens, talented courtesans and a few politically-minded women who fought their way through politics. Today, the social attitude of most modern societies has changed. Women in politics are accepted as being just as good and competent as men. So long as they show qualities of leadership they can be entrusted with local, provincial or national responsibilities. Women have been competing for positions such as prime minister (England, Israel and India), judges, attorney generals and other public services.

The rules of entry to certain firms based on sex, race or minority group have been weakened practically through political means, fights for human rights and through government legislation. Studies like those of L.M. Dewey (1972), R.A. Bryce (1969), A. Foster (1969), and L. Shearer and C. Dunlap (1969) indicate that there has been an increase in awareness and understanding of the realities of human rights in North America. It has become clear that members of society regardless of their sex or color should be given opportunities for obtaining jobs within their interests and skills. Governments, be they federal, provincial or local, particularly in North America, have finally become aware of the problems created by setting barriers which obstruct equality of access to certain jobs in the labour market based on discriminatory structures of the society. Governments have tried to bring resolutions by legislating specific regulations which compel firms in various sectors of the economy to lure certain percentages of workers from minority groups, e.g. women, blacks (men and women), Indians and others. Consequently authority constraints which set

certain rules as prerequisites for entry into various resources (job opportunities) are being reduced.

In the above discussion capability and coupling constraints have been seen to vary or be eliminated through technological innovations, government legislation and social changes. These are some of the variations and changes Hagerstrand failed to take into consideration in his time-space model. It is argued by this writer that such variations hinder any kind of long term pattern of predictability in the time-space prisms of individuals.

5.3 Critique of the Time-Space Prism

In the previous section it was indicated that the capability and coupling constraints which affect an individual's action space can be reduced to a minimum through the application of certain available technological factors and social-political changes. This section sets out to critically analyze the concept of the daily time-space prism which is a measure of a maximum spatial range over which an individual can operate. The variation in the spatial extent of the daily prism is said to depend upon three basic variables.

1. amount of time spent at home
2. the means of movement available
3. amount of time spent away from home.

These three variables in the spatial range of a daily prism are shown in figures 2 and 3. In figure 2 it is evident there is a difference in time spent at home by different individuals. One individual spends more time at home and is probably a housewife or unemployed individual. The other person spends more time away from home base

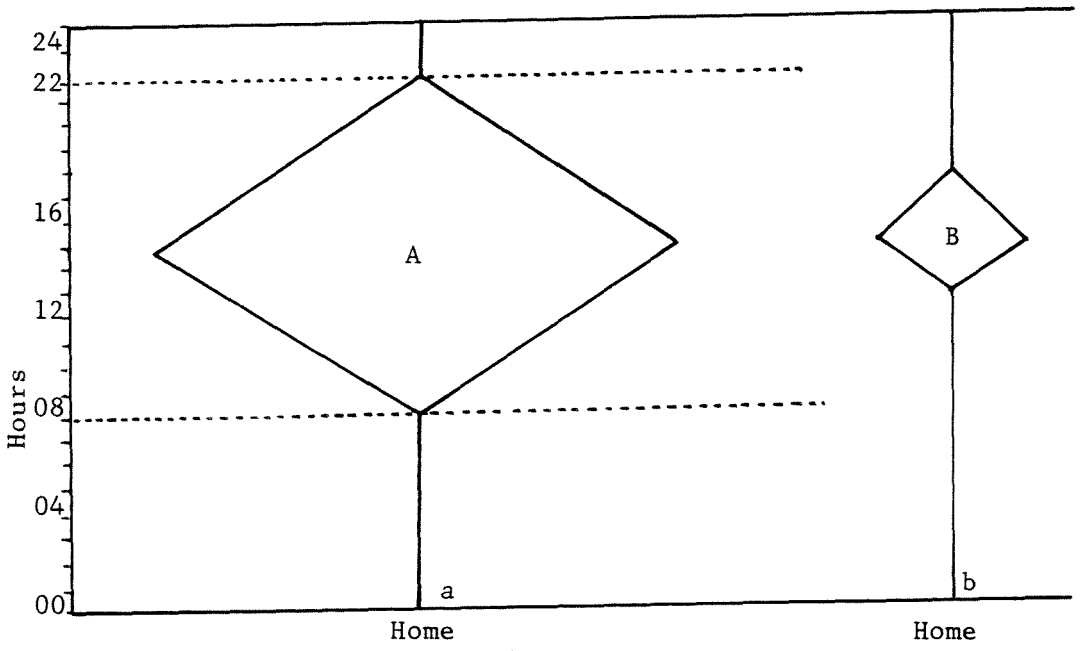

Figure 2: Individuals at 'a' and 'b' leave home bases at different times. They use different modes of transportation. A = car B = walking

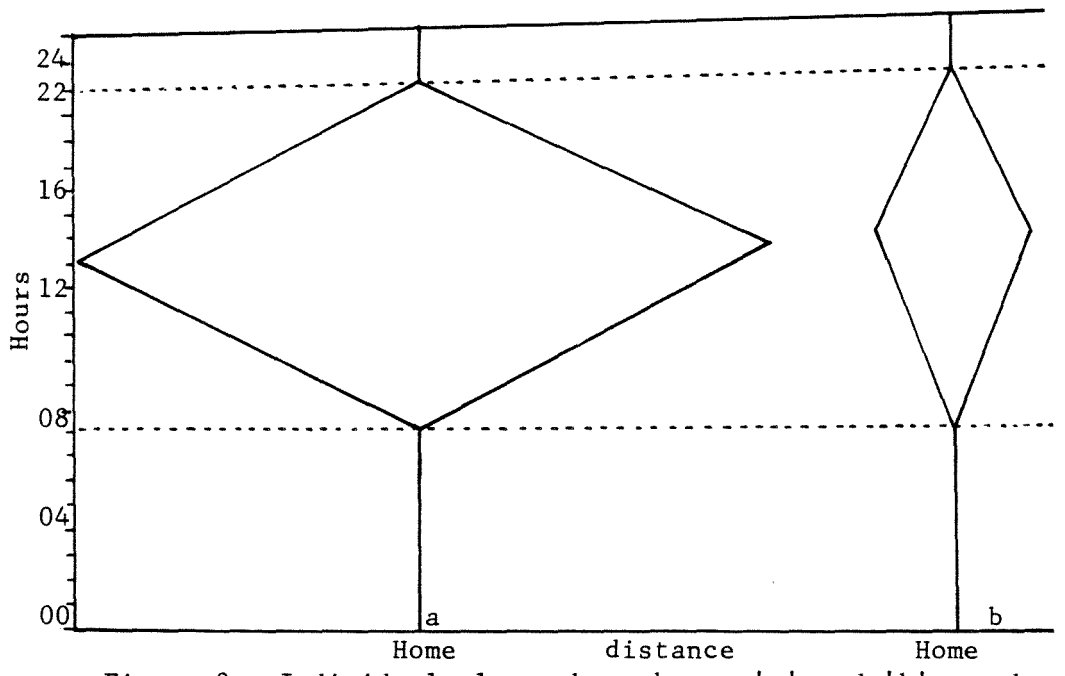

Figure 3: Individuals leave home bases 'a' and 'b' at the same time but the means of movement available varies.

(at work). FFigure 3 shows that both individuals spent the same amount of time away from home but used different transport modes.

Obviously the daily prism assumes that there is a routine and regular occurrence of activities. The implication in the concept of daily prisms is that there is regularity in the habits of the individuals and that activities do occur consistently. The prism includes or anticipates no uncertainties and no occurrence of irregularities. If an individual decides to diversify his activities in order to achieve an optimum satisfaction from the resources available and accessible to him, the prism gets distorted. Since the three constraints - which define the daily time-space prism - can be altered, then the shape and size of a daily prism can be changed or distorted. Figures 4 and 5 show the changes and distortions that can take place on the time-space prism of an individual. The difference in shapes reflects the priorities of the individuals which affect individuals' lifepaths or biographies, therefore, the dimensions of their time-space prisms. People choose and act according to what is convenient to them and according to their values. If an individual places a high value on time for which there are other competing events the individual will choose the transport mode that will maximize his or her return on the expenditure of time depending on his or her cost budget. Adjusting one's movement patterns according to what is most convenient and affordable to that individual influences the dimensions of the action space, hence the shape of the time-space prisms. The dimension of an individual's time-space prism is a function of a number of variables. Factors such as education, religious background, ethnic background, values, lifestyle, distance-decay and others play an

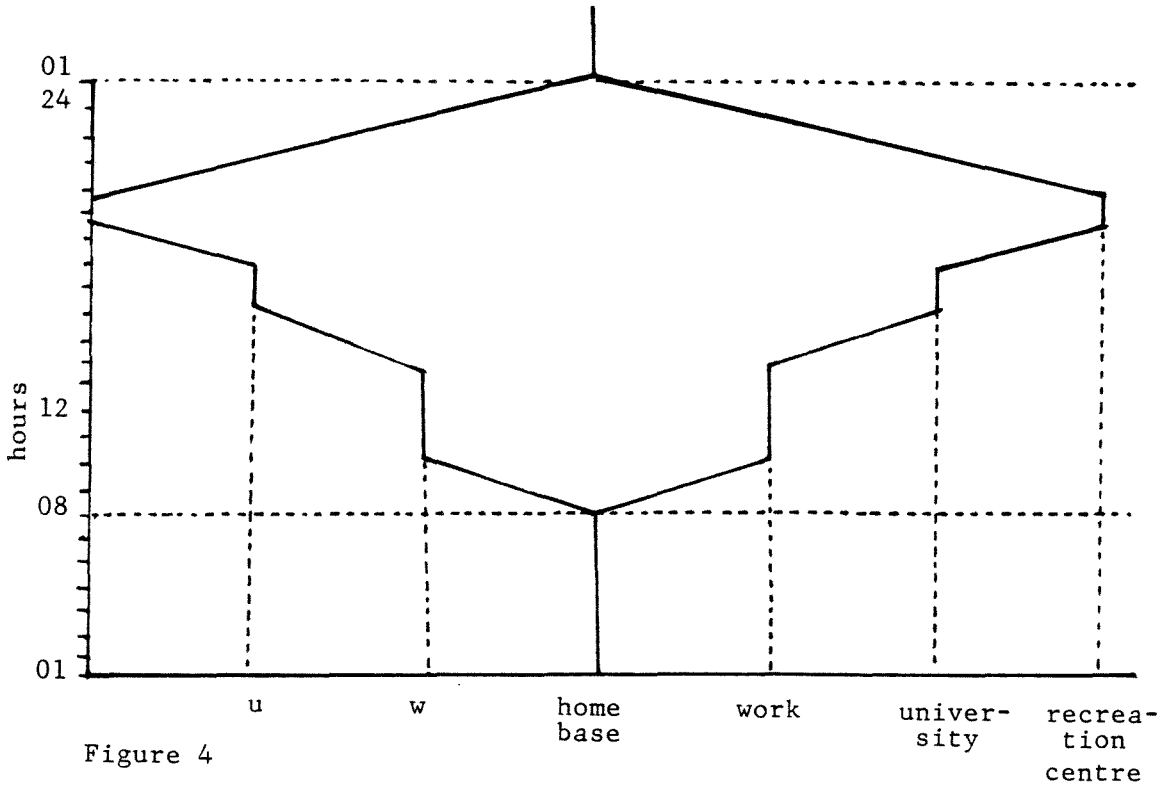

Figure 4

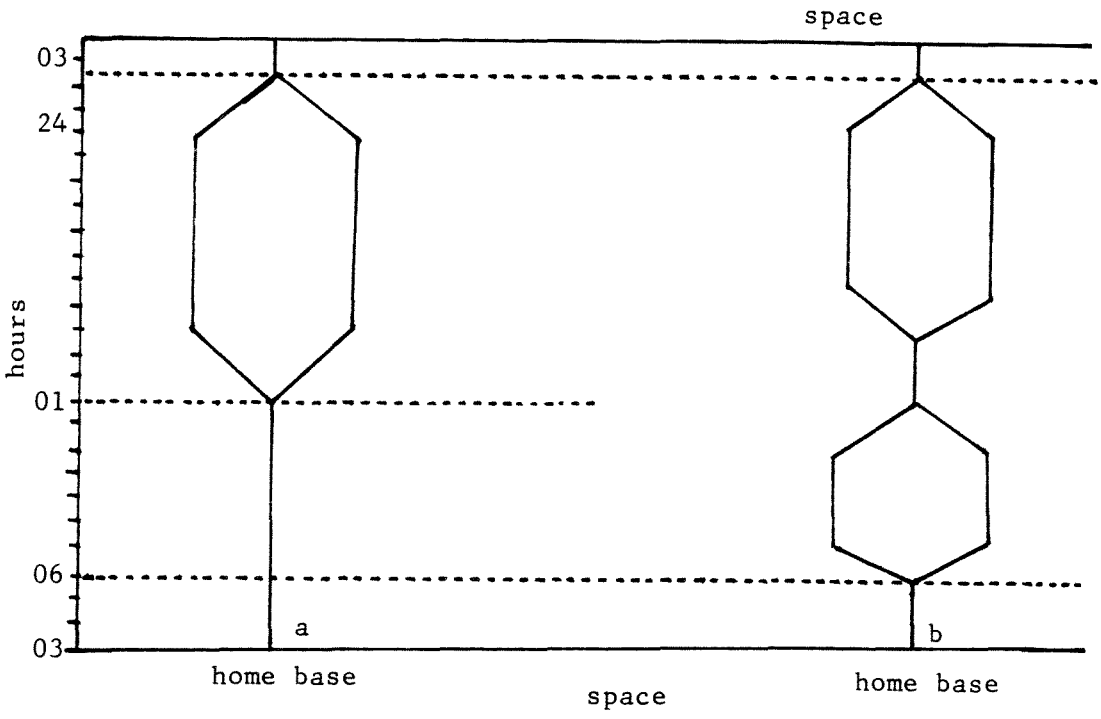

Figure 5

Figures 4 and 5: Some possible variations in the size and shape of time-space prisms

important role in the spatial extent of an individual's time-space prism (Low and Moryadas 1975, 140-144).

The time-space prism by the model is quite static and mechanistic. It has no flexibility nor does it take into account occurrences of unpredictable events or inconsistencies which influence changes in people's actions or choices. People alter their daily time tables or schedules to do things impulsively. Sometimes a person's daily time schedule may be altered by the occurrence of an accident or sickness which was unexpected. The addition of one activity on an individual's time schedule by doing different things each day such as joining a friend after work for shopping, going out to dinner or for entertainment will distort the structure of the prism. The prism neglected the fact that individual behaviour is subject to daily change according to circumstances regardless of one's predefined schedule or scheme. Figure 4 is just an example of how a prism can be distorted by changes in an individual's schemes. For instance, an individual may go to work, then home for lunch and go back to work (Figure 5b) or he/she may go to work then to a social activity and/or to evening classes at a university and from there he/she may decide to go to the recreation centre. (figure 4).

There are various combinations of activities that people can do during the day which may be planned or done impulsively. Variation in an individual's daily time-space prism depends not only upon time spent at home or at work and on the means of movement but upon a complex set of variables comprising an individual's behaviour. Factors influencing an individual's behaviour include social class, state of health, availability of alternatives, fear of danger (e.g. fear of

taking a subway at night because of the possibility of being robbed or harrassed), the cost in effort or in money, pain, etc. Variation in a daily time-space prism, for example, may occur as a result of differences in income level, profession or qualification and personal preferences. For instance, two persons may be residing in the same residential area and have the same time-space constraints (distance to work place) and they both drive cars to work but because of their differences in job titles they may have a different daily prism. Even though both individuals may live in the same house, work for the same company and start and finish work at the same time, their daily prisms may differ in the following way. If one is a salesperson he/she may attend to some sales calls on his/her way to work, thus diverting from the usual path or route taken to work. If the other person is a clerk in the same company he/she would typically go straight to work without diverting his/her route to work.

Similarly, the type of occupation and duration through which a specific task is undertaken affects the shape of a prism. Professors, teachers, as well as church pastors usually work overtime. Their responsibi'ities do not terminate at the end of regular working hours. Even when they are at home they spend a considerable amount of time studying and working. Similarly, pastors have to visit the sick in their homes or in the hospital and counsel families with their various problems. Many of these duties must be attended to in the evenings or during weekends when most families are home from work. The daily prism does not account for such variables. When such activities occur they will produce distortion in the daily prism.

Although the concept of the prism shows some limitations and weaknesses such as the examples given above, overall, the model is adequate for graphical description of micro human geographies. Moreover, it has some advantages over traditional quantitative methods because of its concern with common sense features of everyday life, routine social activities and daily interactions.

A description and critical evaluation of Hagerstrand's time-space model indicate that, although there are limitations to the model, its unique approach in looking at human geography has provided some heuristic value as indicated by studies cited in this paper. There is a clear need for more empirical research in this area and the model itself could be improved in terms of its deterministic nature vis a vis individuals and their use of space and time.

The discussion presented above on the problems and limitations of the time-space model is not intended to say the model is inadequate. The model has been proven to be useful for both descriptive and normative purposes. Moreover, the intent of this essay is to attempt to show and make clear that the time-space model is not incompatible with traditional methods, but rather fills an important gap left by these models.

VI. SUMMARY AND CONCLUDING REMARKS

This essay has attempted to examine the pros and cons of the time-space model critically. It has attempted to show that although the model has some limitations and problems, it also has good qualities. For example, it has the ability to reveal how modern

societies have structured their economic activities and time-space budgets. The model attempts to examine the problems faced by individuals within the societal framework. Thus, it incorporates authority constraints which further limit the freedom of the individuals within the society to take advantage of the opportunities within their grasp. That is, after they have eliminated time-space constraints they still have to strive with rules and regulations preconditioned by the society at large.

On the other hand, the time-space model is not a method of choice for studying the attitudes of people or the products produced by the ongoing processes. In addition, the time-space model tends to be too narrow and to oversimplify reality. For example:

1. It does not explicitly identify the complete sets of variables influencing decisions and choices made by individuals for employment and transportation alternatives.

2. the model does not show differences in people's choices and selectiveness of jobs due to their skills, professions, qualifications, academic status, preferences, values and socio-economic status.

Studies like that of H.F. Lionberger (1960) have shown that the higher the skills, education, and socio-economic status of an individual, the more selective an individual will be in his choices.

3. the model does not explain explicitly the individual's conceptualization of his action space and the individual's perception of the opportunities available to him.

The variation in the choices of opportunities occurs as a result of the individual's personality, perceptive skills, exper-

iences, and possession of marketable skills. What is important in the study of human behaviour is how individuals themselves view the choice situations in which they make decisions for employment and services within commuting range in an urban area. The time-space model does not account for how the individuals perceive the employment market, movement space and their activity spaces. There is an interdependence between an individual's action space and other behaviour not investigated by the model (values, feelings, abilities, awareness of the market conditions, etc.)

In conclusion it can be pointed out that the time-space model is essentially an empirical generalization or axiomatic approach which has no theoretical grounding and is unable to provide logical assumptions from which hypotheses can be derived. As a result this model cannot be used effectively in large scale research projects. On the other hand, it is a valuable tool for schematically studying relations of individuals within a given period, so as to locate their patterns and action spaces.

FOOTNOTES

1 N.J. Thrift, An Introduction to Time - Geography's Concepts and Techniques in Modern Geography, Vol. 13, 1977, p. 5.

2 A. Pred, The Choreography of Existence: Comments on Hagerstrand's Time-geography and its usefulness. Economic Geography, Vol. 53, 1977, p. 213.

3 C. Van Paassen, The Philosophy of Geography: From Vidal to Hagerstrand. In A. Pred and G. Tornquist (eds.) Space and Time in Geography. Lund: C.W.K. Gleerup, 1981, p. 25.

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