NASA Technical Memorandum 102245

Potential Use of Tiltrotor Aircraft in Canadian Aviation

Denyse Gazdag and Larry Alton

December 1990

National Aeronautics and
Space Administration

NASA Technical Memorandum 102245

Potential Use of Tiltrotor Aircraft in Canadian Aviation

Denyse Gazdag, Versatec, Inc., Santa Clara, California
Larry Alton, Ames Research Center, Moffett Field, California

December 1990

National Aeronautics and
Space Administration

Ames Research Center
Moffett Field, California 94035-1000

CONTENTS

SUMMARY

This paper describes the aviation system in Canada as it relates to the potential applicability of tiltrotor technology. Commuter service in two corridors, the Vancouver–Victoria route on the west coast and the heavily traveled Montréal–Toronto corridor in eastern Canada, are examined. The operation of air service from the near-downtown Toronto STOLport and from the Vancouver–Victoria downtown heliport facilities is described. The emergency medical services, search and rescue, and natural resources development sectors are described with regard to the needs that tiltrotor technology could uniquely meet in these areas. The airport construction program in isolated communities of northern Québec and possible tiltrotor service in northern regions are reviewed. The federal and provincial governments' financial support policy regarding the aeronautical industry is to encourage the establishment and expansion of businesses in the field of aeronautics and to make possible the acquisition of new technology. This policy has implications for the tiltrotor program.

INTRODUCTION

To evaluate the tiltrotor's potential applicability in Canada, this report reviews the existing infrastructure and airport conditions in the industrially developed area between Hamilton, Ontario, and Montréal, Québec, in the east, and the heavily traveled Vancouver–Victoria area in British Columbia on the west coast. The needs that potentially could be best met with the use of tiltrotor technology are identified. The role that the Canadian government plays in promoting and supporting the aerospace industry, and the implications for aircraft manufacturing, are also reviewed. This report is by no means exhaustive, and it should be complemented by more detailed analyses of tiltrotor technology requirements in various sectors of Canadian aviation.

The aviation system in Canada has many similarities to its counterpart in the U.S., but it differs in certain areas. As in the U.S., commercial aviation operates in a highly economically developed context, in which intense business activity generates a vast number of transportation needs, for both people and goods. The immensity of the area over which business is conducted creates the need for extensive use of air transportation by the business community, and the general affluence of the Canadian society supports a healthy pleasure air travel business as well. Canada has the highest per capita use of air travel in the world, and it constitutes the western world's second largest helicopter market. Because of its low population density, however, it doesn't have as much air and ground congestion as is experienced in America and Europe.

Abundant natural resources—oil, gas, minerals, forests, and waterways suitable for hydroelectric power generation, mostly found in remote areas—create exploration, extraction, construction, and transportation activities that necessitate the use of aircraft. Some of these projects are conducted on a large scale; more than 100 helicopters were used for the transportation of men and equipment during the first phase of the James Bay hydroelectric project in northern Québec between 1972 and 1980.

Canada's aerospace industry, which ranks fifth in size in the western world after the U.S., France, Britain, and Germany, is in full expansion. Its sales have increased 152% over a 6-yr period,

Note: The information in this report was compiled in early 1989.

from C$2.3 billion[1] in 1980 to C$5.8 billion in 1986, and its 1986 R&D budget was C$580 million, compared with a yearly average of C$200 million between 1975 and 1985. Canada exports 80% of its production, 70% of which is under civilian contracts. The Canadian aerospace industry receives important government help, as does its European counterpart (its American competitor does not).

Roughly 85% of the scheduled passenger service in Canada is controlled by two companies, Air Canada and Canadian Air International (CAI). There are also 37 regional airlines, 11 of which are partly owned by these two national carriers. Canadian Air is privately owned, but Air Canada, the largest carrier, is government-owned. Parliament has been considering the sale of 45% of its shares to the public, for C$300 million. Air Canada's planes have one of the highest load factors among the world's large carriers; in 1987, 71.1% of its seats were occupied, compared with an average of 62.3% for U.S. scheduled airlines.

The following is a comparison of selected statistics for the U.S. and Canada.

	Canada	USA
Population (July 1988)	26,087,536	246,042,565
Total area	5,985,684 mi^2	5,623,566 m^2
Population density	4.4/mi^2	43.8/mi^2
Registered rotorcraft	1,329 (Feb. 1989)	6,800 (Jan. 1989)
Registered fixed-wing aircraft	25,599 (Feb. 1989)	207,086 (Jan. 1989)
Airfields	1,245	15,422
Economic growth rate (1987)	4.4%	2.9%

AIRPORTS

Canada's aviation history covers more than 70 yr. Because of the vastness of the land area and the low density of the population, the establishment of a good air transport system has been essential for the rapid development of the country. Airfields were established throughout the country early in the century, even in some remote northern areas.

Privatization of the Canadian airport system, which until recently was run by the federal government, started in 1985, and is expected to be completed within 15 yr. Already, the management of several small airports has been turned over to the private sector. For major airports, the process is taking longer because of the greater complexity involved. Privatization of services and infrastructures will be the next step.

Government subsidies are available for the construction of new airports and the expansion of existing facilities; they cover as much as 50% of the cost. One criterion that determines the amount of subsidy available is the number of jobs created by the project.

The Toronto and Montréal airports have the heaviest air traffic in eastern Canada; the Toronto airport is the busiest of the two. The Montréal–Toronto line is the most heavily traveled route in Canada (12th heaviest in the world), with a daily average of 50 flights in each direction, and

[1] C$1 = U.S.$0.79 (March 1989).

transporting a total of 6000 passengers between Pearson International Airport and Dorval International Airport. Jet aircraft are used for 85% of these flights.

Montréal Area Airports

Greater Montréal, with a population of 2.8 million inhabitants, has four airports (see fig. 1): Dorval and Mirabel International; and two small private airports, at St. Hubert, south of the island of Montréal, and Cartierville, next to Dorval. Private clubs and the military use St. Hubert. There have been proposals to convert this general-aviation airport into a facility for regional traffic. Canadair now owns the Cartierville airport and uses it as a testing facility, but has plans to sell it and move to Mirabel airport; the land will be used for a housing development.

Mirabel International

Mirabel International Airport, located 56 km (34 mi) north of Montréal, was opened in 1975. It was intended to receive all of Montréal's international traffic, as well as domestic jet traffic. Two main factors prevented Mirabel from reaching its potential traffic volume.

1. Over the years, ten Canadian airports have joined Montréal as international gateways to Canada.

2. The transfer system between Mirabel International, which receives overseas flights, and Dorval International, 39 km (24 mi) away, which handles domestic and transborder flights, is inadequate and inefficient. Consequently, non-origin/destination (OD) travelers choose, if possible, other international airports where connections are more convenient.

At present, Mirabel is operating below capacity, and congestion is not anticipated until well into the next century.

Downtown-to-airport transportation– Mirabel can be reached in approximately 1 hr from downtown Montréal. In general, access to Mirabel by ground transportation presents no problem, because most intercontinental flights arrive and depart outside peak traffic hours. Arrivals occur between 1:30 and 4:30 p.m. and departures between 7 and 9 p.m.

There are plans to establish a helicopter shuttle service from the proposed downtown heliport. However, because demand is not projected to be large enough to support a viable business, the service will be "on demand" rather than scheduled on a regular basis. For the most part, helicopter shuttle service is used exclusively by first-class passengers, and it is estimated that only 10% of these passengers, representing only 1% of the total passenger population, avail themselves of the service. This translates to about 4 passengers per flight, and about 40 passengers per day.

The taxi fare for the Mirabel–Montréal ride is about $50, whereas helicopter transportation would be approximately $100. Time saved in traveling by helicopter would be approximately 50%, assuming 40 min of ground-transportation access time vs 20 min for air transportation. Given these circumstances, demand for helicopter shuttle service is not projected to be great.

Dorval International

Dorval International Airport, located 21 km (12.5 mi) from downtown Montréal, has experienced a sharp increase in traffic recently; forecasts indicate that the trend will continue into the next century. From 1983 to 1987, the number of passengers using Dorval climbed from 5,143,000 to 5,957,000, and the forecast for 1996 is 8,590,000 passengers. It is predicted that by 2001 this figure will increase to 9,850,000 (see percentages in fig. 2).

Helicopter traffic to Dorval averages ten helicopter movements per day, and consists mostly of traffic surveillance service, with some chartered flights.

Downtown-to-airport transportation– Dorval can be reached in 15 to 60 min from downtown, depending on traffic. To expedite travel to the airport it may be possible to convert the right-of-way that runs parallel to the railroad tracks into an express bus lane.

Ottawa Area Airports

The two airports that handle air traffic to the Ottawa metropolitan area, which has a population of 546,849, are Ottawa International, 30 min away from Parliament Hill, and Gatineau Airport, with a 15-min access time (fig. 3). Ottawa International experiences very few congestion problems, and Gatineau, a regional airport, has none.

Toronto–Hamilton Area Airports

Toronto has a population of 2.1 million. It has one international airport (Pearson); a STOLport [1372 meter (4500 ft) runway] on Toronto Island; Buttonville general aviation airport; and Downsview military airport, which is used also by de Havilland as its testing facility (see fig. 4). The market share of each airport is shown in figure 5.

Hamilton, with Hamilton Civic Airport, is 70 km (42 mi) southwest of Toronto. Its population is 306,400.

Toronto—Pearson International

Pearson International Airport handles three times the traffic for which it was designed, which causes airlines to experience more and more delays. This overall traffic increase (fig. 6), which started in 1983, can be explained by the following factors.

1. Upturn in the economy
2. Lower airfares
3. Deregulation

4. Expansion of the charter and commuter sectors

5. More international airlines pressing to come into the lucrative Toronto market

This combination of factors has caused the number of passengers using Pearson International to increase from 13,579,100 in 1983 to an estimated 19,334,000 in 1988. The median forecast for the year 1996 is 26,000,000 passengers, and in 2001 it should reach 30,110,000 passengers.

With full deregulation, which has been gradually implemented since 1983, commuter traffic in Ontario is predicted to increase substantially. The high-density commuter routes are Toronto–Windsor–Sault Sainte Marie and Toronto–Timmins.

To meet the demand, Pearson International Airport needs two more runways in addition to the three existing ones. The most difficult stumbling block is the opposition presented by the anti-noise lobby. A new 24-gate terminal is under construction. This $38 million project is being executed by the private sector.

Economic costs of congestion at Pearson International– It is estimated that the Canadian airline industry is losing millions of dollars every year because of delays caused by congestion at Pearson International Airport. Waiting time for takeoff clearance varies between 30 min and 3 hr. (As of December 1988, a limit on the number of flights per hour was enforced; waiting times are now (in 1990) a maximum of 1 hr.) Short-haul traffic from Ottawa and Montréal sits on the ramp waiting for clearance to land at Pearson. If the wait is too long, the flight is cancelled. According to estimates by the Air Transport Association of Canada, the cost of fuel burned while planes are waiting amounts to roughly $750,000/yr for Toronto-related flights. The figures are similar for Vancouver International Airport.

When 30 planes are lined up on the ground waiting for takeoff clearance, as happened one morning in November 1988, $1 billion of capital is not being productive. Some planes waited so long with engines running that they had to refuel. Those 30 planes were carrying an estimated 2,000 passengers, many of whom missed connections or appointments; those missed opportunities translated into economic losses for both individuals and businesses. (One passenger, an engineer, is now suing an airline for $50,000 because his cancelled flight caused him to miss the deadline for a bid presentation.)

Revenues to the city are also diminished because of the congestion at Pearson and its attendant inconvenience to travelers. For instance, Toronto has lost at least one big convention for 1989. This translates into a loss of $2 million to the Toronto economy.

Although it is impossible to put a precise dollar value on the economic cost of flight delays and cancellations, these problems serve to emphasize the desirability of a convenient, direct, downtown air transport service.

There is some degree of inflexibility as to how traffic scheduling can be changed at Pearson International. For example:

1. Airlines that serve the highly profitable Toronto–Miami route want to run two flights per day, per airplane: higher utilization of the aircraft enables the airlines to offer lower prices. This type of

schedule dictates a departure at 7 a.m. for a return at 3 p.m., so that a second flight can depart at 4 p.m. and return before curfew time, i.e., midnight, after which time jets are not allowed to land.

2. European flights have a narrow time slot resulting from time differences that impose constraints on departure time from Toronto and dictate arrival time from Europe.

The following measures are envisioned by Transport Canada to relieve congestion at Pearson:

1. Build a fourth runway.

2. Extend the jet landing hours beyond the 7 a.m.–midnight limits.

3. Route charter traffic to Hamilton, 70 km (42 mi) southwest of Toronto.

4. Build a new airport at Pickering, east of Toronto, for small planes and business jets.

Planned business center at the terminal building– To better serve the needs of Pearson's business users, Transport Canada plans to add facilities similar to the London STOLport's business center that provide telephone, telex, and fax services as well as stock exchange data display, translation, and secretarial services. The government has issued a call for proposals to the private sector to build the planned business center; it will lease the land on which to build it.

Downtown-to-airport transportation (Toronto–Pearson)– The distance between downtown Toronto and Pearson International Airport is 27 km (16 mi). By car, the time from downtown to the airport is between 30 and 60 min, depending on traffic. By public transportation (half way by subway and then by express bus), it is about 1 hr.

Hamilton—Hamilton Civic

Hamilton Civic Airport has no congestion, and travel time to downtown is only 30 min, at low or peak traffic times. This airport is being considered as a possible site to which to divert charter traffic from heavily congested Pearson International.

Helicopter traffic at Hamilton Civic is about 6 movements per day, involving photography missions, chartered passenger transport, and occasional small-package cargo.

Future Increases in Airport Activity

The passage of the U.S./Canada Free Trade Agreement, in early 1989, will spur increased business activity between the two countries, and this growth will translate into increased cross-border traffic. The major part of this expanded traffic will be in the direction of Montréal and Toronto, the banking, business, and commercial centers of eastern Canada.

It has been estimated that commercial traffic over the International Peace Bridge linking Buffalo and Fort Erie will quadruple as a consequence of the U.S./Canada Free Trade Agreement. Predictably, air traffic between Montréal and Toronto and the major business centers of the eastern United States, including the Detroit and Cleveland areas, all within tiltrotor range, will increase markedly also.

To evaluate the need for tiltrotor service between Toronto and Montréal, and to the major cities of the northeastern United States, we need to estimate the additional movements that will result from increased business between the U.S. and Canada after the easing of trade restrictions, as well as the significant normal growth projected. The increased airport congestion (air and ground) will make attractive the use of tiltrotor flights to conveniently located downtown vertiports. The feasibility of developing downtown service infrastructure in the U.S., capable of handling both U.S. and Canadian traffic, should also be studied.

DOWNTOWN STOLPORTS

Ottawa Rockcliffe and Montréal Victoria STOLports

From 1974 to 1976, the federal government conducted a STOL demonstration program operated by Airtransit, a subsidiary of Air Canada especially set up for the program, that provided a high frequency service between the Montréal Victoria STOLport and the Ottawa Rockcliffe STOLport, 200 km (120 mi) away. Both STOLports were located near the downtown areas (see figs. 1, 3, and 7). The Ottawa STOLport was located on the grounds of an existing airport, formerly a military airfield, and the Montreal STOLport was built on a garbage dump site.

The de Havilland Twin Otter was selected as the appropriate aircraft to implement STOL service. For its intended operation in urban areas it was especially modified with area navigation (R-NAV), microwave landing system (MLS), heavy duty brakes, and lift spoilers; it was, therefore, uncertified. The aircraft modifications, which included interior alterations, reduced seating capacity from 17-20 passengers to 11 passengers. The service was used mostly by government officials and business people traveling for government purposes. The experiment lasted 21 mo, and about 158,000 passengers were carried. The program was not designed to be profitable.

The main objectives of the program were to test the technical, operational, and regulatory components of STOL downtown-to-downtown air service; passenger acceptance of STOL service; community reaction before and during implementation of a new transportation system; economic viability of the system; and public acceptance of permanent STOL facilities.

Subsequent implementation of an economically viable STOL service was never carried out, primarily because no feasible certified aircraft existed, but also because of the oil crisis and the depressed state of the Canadian economy that had dampened the air travel industry, and the two STOLports went into disuse with regard to commercial aviation.

The Ottawa Rockcliffe STOLport is now used exclusively by small aircraft of aviation clubs. The Montréal Victoria STOLport was closed after the STOL demonstration. Installation of transmission lines in 1980 imposed further constraints on approach patterns and limited its potential use to the Dash 7 (50 passengers), the only aircraft that met the specific landing requirements in the new environment.

The Victoria STOLport's runways had suffered extensive damage over the years in the form of mounds and gullies caused by settling and by methane gas escaping from the buried dump. In 1985-1986, Transport Canada conducted a study to evaluate the feasibility of putting the airport back into service. It was estimated that the cost would be prohibitive and, in addition, no intensive use of the

facility was projected for the foreseeable future. Consequently, restoration plans were abandoned and the land was sold to Téléglobe, which will develop a high-tech park on the premises. The initial plans included the installation of a heliport (see map (fig. 1)). The latest plans for the Montréal heliport are discussed in detail later.

Toronto Island STOLport

Officially known as the Toronto Island Airport, the Toronto STOLport opened as a regular airport in 1939. During World War II it was used as a training base for the Royal Norwegian Air Force, and it reverted back to civilian use in 1945. For the next 32 yr, traffic consisted mostly of general aviation movements. Scheduled service started in 1977 with Air Atonabee serving local routes in southern Ontario, and in 1984 STOL service was introduced by City Express. Details of its operation follow.

The Toronto STOLport is located 121 m (400 ft) from the city's shoreline, across a navigable waterway, and is easily accessible by ferry (a 2-min ride). Downtown is 5-6 min from the ferry terminal. The airport is operative for Dash 7's, Dash 8's and ST27's, used by City Express, and for private aircraft. The only jets allowed are those used for medical evacuation.

The first microwave landing system (MLS) to be installed in Canada has been operational at the STOLport since February 1989.

The Toronto Island STOLport is the third busiest commercial airport in Canada; it handles up to 70 regional airline movements per day. The total yearly traffic, including private aircraft, is approximately 200,000 movements, and the airport ranks seventh in passenger usage. A new terminal building is under construction.

A study was done on the economic impact of building a new terminal and digging a tunnel to link the island with the mainland. The present ferry system will limit the passengers-per-year capacity to 1.2 million.

Seventy-eight million people live within 400 n.mi of Toronto. This distance is the STOLport's economically feasible range of operation. Planes that can serve routes beyond this range need an additional 400 ft of runway. The STOLport has one 1,212-m (4,000-ft) runway, and two 909-m (3,000-ft) runways. With its three short runways bracketed by water, this airport cannot be easily extended.

City Express Airline

City Express, the only remaining independent regional airline in Canada, is one of the fastest-growing Canadian carriers (see fig. 8). It operates a service between the Toronto Island STOLport and Ottawa International Airport, Dorval International Airport in Montréal, and the Newark airport in New Jersey, with a fleet of four Dash 7's (50 seats, 250 mph) and four Dash 8's (37 seats, 290 mph).

The 1984 inauguration of service to Ottawa (253 mi away) met with immediate market response. To satisfy the increasing demand, two more Dash 7's were added to the fleet; within a year, traffic

increased from 24,000 to 200,000 passengers . Discounted weekend fares have been very popular; a 65-min Dash 7 flight to Ottawa costs $59, versus $40 for a 6-hr train ride.

In September 1985, a high-frequency service to Montréal, 345 mi away, was started with two 40-seat Dash 8's. Because of its speed and passenger comfort, the Dash 8 has proven to be competitive against large jet services. In 1986, traffic increased to 270,000 passengers. In the spring of 1987, two additional Dash 8's were acquired and service was extended to Newark, NJ, 373 n.mi away, with nine round trips daily. In 1987, City Express carried 400,000 passengers. Its two major routes are Toronto–Ottawa and Toronto–Newark. Per capita usage of the STOL service is lower in Toronto than in Ottawa or Montréal.

The complete downtown-to-downtown service is accomplished with a fleet of City Express buses that pick up passengers and luggage in the central business district of Toronto, Montréal, or Ottawa, and deliver them to the door of the airplane, thus eliminating time consumed in the terminal. When the aircraft arrives at its destination, a bus picks up the passengers directly from the plane and drives them downtown. Passengers must be at the pickup point one hour before departure time. No reservation is necessary for the bus service, and the cost is included in the plane fare. Luggage check-in at the pickup point is an additional attractive feature of the service. The brightly painted buses serve as mobile billboards advertising the service through downtown Toronto, Montréal, and Ottawa.

Passenger surveys conducted at the beginning of operation of the STOL service indicated that 35% of the traffic was coming from train, bus, and auto users, while 3% to 5% of the travelers would not have made the trip if it were not for the City Express air service. It should be noted, however, that business people are faithful to Air Canada and Canadian (formerly CPAir) carriers that land at Pearson International. Pearson is at the west end of Toronto, and its proximity to the bedroom communities makes it more convenient for the residents of these communities than the downtown STOLport is.

City Express is now running 66–72 flights daily out of Toronto Island, with a turnaround time under 20 min. During the week, the biggest loads of passengers originate in Ottawa, Montréal, and Newark. On weekends, the traffic pattern is reversed; most traffic originates in Toronto, and is composed of passengers who want to spend the weekend in Ottawa, Montréal, or New York. The success of the service has resulted in a steady increase in traffic, causing the island facility to become increasingly congested. (Air Ontario has since offered very competitive flights, however.)

It is noteworthy that City Express has been successful even though near-downtown airport facilities exist only at one end of the route. If downtown facilities were available at both ends, there might be an even higher degree of utilization of the service.

Within 2 yr, service is expected to expand to Cleveland, Detroit, Rochester, London (Ontario), Windsor, Québec City, and Boston. Skyking Airlines International, an American carrier, is due to inaugurate a Toronto–Boston service in 1989. Two other airlines, Air Ontario and Inter-Canadian, are expected to use Toronto STOLport soon. Service will be provided with Dash 7, Dash 8, and Dornier 225 aircraft. The BAe 146 may also be used, if the ban on jet landing is lifted by the city of Toronto.

Market elasticity

The downtown-to-downtown air transportation market in Canada is highly price-sensitive, and intercity fares should be the same as or lower than those for non-intercity air travel in order to be competitive. City Express management has observed that (1) fare increases result in decreased business volume; and (2) the after-8 p.m., reduced-fare flights are the most popular.

The following are full coach fares (two-way) for City Express flights from Toronto Island and for Air Canada from Pearson International (all fares in U.S. dollars).

	City Express	Air Canada
Toronto–Montréal	$259	$312
Toronto–Ottawa	$238	$268
Toronto–Newark	$224	$302

Surveys should be conducted of potential users of a downtown tiltrotor service in Canadian cities, in order to assess the acceptability of higher fares as a trade-off for the convenience of downtown-to-downtown service.

HELIPORTS AND HELICOPTER SERVICE

Canada is the the western world's second largest helicopter market. It has 237 private, public, and government heliports, many of them in northern Canada.

Helicopters are used mostly for resource development support, search-and-rescue missions, transportation of skiers to mountaintops, various environmental and scientific research programs in isolated polar regions, and emergency medical services (EMS) missions. For the latter, helicopters are being increasingly replaced by Cessna airplanes because of their higher speed.

Canada does not yet have much experience with helicopter shuttle service between airports and downtown areas. In the mid 1980s it inaugurated its first helicopter service between Pearson International Airport and downtown Toronto. After a few months of operation, the service was discontinued, as discussed below. Another service, started in December 1987 to serve the Vancouver–Victoria route in British Columbia, is enjoying rapid and steady growth. Details of both operations follow.

Toronto's Downtown Heliport

For a few months in 1987, Air Canada provided a shuttle service between the Toronto downtown heliport and Pearson International Airport, 27 km (16 mi) away. Ranger Helicopters Canada operated this service. Specifics of the operation were as follows:

— 34 trips daily, between 7 a.m. and 10 p.m.

— 10-min ride, versus 30-45 min for ground transportation

— Three six-passenger Aérospatiale helicopters

— Fares: First-class Air Canada passengers free

$15 for executive passengers

$35 for discounted fare passengers

$45 for passengers not continuing with Air Canada

The regular shuttle service by bus is $7.50.

Depending on the source of information, various explanations are given for the demise of this helicopter service, including (1) complaints about noise pollution; (2) the high cost of the ride, which prevented generation of enough traffic for profitability; and (3) the location of the heliport at the eastern end of the harbour, which required an additional 10- to 15-min van ride to the city center.

The convenience of the City Express service directly to downtown Toronto is reducing Air Canada's share of the traffic to Toronto.

Vancouver and Victoria Harbour Heliports

Victoria (population 263,000), the capital of British Columbia, is situated on Vancouver Island across the Georgia Strait from Vancouver (population 424,000), the province's commercial and business center (fig. 9). The existence of these heliports is the result of persistence, and communication and cooperation among several entities, namely the municipal and federal authorities and the Harbour Heliports Society, which was formed with the goal of providing Vancouver and Victoria with well-located heliports. The granting of a temporary permit to operate helicopter service from the harbor areas gave the public, who strongly opposed the project, the opportunity to experience first hand the effects of helicopter movements between the two cities. Based on that experience, it was determined that the negative aspects, visual impact and noise pollution, were acceptable.

The Vancouver Harbour Heliport, located near downtown on Burrard Inlet (see fig. 9), is the largest floating North American airport (30,456 sq ft). Its construction, which cost C$1.7 million, was jointly financed by the Vancouver Port Corporation (private) and Canada's Transport Ministry (30%). It has three landing pads approved for day and night operation; the largest, built to handle 50,000-lb loads, is capable of accommodating helicopters up to the size of the Boeing Vertol Chinook. There are plans to reconfigure the heliport to accommodate five helicopters.

The Victoria Harbour Heliport was developed at the approximate cost of $166,000; the city of Victoria contributed about $16,000, and Helijet Airways financed the rest. It is located on land near the outer harbor, 5 min from downtown.

Helijet Airways

Helijet Airways is a newly formed airline that provides scheduled helicopter service between Victoria and Vancouver. Most of its market is composed, in approximately equal numbers, of government employees from Victoria and business people from Vancouver. For these travelers, most of whom prefer to make day trips, time is at a premium. Helijet Airways, with its downtown-to-downtown service approved for day and night operation, provides the service that best meets their needs. The majority of Helijet's customers have been gained from the seaplane service, and the rest of its business is a new market consisting of passengers who had been using the airport or ferry routes. Reservations must be made three to four days in advance.

The Vancouver heliport is within walking distance from downtown, and in Victoria, Helijet Airways provides passengers with free van shuttle service from the heliport to downtown.

Characteristics of the helicopter service

— Trip length: 101 km (61 mi), mostly over water

— Operating hours 0630–2030

— Flight Time 28 min

— One-way fare C$88

— Aircraft: three Sikorsky S-76s (12 seats)

— Average load eight passengers per flight

— Frequency 14 round trips daily

— Dispatch reliability rate 98%. Of 1,934 scheduled trips, only 12 were cancelled because of mechanical problems, and 26 because of bad weather.

Competing services

The Helijet's downtown-to-downtown helicopter service is in competition with 100 daily fixed-wing aircraft flights.

1. Airport-to-airport route (the most saturated in Canada)

— Flight time 25 min

— One-way fare C$61

— airport-to-downtown ground transportation to:

	Distance	Time	Cost
Victoria	30 km (18 m)	30 min	$9 (taxi)
Vancouver	18 km (11 m)	20 min	$6.50 (taxi)

2. Harbor-to-harbor service from Burrard Inlet in Vancouver to Victoria's outer harbour

   — Flight time 35 min

   — Twin Otter float-planes (18 passengers)

   — One-way fare C$76

   — Traffic volume 65,000 passengers/yr

There is also a ferry service:

   — Travel time 60 min

   — Frequency: every 30 min

   — One-way fare C$15

Frequency of service

Raising its level of frequency to the present 14 round trips per day (five days a week) has enabled Helijet to steadily increase its clientele and to build passenger loyalty. Helijet claims to control more than one third of the harbor market. It carried 21,000 passengers in 1987, 59,000 in 1988, and it is expected to carry 73,000 passengers in 1989 (fig. 10).

The maximum-utilization schedule, dictated by the S-76's maintenance requirements of 3 hr of maintenance work for each flight hour, is eight round trips per day per helicopter. In addition to the scheduled flights, there are six to seven charter flights per day for corporate transport. EMS and SAR-mission flights represent less than 5% of the total traffic.

Helijet's passenger load factors are illustrated in figure 11. The present fleet of three helicopters brings down the break-even point to 60%. With its previous fleet of two aircraft, Helijet had to achieve a rate of 70% to break even. The company's revenues, including projections for the early nineties, are illustrated in figure 12.

Noise

Noise-pollution complaints were lodged by the residents of both cities, and by residents of Saturna Island, near the midpoint of the Vancouver–Victoria route. These complaints were successfully addressed by changing the flight patterns and raising the flight altitude of the helicopters to 4,500 ft southbound from Vancouver and 5,500 ft northbound from Victoria. The replacement of the 2-bladed helicopters (B412) by 4-bladed ones (S-76) was another successful noise-abatement mea-

sure taken. It is important to note here that, because of its lower noise profile (see appendix), the tiltrotor would be a more acceptable aircraft to operate in urban areas.

Expanded service to Vancouver International

In November 1987, Helijet started a six-daily-trip service between Victoria Heliport and Vancouver International Airport. Passengers and baggage are transported by van from the helicopter to the main terminal.

Comparative advantages and disadvantages of float plane and helicopter service

Twin Otter floatplane	S-76 Helicopter
Advantages:	
—Ability to fly to alternate airports in bad weather	—Instrument flight rules (IFR) capability extends service during winter
—Shorter time between overhauls	—No steep approaches, flares, and splashdowns
	—Avoids increasingly congested harbours
	—Travel time reduced by 5 min
Disadvantages	
—Visual flight rules (VFR) restrictions limit service during short winter days	—Greater noise pollution
	—Higher direct operating costs
—Some cancellations necessary because of high winds and rough seas	
—High maintenance costs for floats and salt-water operations	

Plans for Expansion of Service

Helijet is considering operation of a service on the 80-mi route from Vancouver International to the ski resort of Whistler Mountain. This is a very attractive, price-insensitive megamarket. However, there are difficult operational problems, including (1) an IFR route involving an 11,000-ft minimum en route altitude (MEA) requirement, on one engine; and (2) icing conditions that are among the most severe in the world.

A downtown Vancouver–Seattle airport service is also being planned.

Tiltrotor possibilities

Helijet Airways is a strong advocate of the new tiltrotor technology, with its potential for delivering more convenient and efficient service. Helijet envisions it being used to serve hard-to-reach areas in mountainous British Columbia, and to link Seattle with the city centers of Vancouver and Victoria.

Montréal's Proposed Heliport

Presently, Montréal's helicopter traffic uses facilities scattered throughout the city and at the international airports. The proliferation of landing pads in the city is increasingly putting the safety of the residents of Montréal at risk. Concerned about the potential for disastrous accidents, the government has ordered the closure of these landing pads by the end of 1989. There is a pressing need for a conveniently located heliport.

Location

One of the potential heliport locations under consideration is a vacant site by the Saint Lawrence River, between the Victoria and Champlain bridges. The area is clear of obstructions on all sides, and the adjacent freeway makes possible quick access (6 or 7 min ground time) to the business center of Montréal, a mere 6 km (3.5 mi) away.

Use

The heliport facility will be used primarily by the police, EMS, and business people. Light cargo transportation, of mail and small packages, is another possible use. The heliport could also serve as a transit point for light cargo going to the Montréal, Ottawa, and Québec City airports. There are no plans for heavy cargo transport, which would require large helicopters, because this mode of transportation is not considered economically viable. Passenger service will be on demand, as explained earlier.

Specifications

The following specifications for Montréal's heliport have been proposed. These plans are subject to change, depending on projected use based on market analysis.

1. Seven hangars are proposed, the largest of which will be 70 by 120 ft, with a clearance of 32 ft. A tiltrotor such as the V-22 would require a width of 90 ft, but smaller corporate-size tiltrotors could be handled at the proposed facility. Should there be a need for a larger tiltrotor hangar, accommodations could be made.

2. Landing surface dimensions will be 700×700 ft. This landing area is more than adequate to handle even the largest tiltrotor now being considered.

3. MLS installation may not be possible, because of the proximity of microwave antennae.

It is anticipated that this planned heliport facility will be fully converted into a vertiport when tiltrotor service is to be accommodated. Tiltrotor use for convenient and quick intercity travel has many advocates in Montréal, both in government and in the business community. Transport Canada has begun a study on tiltrotor vertiport development in Canada.

SEARCH AND RESCUE AND EMERGENCY MEDICAL SERVICES

With its thousands of lakes and waterways, in addition to its thousands of miles of coastal waters intensively used for recreation and commercial purposes, Canada is the scene of numerous marine incidents every year. In 1988, 80% of the 9,262 search and rescue (SAR) missions conducted in Canada were marine incidents.

The Canadian territory is divided into four SAR regions. The Victoria region, encompassing all of British Columbia plus 320 km (200 mi) out to sea, is the busiest. In 1985, it accounted for 3,127 missions, or almost 38% of all rescue operations conducted in the country.

Canadian SAR air missions are carried out by 11 planes and 48 helicopters from the Ministries of Defense and Transportation. The P-3 Orion long-range patrol aircraft have been in operation since 1984. They constitute the only Canadian Air Force resource with the necessary speed, range, and endurance for SAR in remote areas and in the marine environment. In British Columbia, SAR missions are carried out with five Boeing CH-113 helicopters and four de Havilland CC-115 fixed-wing aircraft.

The CH-113s have the following limitations that can adversely affect their ability to perform rescue missions:

1. They are not certified for ice. Consequently, when temperatures of 2°C or lower and visible moisture are predicted, the mission can't be undertaken.

2. They cannot maintain a hover on one engine. If an engine fails during a hoist operation, the aircraft will fall to the ground (or water).

3. They have limited altitude capability. This constitutes a serious drawback for missions in many areas of the Rocky Mountains.

The CH-113s have been used since 1965, and several have accumulated more than 10,000 hr of operation. They are expected to remain in service until at least the early to mid-1990s, when they might be replaced with the Anglo-Italian EH-101.

For certain kinds of rescue missions, both helicopters and fixed-wing aircraft must be used, each compensating for the other's limitations. Because of its faster speed and longer range, the CC-115 airplane will go first to find the scene, and guide the helicopter, which will make the rescue using its hovering capability. In some cases, the helicopter performs the rescue and then lands at the nearest airstrip to transfer the victims to an airplane for a faster trip to the hospital.

For the rescue of people at sea, in areas unreachable by helicopter, rescuers resort to the use of the sea SKAD (Survival Kit Air Droppable), dropped from an airplane. Unfortunately, this life raft's aerial inflation feature makes it vulnerable to wind and high seas. Consequently, accuracy is often not good, with potentially disastrous consequences for the people in need of rescue. Even if a recently improved delivery system alleviates this problem, it will not be able to match the tiltrotor in ability to rescue survivors immediately after they are sighted.

Fixed-wing airplanes, because of their speed, are increasingly replacing helicopters for EMS missions. The advantage of speed in the air, however, is counterbalanced by the inability to access all terrains and to land near hospitals, and thus the fixed-wing aircraft do not completely fill the need for delivering better EMS services.The vastness of the Canadian territory, and the low density of population in many areas, require an EMS transport system that incorporates speed, range, and all-terrain accessibility. All three of these features are uniquely exhibited by the tiltrotor.

In Canada's coastal waters and in the Great Lakes, quick rescue of survivors is important. Other missions take place in remote, hard-to-reach, mountainous areas (virtually all of British Columbia is considered mountainous). A factor that affects the survival rate of people who need rescue is the extremely low temperatures that occur throughout the country during much of the year. Time is of the essence for the success of rescue missions. It is clear that, because of geography and climate, Canada's SAR missions would be greatly enhanced by the use of tiltrotors. For EMS and SAR missions, tiltrotor marketability will depend on demonstrating that a greater number of missions can be carried out with a greater rate of success (i.e., number of lives saved).

NATURAL RESOURCES DEVELOPMENT SUPPORT

Canada has the most diversified mining industry in the world, which contributes more than 10% of its GNP. Mega-resource-development projects worth $440 billion have been scheduled for construction in Canada between 1981 and the end of this century. Eighty percent of these new projects will be in offshore locations and in remote regions of the west and the north. Many of the sites are inaccessible to ground transport because of terrain or weather conditions.

Traditionally, natural resource development projects have required the creation of new towns for workers. New towns in desolate areas don't offer the amenities and social environment conducive to retaining the work force for long periods of time. Consequently, work-force turnover in the mining industry is high and productivity is low for many northern projects. Recently, government policy dictated that workers be housed in already existing towns and be transported to the site of exploration. The policy stated that "the Alberta Government will encourage the improvement and growth of existing towns and facilities rather than the development of entirely new ones. It recognizes the weakness of 'one-company' or even 'one-resource' communities and will promote economically feasible diversification whenever possible." In other cases, environmental and ecological constraints prevent the creation of new towns.

Several resource development companies have provided their workers with commuter transportation from existing towns to mining sites. Bus commuting can be the cheapest mode of transportation when roads are available. Unions, however, have demanded travel-time compensation, which must to be added to the direct cost of transportation; total commuting cost is thus increased considerably. Air transportation then becomes a better alternative.

Surveys conducted by mining companies indicated that people have negative feelings toward company mining towns, and concluded that the "fly-in" concept could achieve the requirement of a satisfactory and stable work force. The fly-in system varies, depending on the location of the mine and its distance from the town. Two examples of the program, in Alberta and Saskatchewan, follow.

At the Luscar-Sterco Coal Mine, located 60 mi south of Edson in a mountainous region of Alberta, helicopters were used for daily commuting. This arrangement, favored by the workers, contributed to increased stability in the work force, to the benefit of the company. In 1980, the Luscar-Sterco's employee turnover rate was 18%, half the average industry rate.

The positive results achieved at the Gulf Minerals Canada Ltd.'s project at Rabbit Lake in Saskatchewan, 430 mi northeast of Saskatoon, is another example of the advantage of air commuting versus creating a new town. Considering work force morale, stability, and productivity, Gulf, in 1975, opted for the fly-in system even though its cost would be higher than the direct capital and operating costs associated with the creation of a new town. Gulf chartered one F-27 and one de Havilland Twin Otter to transport its workers from chosen towns to the mining site. The workers are on a seven-day-in/seven-day-out schedule, working 11 hr per day. Productivity has been very good, with all goals met or surpassed.

Similar long-range commuter operations have been studied for Yukon projects.

Mining activities in northern Québec require fixed-wing air transportation of personnel and equipment from Montréal to the mining towns of Val d'Or, Matagami, Chibougamau and Schefferville, located 300 to 850 mi north of Montréal. From there, helicopters transport men and materials to the sites of exploration, extraction, or building activity.

Because helicopter transportation is expensive, the mining companies build roads to these sites whenever possible. Some areas are too remote to make ground transportation feasible.

The Québec provincial government has undertaken a vast hydroelectric project in the James Bay region of northwestern Québec. The first phase took place from 1972 to 1980; the second phase, in which 3 more dams will be built and high-tension lines will be installed down to the American border, is expected to take 10 yr to complete. The Québec government approved this $24 billion project in March 1988.

During the first phase, 100 helicopters were used to transport men and materials. Since 1980 the territory has been provided with some ground transportation infrastructure, so fewer helicopters will be needed in the second phase. Some helicopters will be needed after completion of the project for maintenance and patrol.

Sixteen to twenty helicopters are presently used in offshore drilling. In July 1988, an important project was approved for offshore oil drilling, with encouraging implications for the helicopter industry. The Hibernia consortium, consisting of four oil companies, received federal government authorization to develop the Hibernia oil fields, 315 km (190 mi) off the coast of Newfoundland.

Several possible new sites of exploration in the Atlantic along the Labrador coast have been identified. Should they be developed, the vertical-takeoff-and-landing aircraft market will be expanded considerably.

Natural resources development projects constitute another niche for the tiltrotor. Given its range, speed, payload capacity, and all-terrain accessibility, the tiltrotor offers the advantage of making direct transport from population centers to the project sites possible. Use of the tiltrotor would eliminate, in many cases, the extra manpower and time required to make the transfer from airplane to helicopter, and decrease access time to the sites.

Other areas of northern Canada are rich in natural resources, and their development generates similar air transportation needs that might be better served with the use of the tiltrotor.

Data on the helicopter and fixed-wing aircraft operations for natural resources support missions should be obtained and evaluated to assess the tiltrotor characteristics needed for these uses. Demand for the technology will depend on the improved profitability resulting from the use of the tiltrotor versus other modes of transportation.

LOW-DENSITY, ISOLATED COMMUNITIES

According to agreements signed in 1982 and 1983 between the Canadian government, the Québec government, and the Inuit and Cri populations of northern Québec, 14 native Canadian communities of northern Québec are to be provided with airport facilities. As can be seen in figure 13, these settlements are scattered from the southern tip of James Bay to the northernmost part of Québec province.

The first airport was opened in August 1985, and the program should be completed by 1992. Four airports are still under construction, but 10 have been opened. Duration of construction work varied from 3 mo for the Salluit airport to 2 yr for the others. Construction sites must be closed during the winter months, and they usually reopen in May.

The federal government's financial contribution to this program is projected to be $78,874,800, and the Québec provincial government will contribute a total of $48.8 million to the construction of the Inuit airports.

Scheduled service to these remote airports is provided by one airline, Air Inuit, with Twin Otter aircraft.

The construction and maintenance of an airport network in the far north is expensive. The use of the tiltrotor would eliminate the need for building such an airport system, and at the same time provide isolated communities with needed air transportation.

It is important to evaluate the total costs incurred in the implementation of the northern Québec air transportation program and compare them with the potential expenses associated with tiltrotor service in similar regions, to establish the feasibility of tiltrotor service to isolated communities of the Canadian north.

Data must be obtained on the low-density settlements of northern Canada: their location, their air transportation needs, and the existing air services and infrastructure facilities that are available. This

will make possible the evaluation of vehicle requirements and potential markets for the tiltrotor in those remote regions.

Tourism

There is an additional demand for air transportation, mostly from hunters and fishermen, especially during autumn. At present, this sector represents a very small percentage of the demand for air service.

GOVERNMENT SUPPORT TO THE AEROSPACE INDUSTRY

Export Credit Financing

The Canadian Export Development Corporation, a federal agency, offers export credit financing at subsidized rates. It loans 85% of the cost of purchase of aircraft built in Canada, provided that the aircraft contains 60% Canadian components. Pratt and Whitney Canada powerplants typically represent almost 30% of the basic price of an aircraft. As long as a company demonstrates that it will reach the required 60% within 5 to 10 yr, it has access to the government financing services. Depending on the trade agreements between Canada and the country of the buyer, the interest on the loan is nonexistent or on the order of 3% or 4%. Of the remaining 15% of the cost of purchase, 10% is sometimes granted, as a gift, by the Aid to International Development agency. In this case, all that is required for the buyer to invest is the remaining 5% of the purchase cost.

Financial Support to Industry

The federal and provincial governments administer aid programs aimed at encouraging the establishment and expansion of aeronautics businesses and to make possible the acquisition of the latest technology. These programs help industry make investments, they grant subsidies or loans for research and development (R&D), and they help defray the cost of specialized training. There is a program for exchange of specialized training between Canada and foreign countries; if a specialty does not exist in Canada, the government subsidizes a high percentage of the training cost. For R&D, the industry's budget for 1986 was 30% financed by the federal government. For companies that want to participate in the Eureka program, the government finances up to 50% of expenditures. (Eureka is a European program to promote R&D projects; it involves 20 governments and more than 600 industrial companies and public research institutions.)

Two foreign companies that have benefited from the federal and provincial governments' assistance in establishing production facilities in Canada are Messerschmitt-Bolkow-Blohm (MBB) of Germany and Bell Helicopter of Texas. The benefits to Canada are technology transfer and jobs.

When, in 1984, MBB established its helicopter production facility at Fort Erie in Ontario (its only company-owned helicopter manufacturing facility outside Germany), it received government assistance totaling C$35 million; 60% was granted by the federal government and 40% by the province of Ontario. This MBB venture represented a total investment of $72.6 million. The Fort Erie

plant produces the BO 105LS family of helicopters for the world market. The initial 30% Canadian materials content of the helicopters assembled at Fort Erie was to be increased to 70% with the installation of the PW205B engines.

The cost of Bell's helicopter manufacturing program in Canada, covering the production of the Model 400 Twin Ranger family, had initially been established at $514 million in 1983. The government had agreed to contribute C$210 million of this total; sixty percent (60%) was to be provided by the federal government and 40% by the Québec government. Because of diminishing demands in the helicopter market, however, the program was scaled down. In the new program, in which Bell invested $155 million, the company agreed to move four production lines to Montréal (the 212, 412, and 206B JetRangers and the 206L LongRanger). About 60% of the 206B JetRanger and 206L LongRanger helicopters are manufactured in Canada.

Canadian/European Industrial Agreements

The easing of trade restrictions between the U.S. and Canada in January 1988 caught the attention of European firms looking for a stepping stone to lucrative North American markets, and the number of Canadian/European cooperative ventures has been growing.

In an effort to promote technology transfer agreements in the aerospace industry, Québec offers foreign businesses attractive financial incentives, including two-year tax holidays (this feature is unique to Québec). This policy has brought an encouraging response from French companies: 22 of 28 companies (79%) that signed industrial agreements with Canadian partners in the past two years have established themselves in Québec.

A major contract signed in September 1988 between Aérospatiale of France and the Montréal-based aircraft manufacturer Canadair involves the design and construction of six major fuselage components for the A330 and A340 aircraft. This is the first major Airbus industrial agreement in North America, and grants Canadair approximately 10% of the portion of the A330–A340 airframe production for which Aérospatiale is responsible. Canadair's total participation, involving an estimated $1.5 billion, will represent roughly 4% of the entire airframe production of 600 aircraft. This program requires an investment in the amount of $157 million, part of which is for R&D. A loan from the federal government will cover $37.3 million of these start-up costs, and an equal amount will be loaned by the Québec government.

This subcontract agreement between Canadair and Aérospatiale is viewed by some (but not by Air Canada, Canadair, or Airbus Industries of North America) as a compensation to Canada for last July's sales of Airbus 320s, which significantly increased Airbus' market penetration into Canada. Air Canada, which is 55% government-owned and is Canada's largest carrier, placed orders and options for 54 A320s, and Canadian Air International (CAI) ordered 51. These two large orders increase Canada's Airbus fleet considerably, which previously consisted of only 14 A310s purchased by Wardair Canada, Inc., in January 1987.

In November 1988, a second Canadian–European agreement was signed between Canadair and British Aerospace, for $400 million. The contract covers the manufacturing of parts of the wings for the A330 and A340 aircraft.

These two Canadian–European manufacturing agreements, which the government's financial support helped realize, are resulting in valuable advanced technology transfer to Canada, and in the creation of an estimated 750 new jobs in the Canadian economy. The new joint ventures involve not only production but also cooperation in marketing and distribution. An example is the Canadair–Aérospatiale agreement on the marketing of the Super Puma.

CONCLUDING REMARKS

From the somewhat restricted overview that is presented here, one can see that the tiltrotor has potential commuter transportation applicability in Canada. Direct downtown air transportation is a service that is needed in the Canadian market place, as evidenced by the increasing number of air travelers that use the STOLservice to and from the Toronto STOLport in eastern Canada, and the helicopter service to and from the Victoria and Vancouver Harbour heliports on the west coast.

The efficiency-reducing and economically costly congestion existing at Pearson International, and the steadily increasing traffic at Dorval, are only the beginning of a worsening situation, according to the forecasts for air traffic volume at these two airports for the rest of the century. Time-conscious, efficiency-minded business people will demand alternative ways to travel between the business centers of Toronto and Montréal.

Use of tiltrotors to alleviate the resulting airport congestion could be integrated into the air transport systems of Canada as well as the U.S. The infrastructure for handling tiltrotor movements in Eastern Canada already exists or is being planned.

Natural resources development support, EMS, SAR, and service to isolated areas of the north are four missions for which the tiltrotor's speed, range, and all-terrain accessibility seem to offer significant advantages in Canada.

A more detailed analysis of the market sectors described in this report will be necessary in order to assess the market's full potential.

APPENDIX

Community noise level estimates of the tiltrotor in the turboprop mode are significantly lower than those for typical turboprop aircraft and helicopters; noise was well within limits permitted by regulations (see "TR est" in figure A1). Hovering noise levels are the highest for the tiltrotor. They are estimated to be only slightly higher than turboprop sideline levels, but lower than hover noise levels for other similar helicopters. Presumably, operations in the hovering mode would be minimized in noise-sensitive areas by means of steep approaches and flares at ground level.

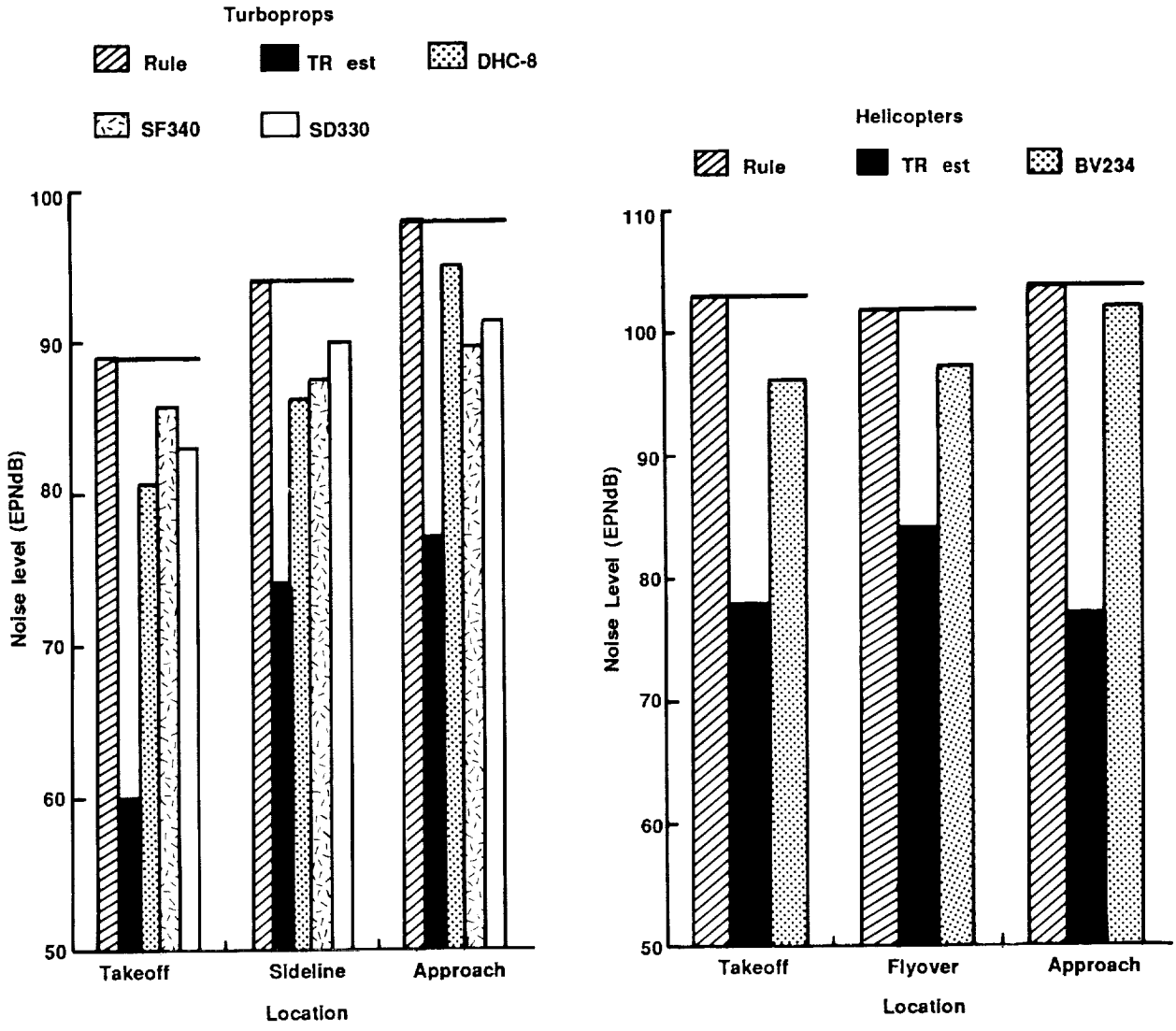


Figure A1. Comparison of noise levels of tiltrotor aircraft with those of turboprops and helicopters.

BIBLIOGRAPHY

Aerospatiale Awards $1.2-Billion Airbus Subcontract to Canadair. Aviation Week and Space Technology, vol. 129, Oct. 1988, p. 103.

Air Canada Starts Helicopter Service. Canadian Aviation, vol. 59, 1986, p. 13.

Aviation Aggregate Demand Indicators, Transport Canada, Spring 1988.

Canadian Operators Look to James Bay. Rotor and Wing International, vol. 22, 1988, p. 70.

Dagenais, R. C.: Search and Rescue in Canada, International Symposium on Satellite Aided Search and Rescue, Toulouse, France, April 1984, pp. 81-85.

Evans, Brian: A Canadian Roundup. Professional Pilot, vol. 22, 1988, pp. 54-57.

Gilmore, J.; Ross, D.; and Sladek, G.: Integration of Ground and Air Services Through Use of Stolmobiles. International Air Transportation Conference, Montreal, Canada, June 1983.

Holstein, William J.; Schiller, Zachary; Terry, Edith; and Zellner, Wendy: Getting Ready for the Great North American Shakeout. Business Week, April 4, 1988, pp. 44-46.

Hughes, David: Canadian Orders Strengthen Airbus' Role in North America. Aviation Week and Space Technology, vol. 129, 1988, pp. 68-69.

Jansen, Doug: Helijet Schedules Success. Helicopter World, vol. 8, 1989, pp. 20-22.

Lambert, Mark; and Bulloch, Chris: Canada's Aerospace Flourishes with New Owners. Interavia Aerospace Review, vol. 42, 1987, pp. 631-635.

Lightfoot, R. N.: VTOL As It Applies to Resource Development in the Canadian North. AIAA Paper 81-2640, V/STOL Conference, Palo Alto, Dec. 7-9, 1981.

MBB in Canada Tests the PW205. Rotor and Wing International, vol. 22, 1988, pp. 70.

Mac Burnie, Eric: Hoping with Helijet. Canadian Aviation, vol. 62, 1989, pp. 27-31.

Mc Laren, Grant: Department of National Defense 412 VIP Squadron. Professional Pilot, vol. 22, 1988, pp. 58-61.

Mc Laren, Grant: Helijet Uses S76s to Link Vancouver and Victoria. Professional Pilot, vol. 23, 1989, pp. 70-73.

Mc Laren, Grant: Toronto's City (Center) Express. Professional Pilot, vol. 22, 1988, pp. 62-64.

Mc Lean, Herbert: Helijet: A Helishuttle that Negates the Naysayers. Rotor and Wing International, vol. 22, 1988, pp. 50-54.

Picton, John: Airport Agonies. Toronto Star, Part 1-10, Dec. 4-13, 1988.

Proceedings of the 22nd Annual Symposium, Survival and Flight Equipment Association (SAFE), Las Vegas, Nevada, Dec. 1984, pp. 216-219.

Regional News-Canadian Comments. Helicopter International, vol. 10, 1987, p. 125.

Stein, Kenneth J.: Canada Awards Contract for MLS Installations at Toronto Island. Aviation Week and Space Technology, vol. 128, 1988, p. 121.

Smith, Barry D.: On Board with Canada's Busiest SAR Squadron. Rotor and Wing International, vol. 22, 1988, pp. 64-66.

STOL Demonstration Montreal-Ottawa 1974-1976 III Data Report, Transport Canada, Sept. 1978.

Swartz, Kenneth: Made in Canada. Helicopter International, vol. 10, 1987, pp. 126-127.

Toronto Harbour Commission, Toronto Island Airport 1939-1989, 1989.

Transport Canada: Air Forecast System Vancouver International Airport, 1988.

Urauhart, John: Air Canada Launches Ad Blitz to Help Push Public Offering, but Critics Aren't Impressed. Wall Street Journal, Sept. 23, 1988.

The World Fact Book, Washington, D.C., Central Intelligence Agency, 1988, pp. 41-42, 245-247.

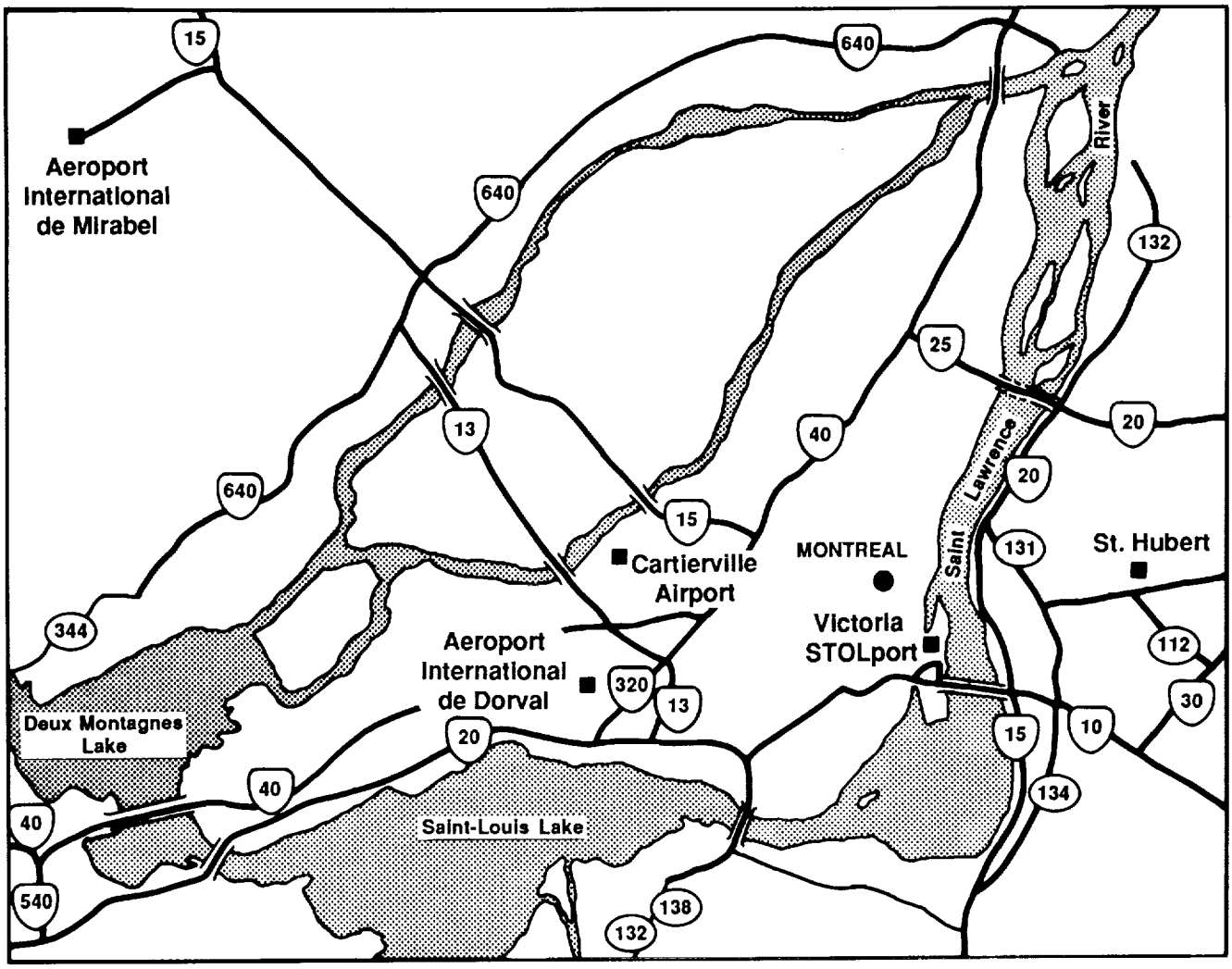
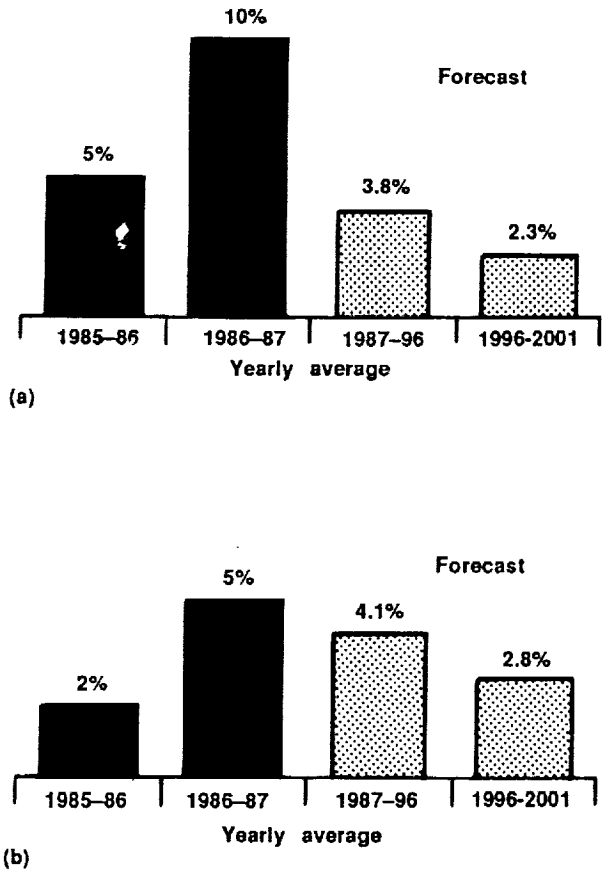


Figure 1. The greater Montréal area, showing airport locations.



Source: Transport Canada Statistics

Figure 2. Increase in traffic at Dorval International Airport, 1985 to 2001. (a) Percent increase in aircraft movements; (b) percent increase in passenger volume.

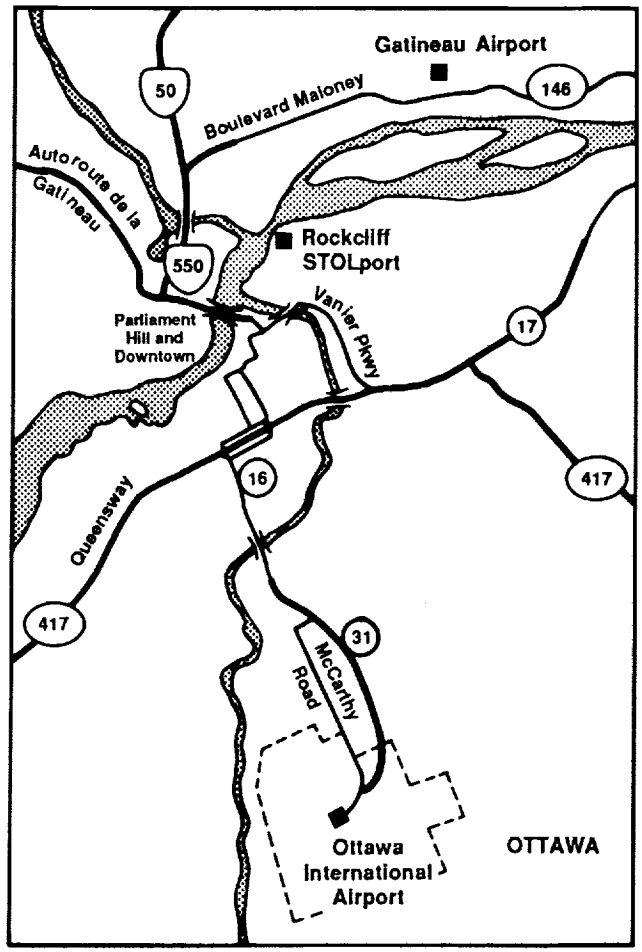


Figure 3. The Ottawa area, showing airport locations.

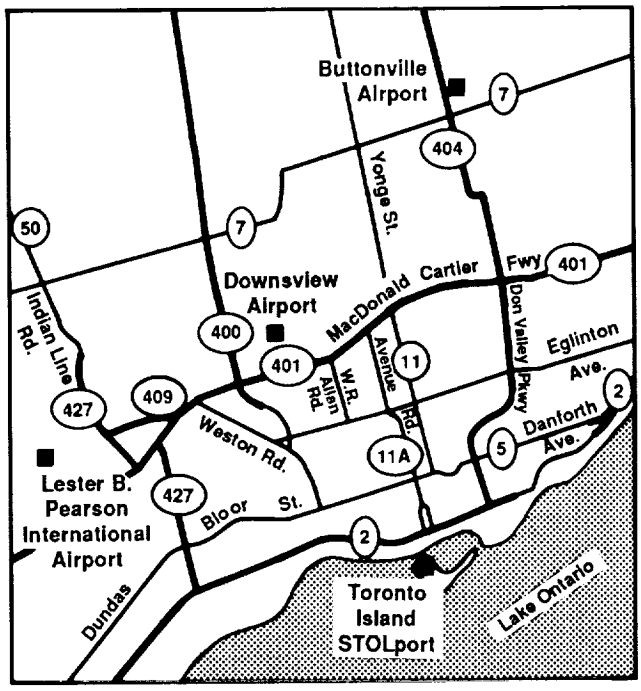


Figure 4. The Toronto area, showing airport locations.

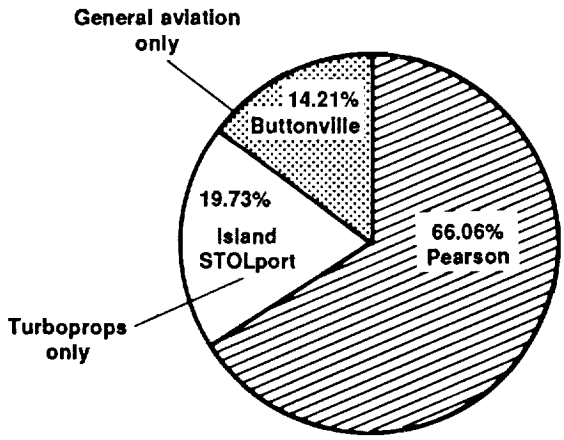


Figure 5. Percent of 1987 aircraft movements at Toronto's three airports.

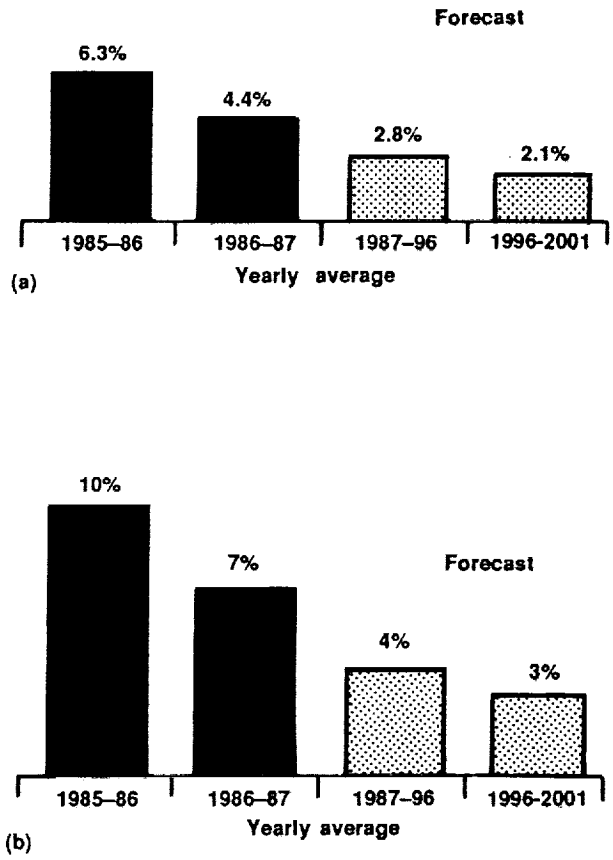


Figure 6. Increase in traffic at Pearson International Airport. (a) Percent increase in aircraft movements; (b) Percent increase in passenger volume.

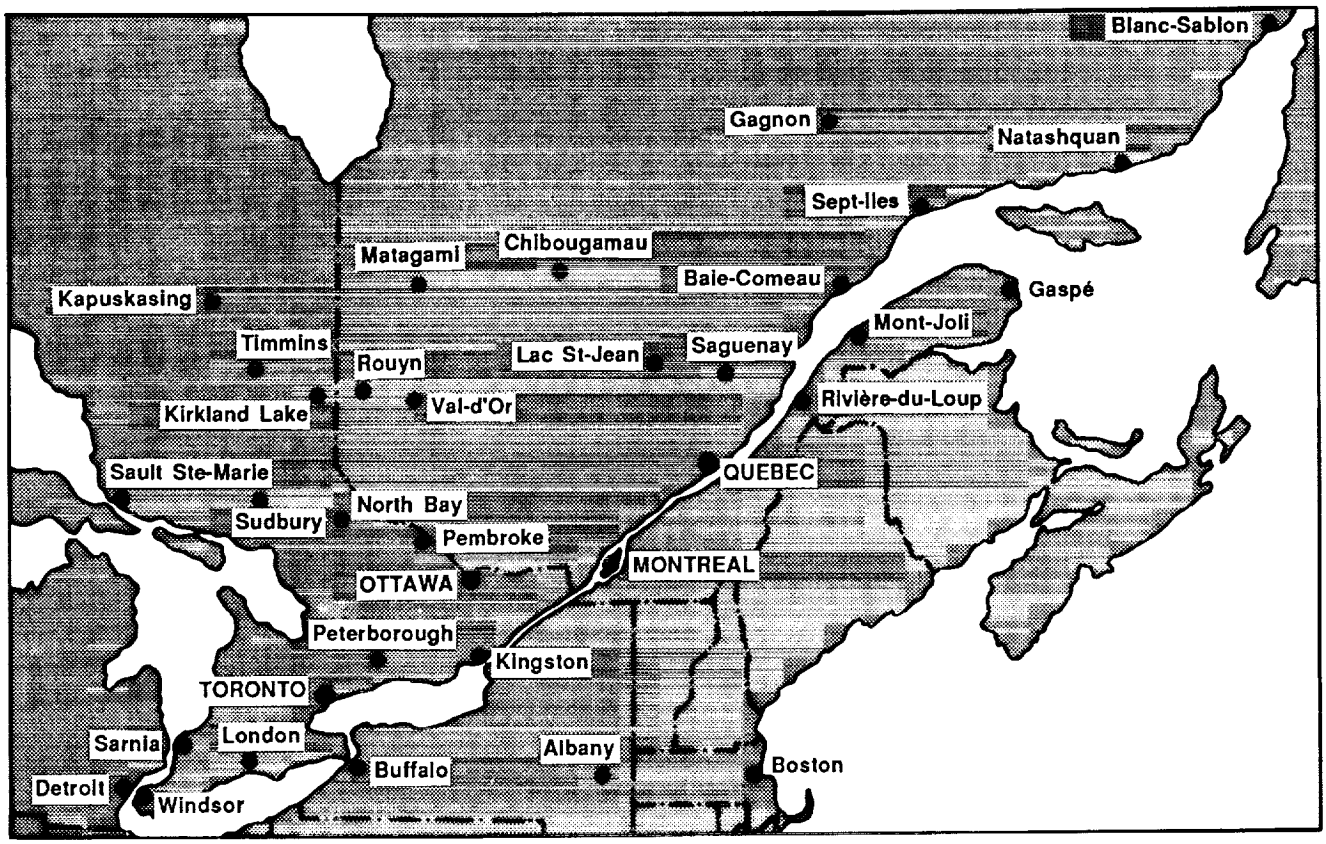
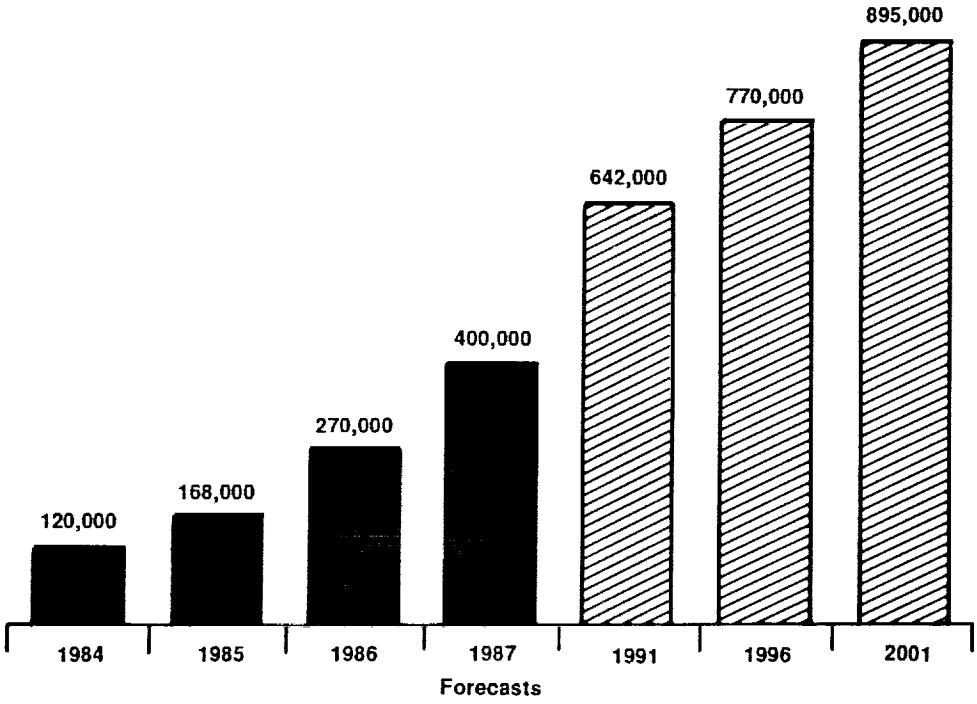


Figure 7. The Montreal–Ottawa–Toronto region.



Sources: Toronto Island Airport Statistics; Transport Canada Statistics

Figure 8. Passenger volume of City Express Airline.

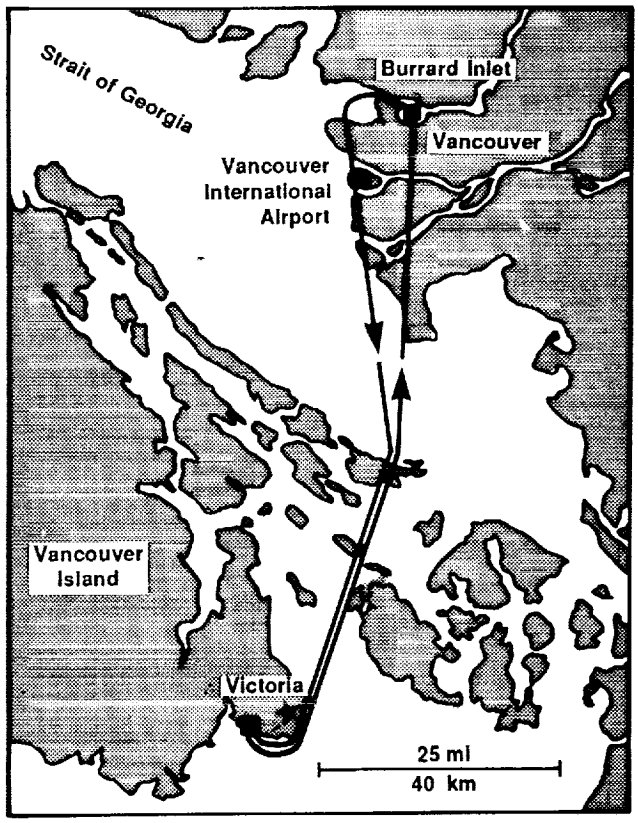
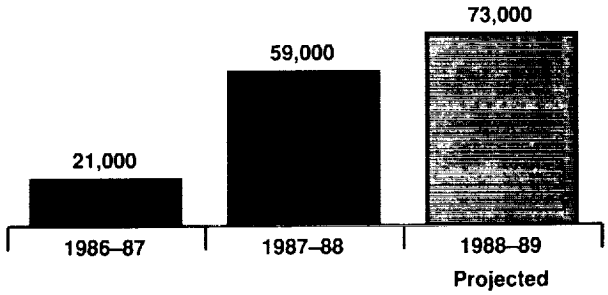
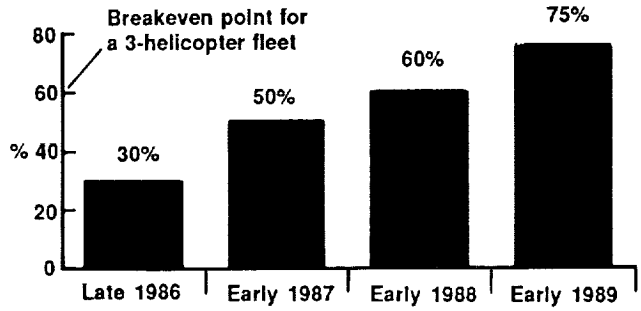


Figure 9. The Vancouver–Victoria area and Helijet Airways flightpath.



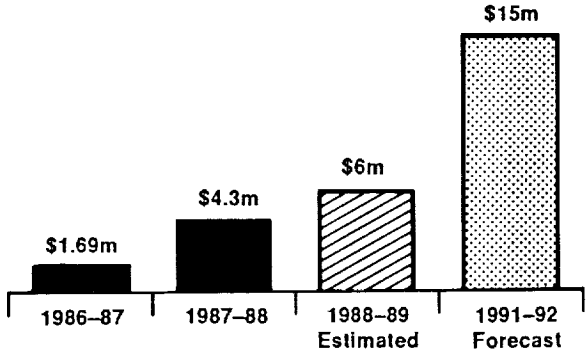
Source: Canadian Aviation, January 1989

Figure 10. Passenger volume for Helijet Airways.



Sources: Helicopter World, Jan-Mar 1989
Professional Pilot, January 1989

Figure 11. Passenger load factors for Helijet Airways.



Sources: Canadian Aviation, January 1989
Helicopter World, Jan-Mar 1989

Figure 12. Revenues for Helijet Airways.

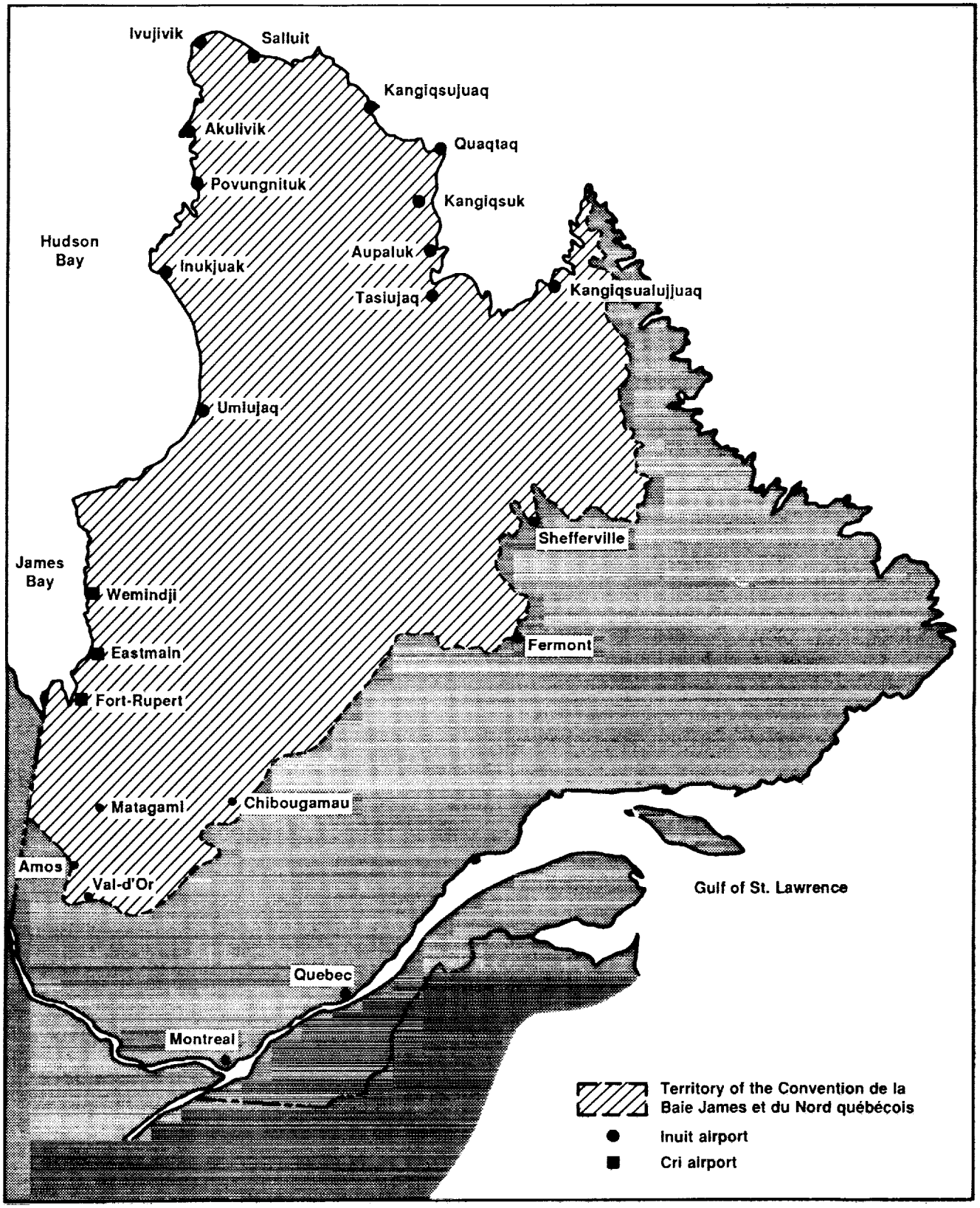


Figure 13. Settlements of northern Quebec.

NASA
National Aeronautics and Space Administration

Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM-102245		

4. Title and Subtitle	5. Report Date
Potential Use of Tiltrotor Aircraft in Canadian Aviation	December 1990
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Denyse Gazdag (Versatec, Inc., Santa Clara, California), and Larry Alton	A-89269
	10. Work Unit No. 505-69-51

9. Performing Organization Name and Address	11. Contract or Grant No.
Ames Research Center Moffett Field, CA 94035-1000	
	13. Type of Report and Period Covered Technical Memorandum

12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code
National Aeronautics and Space Administration Washington, DC 20546-0001	

15. Supplementary Notes

Point of Contact: Larry Alton, Ames Research Center, MS 237-11, Moffett Field, CA 94035-1000
(415) 604-5887 or FTS 464-5887

16. Abstract

This paper describes the aviation system in Canada as it relates to the potential applicability of tiltrotor technology. Commuter service in two corridors, the Vancouver–Victoria route on the west coast and the heavily traveled Montréal–Toronto corridor in eastern Canada, are examined. The operation of air service from the near-downtown Toronto STOLport and from the Vancouver–Victoria downtown heliport facilities is described. The emergency medical services, search and rescue, and natural resources development sectors are described with regard to the needs that tiltrotor technology could uniquely meet in these areas. The airport construction program in isolated communities of northern Québec and possible tiltrotor service in northern regions are reviewed. The federal and provincial governments' financial support policy regarding the aeronautical industry is to encourage the establishment and expansion of businesses in the field of aeronautics and to make possible the acquisition of new technology. This policy has implications for the tiltrotor program.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Tiltrotor applications Helicopter service STOLport commuter service	Unclassified-Unlimited Subject Category - 03

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	38	A03

NASA FORM 1626 OCT 86

For sale by the National Technical Information Service, Springfield, Virginia 22161