CANADIAN TRANSPORT COMMISSION
RESEARCH BRANCH

# INTERCITY PASSENGER TRANSPORT STUDY

SEPTEMBER 1970

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## INTERCITY PASSENGER TRANSPORT STUDY

A study of passenger transport in the urbanized corridor between Windsor, Ontario and Quebec City, P.Q. with a comparison of alternate strategies in the Montreal-Ottawa-Toronto portion of this corridor.

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# SUMMARY


The purpose of this study is to provide a preliminary evaluation of the potential application of new technology to intercity passenger travel in Canada and to identify those technologies where further research and development seems justified. Special emphasis is placed on the travel requirements of the Montreal/Toronto/Ottawa Corridor.

Technological and cost characteristics for several innovative modes of transportation including short take off and landing aircraft, tracked air cushion vehicles and new forms of high-speed rail transport are compared with existing technologies for conventional air, rail and bus services.

The study presents information on present travel patterns and population characteristics of the region. Data on travel patterns and factors influencing modal choice, collected as part of an origin/destination survey conducted during the Summer of 1969, are summarized and form the basis of travel forecasts which are developed in the report. A mathematical model is also developed which can be used to forecast travel demand for different modes of transportation on the basis of estimates of population and income growth as well as the service characteristics (such as cost, time and frequency of service) of available modes of transportation.

Six different development strategies are then compared in terms of the revenues, costs and traffic volumes associated with each over a twenty year time period. These strategies include present technology with minor modifications, three different high-speed rail technologies involving successive reductions in total running time between Toronto and Montreal through the introduction of Turbo type equipment and major track improvements, a strategy involving the use of short take off aircraft and finally the development of a tracked air cushion vehicle system. These strategies are subjected to an economic evaluation in which the contribution that each strategy makes to the overall financial profitability of the entire intercity passenger system is compared to the present technology strategy.

Based on this financial analysis, the major conclusion of the study is that the most profitable strategy to adopt involves maximizing the potential of existing railway facilities through the introduction of new vehicle technology such as the Turbo train. Heavy capital expenditures to improve the existing track structure do not appear to be justified on financial grounds.

However, considering other objectives such as regional development or the development of export oriented industry, short take off and landing systems and tracked air cushion vehicle systems are two strategies which stand out as worthy of further research and consideration, though each involves relatively small financial losses over the 20 year study period. Suggestions are included for further research and refinements of the present analysis.

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**INTERCITY PASSENGER TRANSPORTATION STUDY**

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# CONTENTS

# 1 INTRODUCTION

## 1.1 Objectives

The primary objective of this study is to identify intercity passenger transport technologies which have the greatest potential for application on the Canadian scene. Working on the assumption that the probability of new technologies becoming commercially viable is highest where the market is greatest, this evaluation has been carried out in the highest density corridor of the country between Quebec City and Windsor, Ontario and specifically has concentrated on the intercity passenger travel requirements of the Montreal, Ottawa, Toronto corridor. By forecasting demand and assessing performance of different forms of technology the objective has been to identify those technologies which look most promising and which should be the focus of further research and development.

## 1.2 The Canadian Corridor

Rapid urbanization is common throughout the world. In some areas cities have expanded and grown together to form an almost continuous urbanized region for which the word megalopolis has been coined. In such situations, cities become less independent and their interaction with one another creates a complex congestion problem.

Transport in these growing megalopoles has been the subject of several studies the most notable of which has been the U.S. North East Corridor Study. Other studies have been carried out for the California Corridor, for the London Northwest Corridor in Great Britain, for the Rhine-Ruhr Corridor in Germany and for the Tokyo-Osaka Corridor in Japan. In fact, the construction of the New Tokaido Line in Japan is a good example of new transportation facilities specifically designed to meet the megalopolitan transportation demand.

In Canada, urban growth is also taking place at a fast rate but the combination of wide spacing of cities and relatively low population density has thus far not resulted in the situation described above. An examination of population distribution in Canada however, shows the nucleus of an urbanized Corridor extending 715 miles from Quebec City to Windsor,[1] Ontario containing almost half the nation's population. It is intercity travel in this Corridor that is the primary subject of this study.

The much lower density of the Canadian Corridor is immediately apparent from a comparison with three other urbanized Corridors shown in Figure 1.1. Here Corridor length is shown to scale whereas population is proportional to the diameter of the circles. Note, as shown in Table 1.1, that the ratio of population per linear mile in the Canadian Corridor is less than one-seventh that of the U.S.A. Northeast Corridor. Within the Canadian Corridor

**Table 1.1 Size Comparison of Urbanized Corridors**

| Corridor | Length (Miles) | Approximate Population (millions) | Population/ linear mile |
|---|---|---|---|
| Canada (Windsor-Quebec) | 715 | 10 | 14,000 |
| Canada (Montreal-Toronto) | 325 | 6 | 18,000 |
| USA (Northeast) | 450 | 45 | 100,000 |
| Japan (Tokyo-Osaka) | 370 | 35 | 95,000 |
| U.K. (London-Northwest) | 200 | 20 | 100,000 |

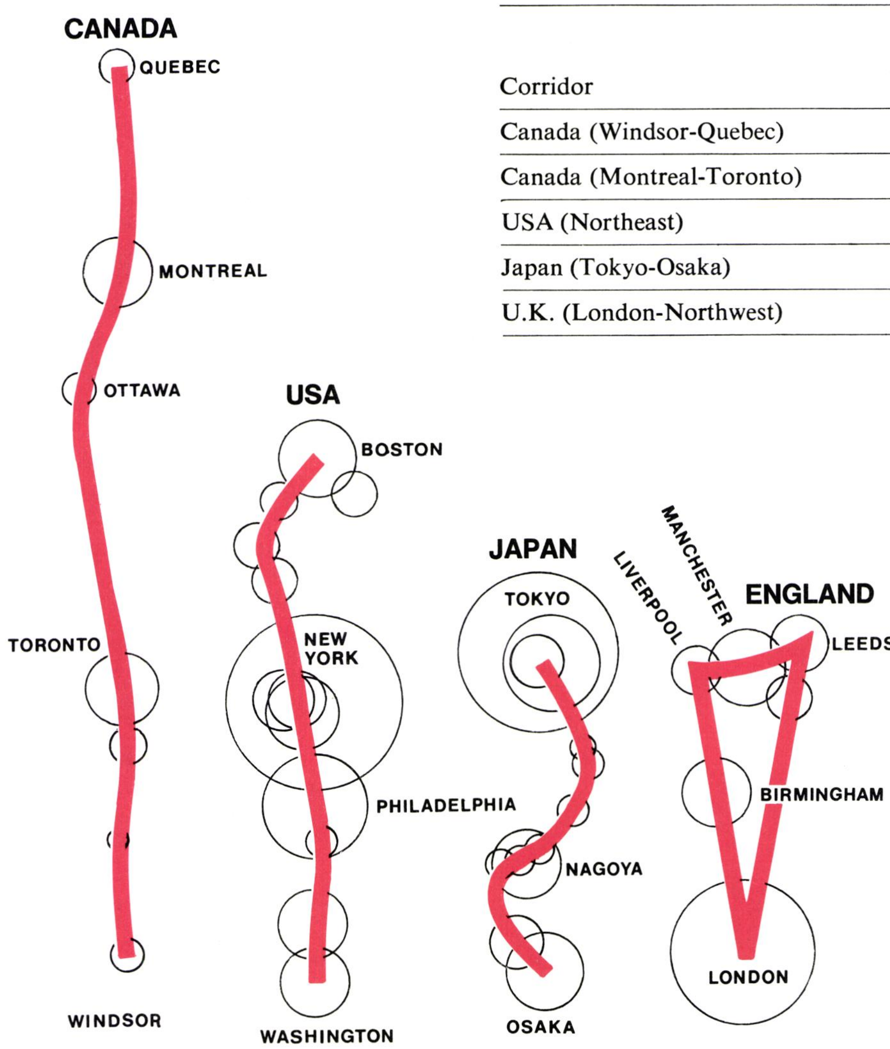



**Figure 1.1 A comparison of intercity corridors (length and population are to scale).**

[1] Although the Detroit area is at the end of the corridor, there is little interaction across the international border and the area is not included as part of the corridor.

however, the route mile density between Montreal, Toronto and Ottawa is appreciably higher.

This low ratio of population/linear mile explains why the Canadian Corridor has not experienced the congestion and ensuing intercity travel restraints that have characterized other corridors. Furthermore, an examination of intercity travel trends together with future plans for transport facilities such as airport expansion at Toronto and Montreal as well as provincial highways indicates that the capacities of all modes should keep ahead of demand well into the future. Thus, this initial study of intercity travel can take a broad look at all aspects of intercity travel without the pressure of immediate problems with their requirement for short term action, which, for example, have tended to dominate the U.S. Northeast Corridor Study. However, there is a limit as to how broad a field or how far ahead this initial study can explore. It is necessary to be able to evaluate technical and economic aspects of transport modes, and this can only be achieved realistically for a limited time frame. Hence this study has been set to cover the twenty year time period from 1970 to 1990.

A study of intercity travel should of course consider a wide range of related topics such as the substitution of communications for transportation, impact of transportation on regional development, the special transportation requirements of the poor and handicapped, noise and air pollution, and the effects of transportation on ecology. While some of these topics are briefly discussed in this report, the primary scope of the work has been concerned with the technology and economics of intercity travel.

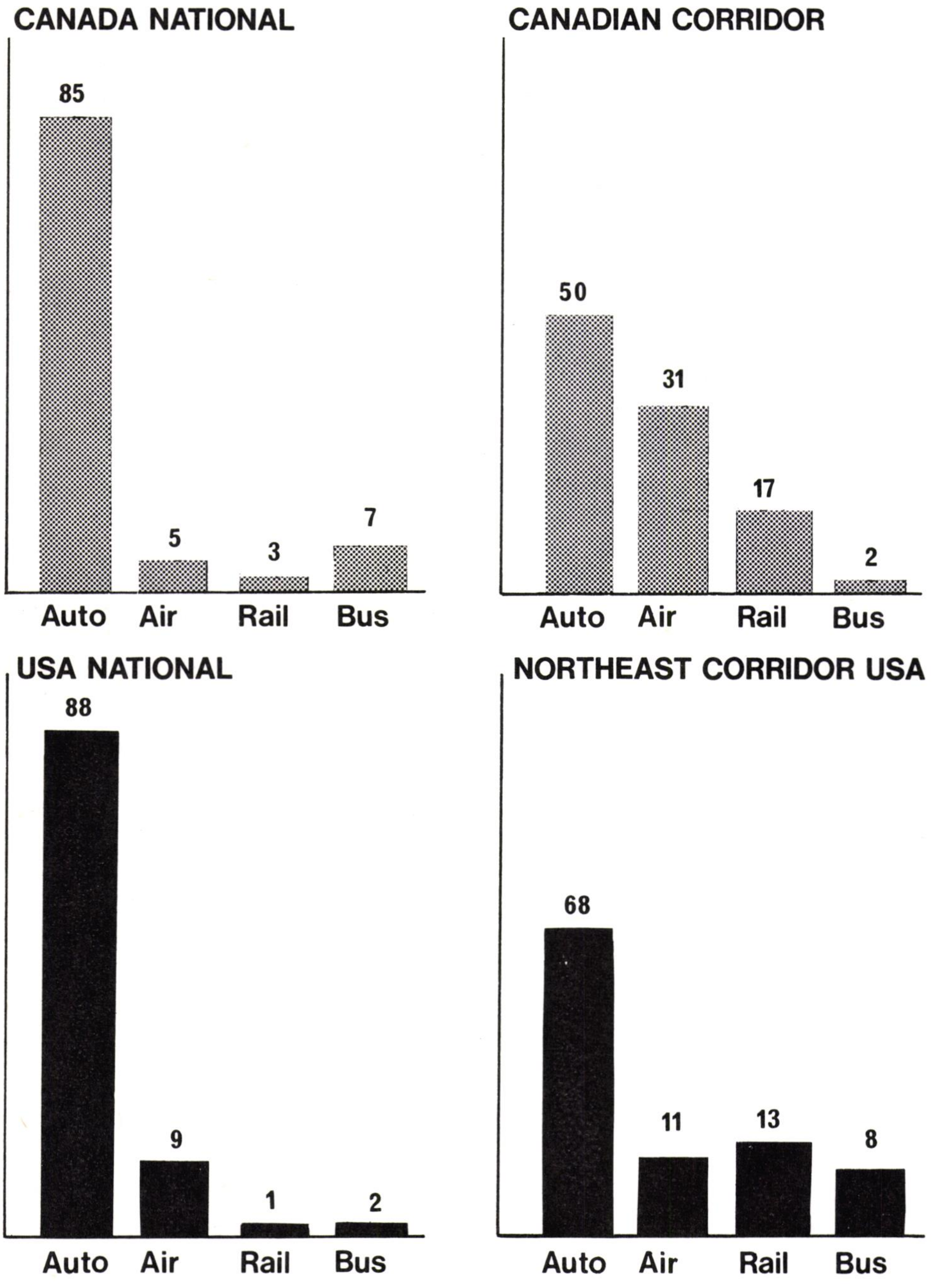



**Figure 1.2** **A comparison of modal splits. Percentage by each mode, nationwide and in an urbanized corridor for Canada and the USA.**

Having identified certain technologies which look most promising, it is suggested that work in these other areas should also be initiated with respect to those technologies.

In addition, while the study deals with intercity travel in the Corridor region, such travel obviously cannot be entirely divorced from considerations of transportation problems within cities since in certain cases as much time, and as much cost is incurred in getting into or out of a city as in making the trip between cities. This is particularly true in the case of intercity air travel where the problem of airport access is becoming increasingly more difficult. It is expected that subsequent work in this area would consider more closely the question of interaction between urban and intercity transportation systems.

Finally, there is a question of the relevance of this study of intercity travel in the corridor to other intercity travel in Canada. Intercity travel in the corridor differs from travel outside the corridor in that the common carriers capture a significantly higher percentage of the market as shown in Figure 1.2. This is due partly to the higher proportion of business travel—which is less price sensitive—and partly due to the greater volumes of travel which permit the common carriers to offer reasonably frequent service. Hence, the extension of this study to intercity travel outside the corridor must be carefully qualified.

## 1.3 The Corridor Study

Figure 1.3 shows the main components of the Corridor Study. The principal work path is labeled (A) and involved a survey of existing work, the development and calibration of models to predict intercity volumes and the modal split of these volumes. These models were then used to predict travel volumes for a series of alternative development "strategies" designed to test the feasibility of various new technologies. In the final stage, the performance of these strategies was evaluated.

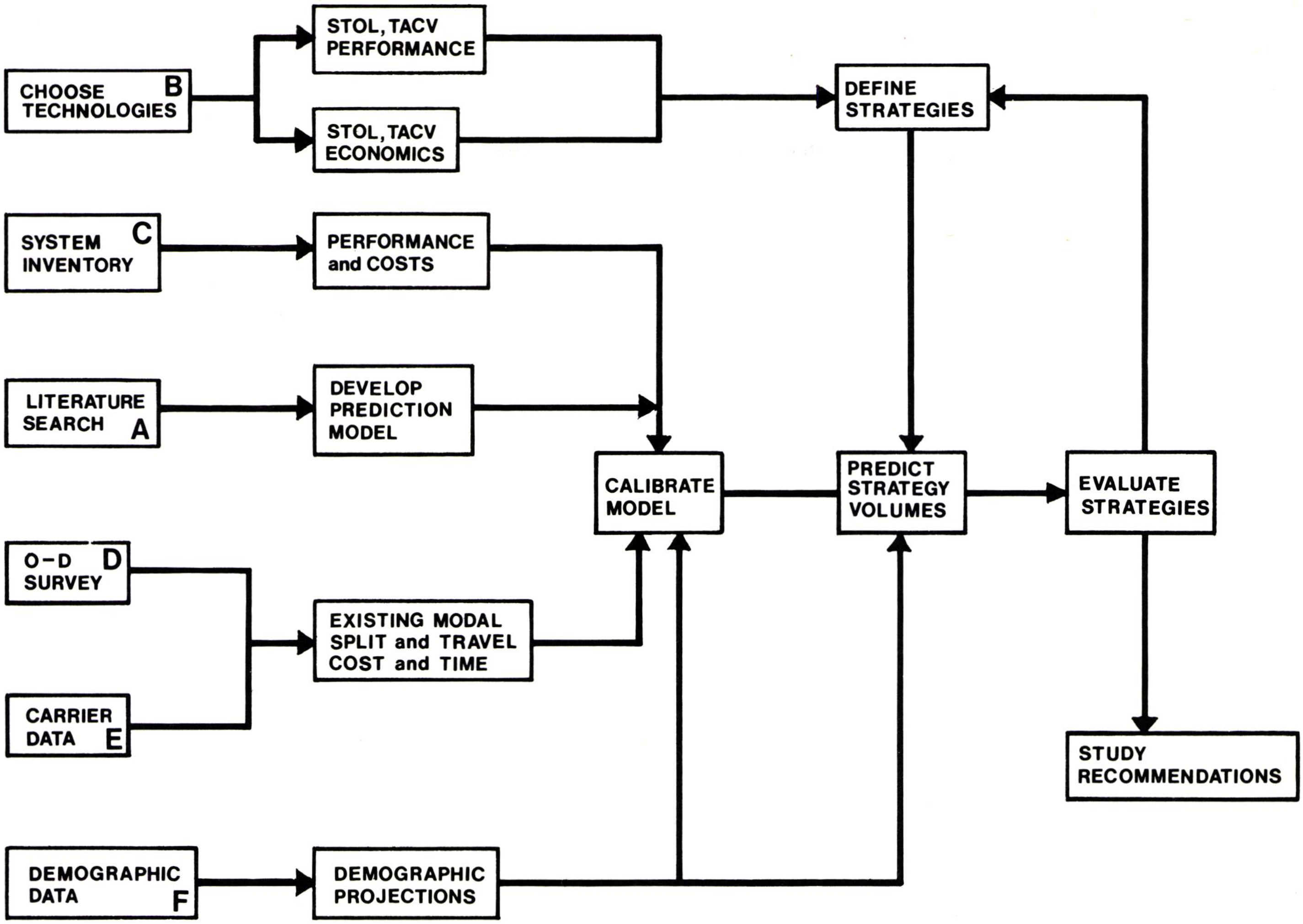



**Figure 1.3 Work flow chart for the Intercity Passenger Transport Study.**

Five other inputs to the study were developed concurrently.

(B) **Technology**—An investigation was made of a wide range of new technologies; many concepts were discarded while the more applicable ones were studied in depth with respect to their performance characteristics, physical requirements, and development time scale costs. This input was used to define and later to help evaluate the strategies.

(C) **System Inventory**—In conjunction with the examination of new technology, data was obtained on the performance and cost of existing transport modes in the Corridor. Certain items such as travel times, fares, and frequency were easily obtained but direct and indirect operating costs of each mode were difficult to determine in a comparable form.

(D) **Origin Destination Survey**—Existing data on modal travel volumes was available from the various carriers and the Department of Highways, Ontario. However, this data was not sufficiently detailed to obtain a complete picture of intercity travel and it was necessary to carry out an origin-destination survey. Limitations on time and effort restricted the survey to common carriers on four intercity links between Quebec City, Montreal, Ottawa and Toronto. A self-administered questionnaire was developed and some 90,000 travellers were surveyed during an eight week period in summer 1969. The resulting 50,000 responses were coded and analyzed. As well as basic O-D information, details were obtained on the traveler's residence, age, sex, income and linguistic characteristics, along with details on the mode, cost and travel time to the specific terminal, and the time spent waiting in terminals. A description of this O-D survey with a copy of the questionnaire is contained in Appendix 1.

(E) **Carrier Data**—Passenger flows were obtained for each mode from the respective carrier and were used in conjunction with the O-D survey results to obtain existing modal splits. These, along with travel costs and travel times (including access and wait times obtained from the survey), served to calibrate the demand model.

(F) **Demographic Data**—Projections of future population and income distribution were made from data provided by Federal, Provincial and Municipal sources. The study also examined social attitudes to travel, characteristics of users, telephone use and its relation to intercity travel, and the linguistic distribution of population and its effect on travel.

These various inputs were combined to calibrate the analytic models, and thus to predict the passenger volumes and modal splits for each alternative development strategy. Each strategy was then evaluated and compared with the present transport system for a range of economic conditions. This procedure is detailed in Chapter 6. Study recommendations were developed from these strategy comparisons and are summarized in Chapter 7.

# 2 TECHNOLOGICAL EVALUATION

## 2.1 Introduction

This section deals initially with an examination of new technology that might be used in the corridor and secondly with possible changes in the technology of existing modes. For both new and improved technologies, it is necessary to obtain details of development and implementation costs, direct and indirect operating costs, time scale for implementation, passenger capacities and point to point travel times.

This data is then used to determine the share of the travel market a new mode would obtain. However, for an initial evaluation of technology it is adequate merely to estimate the magnitude of the travel market between major city pairs of the corridor, and determine whether a system can supply this market within reasonable cost restraints. Systems that appear feasible are then studied in detail and fed into the analysis through a continual feedback path where the estimated cost per trip provides a modal split volume which in turn revises the cost per trip. Systems or concepts which were examined initially are listed as follows:

**Highways**—There have been a number of proposals to obtain greater safety, greater capacity and higher speeds from expressways by introducing automatic control. Buried electrical wires in the pavement would serve to both steer vehicles and control their speed and spacing. Successful experiments have been demonstrated in the U.S.A. in automatically controlling both cars and buses.

However, the immense cost and logistics involved in instituting an automated highway places such a scheme beyond the 20 year time frame of this study.

A less complex approach for increasing highway speeds is the restricted access expressway. Only vehicles built and maintained to a specific standard and operated by drivers with an advanced driving licence (subject to periodic medical and driving ability checks) would be permitted access. Speed limits could be raised to 90 or 100 mile/hr. Entrance to the expressway would involve a checkpoint at which the condition of both vehicles and drivers would be monitored. Restricted access expressways would be most applicable between cities where existing expressways are congested and duplicate facilities are needed. They do not seem appropriate for the Canadian Corridor within the study time frame. Less major technical innovations in highway travel are discussed in Section 2.2.

**Guided Ground Transport**—Relative to their cost monorails do not offer adequate speed or any other advantage for intercity travel, and are not considered. The very high speed concepts such as the Edwards Gravity Vacuum Tube or the Foa Jet Propulsion Tube could be developed to an implementation stage within the study period but there are numerous unresolved technical problems, which together with the indicated high costs and capacities beyond the corridor requirements, eliminate these concepts from further consideration. Tracked Air Cushion Vehicles with speed capabilities up to 250 miles/hr. and high speed rail operations are discussed in Sections 2.4 and 2.5.

**Air Transport**—Advances in conventional aircraft and short take off and landing aircraft (STOL) are discussed in Section 2.6. Vertical take off and landing aircraft (VTOL) were eliminated from consideration after discussion. Although VTOL aircraft are in military use, the development of a commercial unit capable of adequate speed and economic operation over the stage lengths in the Corridor is considered doubtful within the 20 year study period. In addition, such aircraft would have to serve city centres directly to provide advantages over conventional air services and would create problems with their high noise levels.

The following sections discuss by mode, specific aspects of transport technology that have been selected as relevant to the Canadian Corridor in the twenty year time frame. The costs of implementing and operating new technology are discussed relative to present-day operating costs. However, most details of present transport operation, including fares, schedule time and operating costs are contained in Chapter 3.

## 2.2 Automobile

The automobile is the dominant mode in intercity travel. For Canada as a whole, some 85% of all intercity trips are by car while in the corridor just over half of such trips are by car. (Refer to Figure 1.2) This dominance will continue over the period of the study as the car provides a flexibility and convenience unmatched by any public carrier and in most situations at lower cost per passenger mile. While the car is more convenient over the shorter intercity distances, its competitive ability with the public carriers is a function of cost, travel time, convenience and to a lesser extent of safety.

Anticipated changes in automobile travel over the 20-year time period consists of three items:

(1) **Cost**—The trend over the past decade has been a small annual decrease in operating cost in terms of constant dollars. (*2*) A tapering off in this trend, or possible reverse can be expected due to the advent of pollution control and manatory safety features which tend to increase both gas consumption and purchase prices.

(2) **Speed**—The past decade has seen an annual increase in average intercity speeds of approximately 0.5 mile/h., to values in the high fifties. (*2*) This has been due to improvements in the highway network, (particularly the construction of expressways) and to automobiles with larger engines and safer high speed characteristics.

Intercity average speeds are now approaching legal speed limits and in conjunction with increasing urban congestion and only minor improvements in the already well developed intercity highway network, this trend to increased speeds will taper off. There will, however, be significant improvement in certain city links, with the completion of all planned expressways. There is also the possibility that certain legal speed limits will be increased.

(3) **Safety**—The present complacency about deaths, injuries and property damage resulting from motor vehicle accidents appears unlikely to change. However, more and more legislation in this field is leading to improved safety in both highway and automobile design. Less popular safety measures such as tighter

control of driving privileges and a thorough periodic vehicle inspection can be expected to be introduced within the study time frame. While it can be expected that as a result of the above changes, accident rates should continue to decrease, it is not expected that such a trend would materially affect automobile usage for intercity movements. Technical changes are not expected to have much impact on motor vehicles. Propulsion by steam, electricity or gas turbines is unlikely to appear in private vehicles suitable for intercity travel. Automated highways have already been discounted but improvements in traffic control can be expected.

## 2.3 Buses

Intercity bus travel is provided in the corridor by a small number of major companies with numerous small companies operating local or connecting services. The major bus companies work together and in conjunction with other Canadian and U.S. carriers to provide through buses to many points in North America, and also to provide a considerable volume of charter services. The trend is to provide express intercity services but local services remain between small communities and providing the only common carrier service to the many places no longer served by trains and not capable of supporting air service.

Modern intercity buses have reached an advanced state of development. Up to 40 feet long and 8½ feet wide, they tend to the maximum size permitted on highways often equipped with three axles and power up to 400 brake horsepower from a V-12 diesel engine. Express intercity buses are noted for their ability to reach and maintain the 70 mile/h. speed limit on expressways. Passenger accommodations vary from 38 to 53 seats and include air conditioning, reclining seats and a washroom, at the expense of some seats.

The bus network in the corridor is described in Section 3.1. Operating costs average 1.84¢/seat mile, made up of 0.90¢ in direct costs and 0.94¢ in indirect costs. The labour content of these costs is high and hence the trend of decreasing costs for automobiles will not apply to buses. Their costs will increase with wage rates. However buses will share with cars any improvements to the highway network and the major routes.

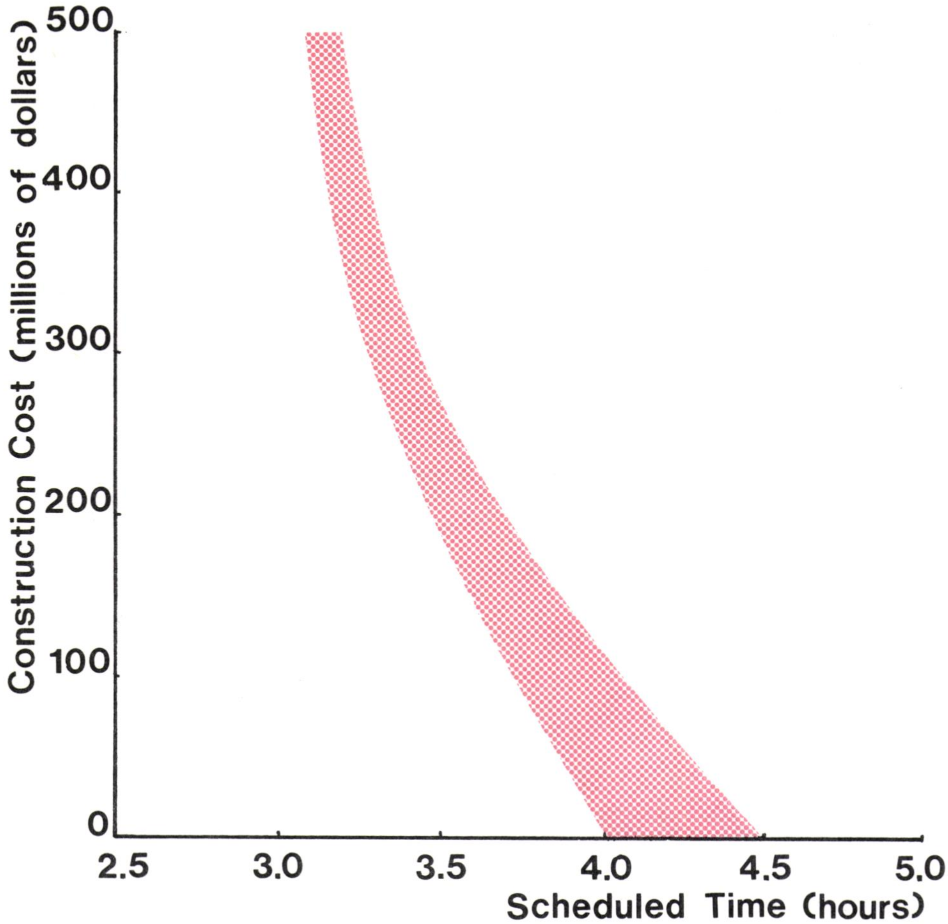



**Figure 2.1** **Cost of railroad track improvements for higher speed operation between Montreal and Toronto.**

New technology is not expected to have any significant impact on intercity buses. Gas turbine engines have been successfully demonstrated on intercity buses and should appear in production models within 3 to 5 years. They provide more power with less pollution and lower noise at cruising speeds, but at a penalty of higher first cost and increased fuel consumption. There is some incentive to increase bus capacity and hence reduce labour costs per passenger mile. Articulated buses are common in some European cities and AC-Transit in California has an experimental articulated bus for commuter service. However, the suitability of such units for intercity service is questionable. One of the advantages of the 40-50 seat bus is both its low cost (around $60,000) and the flexibility of this unit size which permits the operator to match the number of seats to the passengers, particularly on busy routes where a scheduled bus may have many "sections".

Intercity bus operators have a justifiable reputation for efficiently promoting and serving their part of the travel market. Chapter 6 of this report indicates that whatever strategies are developed in intercity travel, buses will maintain a significant portion of the market (about 5%) which will grow as the population grows. One trend will be to improve the image of bus travel with better terminals and more comfortable buses.

## 2.4 Railroads

Present-day railroad technology is the result of many decades of cautious development with a result that trains in the Corridor operate with good reliability at schedule speeds of 50 to 70 mile/h. Higher speed is one requirement needed to attract more passengers.

Limitations on maximum speed are due to train power to weight ratio, suspension capabilities, adhesive capabilities, track grade and curvature, as well as the need to share tracks with freight and commuter trains. Higher speed trains are operated in several countries. The Japan National Railways operate at up to 150 mile/h, many European intercity services operate at top speeds between 100 and 125 mile/h, while the SNCF (French National Railways) hold the world rail speed record of 205 mile/h.

However many of these limitations can be overcome, power requirements can be readily met, particularly with electric propulsion, and suspensions have been developed for high speed operation. Rail adhesion can be controlled by chemical or plasma arc cleaning, although in general, rail adhesion is not a critical problem for the speeds in question (*15*). The problem in many intercity services both in Canada and abroad is track curvature and the ensuing speed restrictions.

Theoretically, any curve can be superelevated to permit operation at any particular speed without creating any overbalancing forces. However, such superelevation is only for that "particular speed" and with slower freight trains using the same track, together with the ever present possibility of an unscheduled stop on superelevated track, there is a practical limit to superelevation of 6 to 8 inches. This still provides severe speed restrictions on sharper curves. Two solutions to higher speeds remain: one is simply to remove or reduce curves by building new alignments; the other to arrange for the train to tilt on curves and so effectively increase the superelevation. This latter concept is employed on the Turbo-trains now operating on the Corridor between Toronto and Montreal and will be used on the Advanced Passenger Train (APT) under development by British Railways. In all cases of higher speed operation, it becomes desirable to eliminate grade crossings and fence the track from trespass, whether by animals or people.

Figure 2.1 shows the estimated cost of track improvements required to decrease schedule times between Montreal and Toronto. The width of the band represents performance differences between various types of equipment. With no investment in trackage, conventional equipment with a high power-to-weight ratio can maintain a 4½-hour schedule while Turbotrains now operate on a 4-hour schedule. Construction costs are based on data provided by the CNR and allow for incremental improvement by relocation, track strengthening, grade separation, fencing and signalling. These improvements are costed on the basis of a 135 mile/h maximum speed. In certain locations, this is achieved by the reconstruction of existing lines while entirely new construction is required in other sections. A third track for exclusive use of passenger trains could be constructed over 40% of the route at the same cost as reconstruction of the existing lines to the same standard.

The 500-million dollar maximum shown on Figure 2.1 involves reconstruction of the entire 335 miles from Montreal to Toronto to a 135 mile/h standard. This curve cannot be extrapolated upwards as it is possible that the incremental cost of going to still higher speed on certain sections may be relatively low. In this case, the curve would tend to flatten, until speed is sufficiently high to require an entirely different track structure.

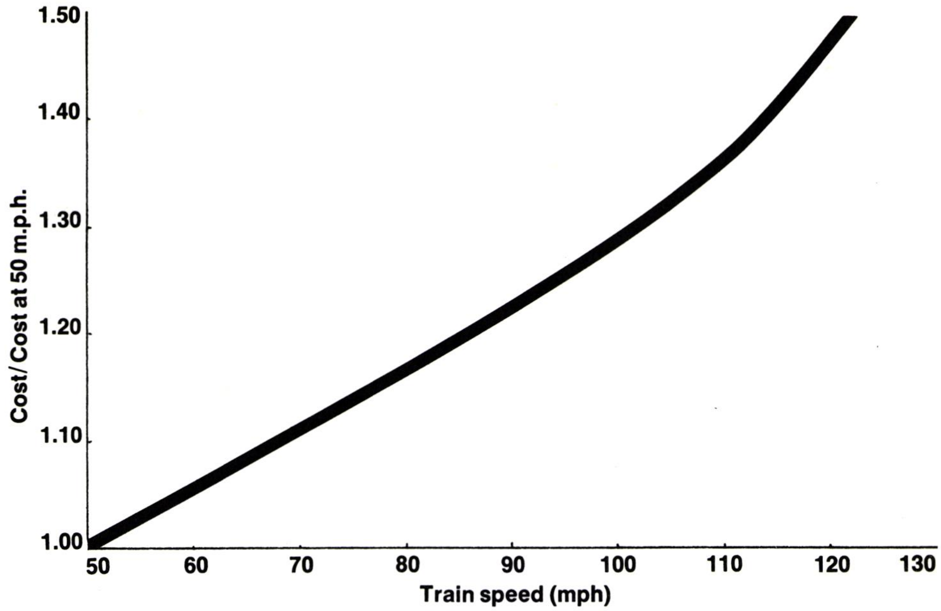



**Figure 2.2 Increase of railroad track maintenance costs due to increasing speed.**

In addition to the initial construction costs required for high-speed services, maintenance costs are also increased. While the effect of train speed on track maintenance costs is not well understood, Figure 2.2 illustrates the speed-maintenance cost relationship used by British Rail (*14*), based on the assumption that maintenance cost is directly related to stresses produced in rails at different speeds.

Modern track structure uses continuously welded rail (cwr) on wood crossties or concrete crossties where these are competitive with wood ties. The advantages of this conventional track structure are the ease of alignment and relatively low installation and maintenance costs, using highly mechanized procedures. However with higher dynamic loadings from the accelerated freight and passenger trains, a more stable track structure appears to have advantages. Work on advanced track structures (*5*) has produced several concepts of stiffer roadbeds using a continuously laid concrete slab. It is not clear whether these alternatives are economically viable. Work on track structures is continuing in the U.S.A., Europe and Japan, and it is anticipated that the newly formed Canadian Institute of Guided Ground Transport at Queen's University, Kingston, will become involved in this field.

A large part of the cost of providing rail services is unaffected by small changes in the scale of operation. For example, on a line such as the CNR Montreal-Toronto mainline, train control costs would not be reduced if fewer passenger trains were operated. Hence for the purposes of this study, costing was limited to only those elements of cost which would be affected by addition or removal of specific services. This class of costs is commonly referred to as "avoidable" operating costs.

The following elements of operating cost were estimated for conventional and Turbotrain equipment:

fuel
crew wages
benefits and overhead on crew wages
equipment maintenance
equipment cleaning
depreciation of train equipment
interest on equipment investment
train supplies
switching

CNR provided output from a train simulation program as a basis for estimates of fuel consumption and schedule times. Crew wages were based on current operating agreements while data for remaining costs was drawn from a number of sources in the operating industry and from published data.

A 20-year depreciation period was used for conventional train equipment (both locomotives and cars) with Turbo equipment depreciated over 15 years. One-half of the expenses associated with dining and parlour-car services was assumed to be recovered from revenue other than the basic ticket cost.

Figure 2.3 shows the variation of avoidable operating costs with increasing passenger volume for conventional equipment on the Montreal-Toronto line. At low volume, (the top of the curves) costs are based on a four-car train. The train consist is held fixed until load factor reaches 100 percent, at which point cars are added to give increased capacity and a corresponding increase in unit cost. Each curve represents a lower bound to operating cost for a particular service frequency and actual costs would lie in the area above this envelope, depending on the load factor which is actually achieved. It should be noted that train speed is not a constant in this illustration, but varies with the ratio of train power to weight.

Estimated operating costs for Turbotrain operation are shown in Figure 2.4 for Montreal-Toronto operation. Discontinuities in the cost curves are much greater than for conventional equipment since capacity is increased by addition of full seven-car sets, rather than the incremental addition of single cars.

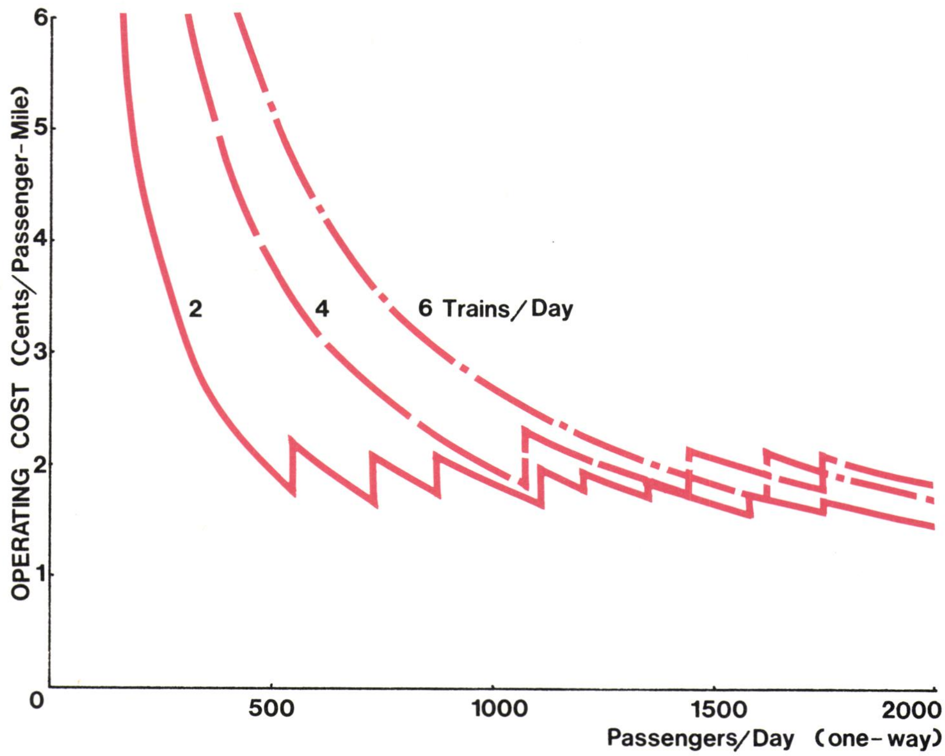



**Figure 2.3** **Operating cost for conventional railroad equipment—Montreal-Toronto, with existing track and existing speed limits.**

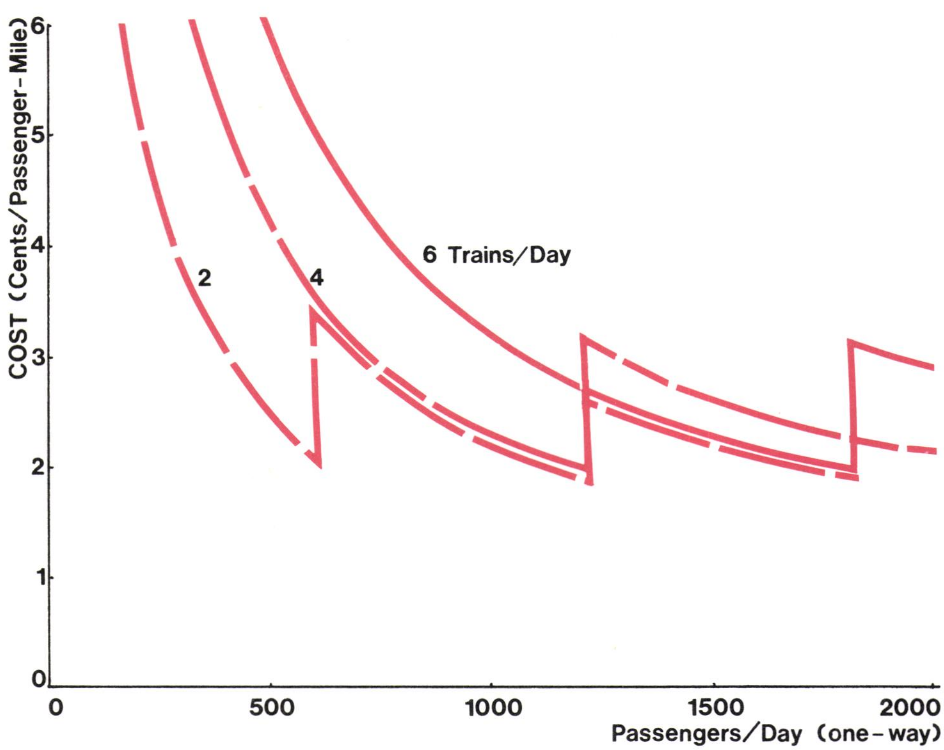



**Figure 2.4** **Operating cost for 7-car Turbotrain sets—Montreal-Toronto, with existing track and existing speed limits.**

## 2.5 Tracked Air Cushion Vehicles

The maximum feasible speed for regular rail operation is limited by the force that can be transferred between steel wheels and steel rails. The exact value of this limiting speed is a point of controversy. Japanese experience suggests that 200 mile/h is the practical upper limit while European railroads indicate that even higher speeds are possible. To attain speeds of this order, an entirely new alignment would be required, costing considerably more than the 1.5 million dollars per mile estimated for 135 mile/h operation between Montreal and Toronto. The high cost involved in a new alignment suggests the feasibility of jumping to a new technology, which is free from the limitations of railroad operation. The most promising ground-transport technology for this jump is the Tracked Air Cushion Vehicle (TACV) concept, a system of high-speed vehicles supported and guided by cushions of air and operating on a fixed guideway. Elimination of physical contact with the guideway permits greater speeds, lower resistance to motion and less noise, while the air cushion itself acts as part of the suspension system and contributes to comfortable riding qualities. The lack of physical contact with the guideway precludes frictional propulsion, requiring propulsion by air thrust or linear electric motors. Both of these propulsion types are less efficient than propulsion by friction. Propellers and jet engines both present a noise problem while the linear motor is a new technology not yet proven at the power and speed requirements of an intercity TACV.

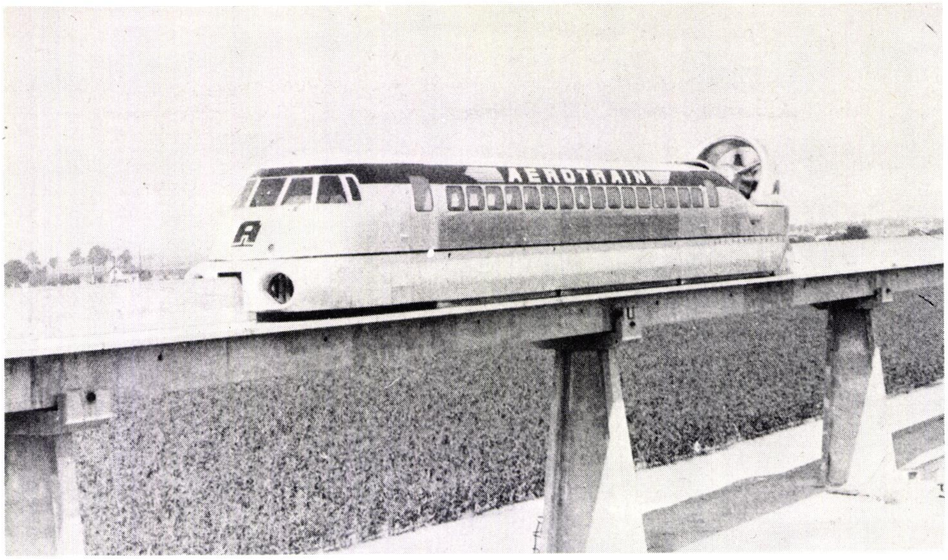


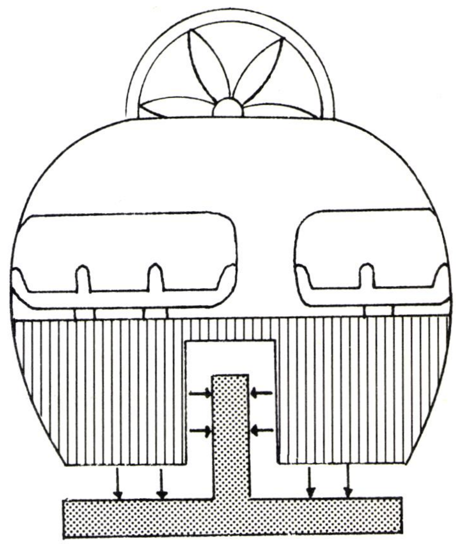
**Figure 2.5 Bertin Aerotrain I-80 vehicle on elevated guideway.**

Development work on TACV's is underway in four countries: France, Britain, the U.S.A. and Japan. Bertin et Cie, a French company, have pioneered the development of the TACV and have built and operated a three-quarter scale and full scale "Aerotrain" utilizing a propeller-driven vehicle on an inverted "T"-shaped guideway. They are now working on linear motor propulsion and have demonstrated a prototype at moderate speeds. The British company, Tracked Hovercraft Limited (THL), have operated scale models with linear motor propulsion and have almost completed a full scale test track. Their system uses vehicles which straddle a box-beam with an aluminum reaction rail for the linear motor attached to the upper surface. Power collection rails are attached to the side surfaces of the box-beam. The U.S. Department of Transport has initiated numerous studies on many aspects of TACV's. They have used both Bertin and THL as consultants and have attempted to tap the U.S. aerospace industry for expertise. Contracts with the Garrett Air Research Company resulted in a study of linear motor technology and the design and construction of a 3000 h.p. linear motor mounted on special railroad trucks. Due to delays in acquiring a test site (the test track is now being built in Pueblo, California), this motor has not been tested at speed. Consultants to the U.S. D.O.T. appear to favour a U-Shaped guideway. The Japanese are relative newcomers to the TACV field and are investigating a linear-motor propelled vehicle for possible application in the congested Tokyo-Osaka Corridor.

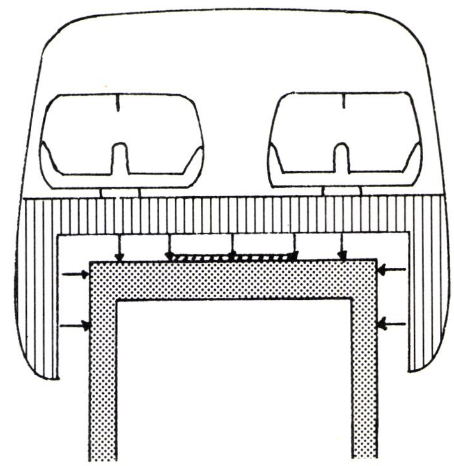
The only TACV system with operating experience is the Bertin I-80 Aerotrain, and hence this first-generation system has been costed for construction and operation between Montreal, Ottawa and Toronto. The I-80 system uses a variable-pitch propeller for propulsion and partial braking and has a maximum speed in the order of 190 mile/h. Bertin claim that vehicles can safely operate at two-minute intervals. With these minimum headways, the system would provide adequate capacity for estimated intercity travel demand into the early 1990's. However, vehicles of the I-80 design cannot be coupled to form trains and consequently the system could not accommodate high-density traffic generated by major airports. This, together with high noise levels and an inflexible track configuration are serious disadvantages of the first-generation system. In addition, there are as yet unresolved problems of vehicle hunting under side winds and operational problems related to Canada's winter climate. These facts, viewed together with the implementation time frame for TACV operation, suggest that a second-generation system using linear motor propulsion would be more appropriate for application in the Toronto-Montreal Corridor.

**The Aerotrain I-80 System** utilizes single-unit vehicles travelling on an inverted-T guideway. Four air cushions are used for supporting the vehicle, and another four are used against the "stem" of the ⊥ for guidance. In the prototype, propulsion is provided by two gas turbine engines driving a 7½ foot diameter propeller. Braking is by means of thrust reversal, friction from gripping the guideway, and by reducing lift power. Maximum speed of the I-80 prototype approaches 190 mile/h with cruising at 155 mile/h. An illustration of the prototype I-80 vehicle is shown in Figure 2.5 and a cross-section in Figure 2.6.

The I-80 guideway can be supported above ground level on concrete columns to reduce excavation and avoid at-grade crossings with roads and conventional railways. The ⊥-beams for guidance can be constructed by conventional methods in a central location using prestressed, post-tension concrete. The beams are supported at the ends by columns resting on



**Bertin I-80 Aerotrain (First Generation TACV)**



**Tracked Hovercraft Limited (Second Generation TACV)**

**Figure 2.6 Cross-section of Tracked Air Cushion Vehicles.**

piles or spread footings according to ground conditions. The most economical span length is 75 feet. Track switches for TACV's are complex and require low speed operation. As a consequence, the capacity of a single-track system is severely limited; and a double-track configuration will be necessary for estimated traffic volumes in the Corridor.

A preliminary alignment was prepared between downtown Montreal, Dorval, Ste. Scholastique (the new Montreal Airport), Ottawa and Toronto, and is shown in Figure 2.7. While this alignment may be refined later, it provides an adequate basis for preliminary cost estimates. A design speed of 250 mile/h was used for this preliminary alignment. The alignment follows some straight sections of existing railway rights-of-way, especially in built-up areas where the choice of routes is restricted.


**Figure 2.7** **Approximate alignment for a Montreal-Ottawa-Toronto Tracked Air Cushion Vehicle service.**

**Table 2.1 I-80 Aerotrain Specifications**

| | |
|---|---|
| *Vehicle* | —Overall length 85′<br>—Overall width 10′ 6″<br>—Empty wt 24,800 lbs.<br>—Gross wt 44,000 lbs.<br>—Capacity 80 passengers plus baggage |
| *Propulsion* | —Two 1,300 HP gas turbines<br>—One 7.5′ diameter propeller (variable pitch and shrouded) |
| *Lift & Guidance* | —Eight air cushions adjustable for stiffness, all individually fed from a 720 HP free-turbine driving two axial fans. |
| *Performance* | —Cruising speed 155 mile/h<br>—Maximum speed 190 mile/h<br>—Normal rate of acceleration and deceleration, 2 mile/h/s (0.1g)<br>—Maximum grade permitting a constant speed of 155 mph—5% |
| *Guideway* | —Width 11′ 3″<br>—Height of "T"-stem 3′ 0″<br>—Double track spacing 15′ 0″ on centres |

**Table 2.2 Capital Costs in Million Canadian Dollars for a 350 Mile Double Track TACV System Between Montreal, Ottawa and Toronto**

| | I-80 Aerotrain (1) (First Generation) | THL Hovertrain (2) (Second Generation) |
|---|---|---|
| Guideway | $430.0 | $416.0 |
| Stations | 35.0 | 32.0 |
| Vehicles | 36.0(4) | 35.0(5) |
| Control & Communications | 42.0 | 42.0 |
| Maintenance Facilities | 5.0 | 4.0 |
| Linear Motor Reaction Rail | — | 67.0 |
| Power Rails & Substations | — | 84.0 |
| Miscellaneous | 7.0 | 5.0 |
| TOTAL | 555.0(3) | 685.0 |

NOTE: These two columns of costs are not directly comparable, see text.

**Costs**—Subsurface conditions and topography were among the more important physical conditions examined along a proposed line. Both a single track line and a double track line were evaluated in a De Leuw Cather report to the CTC.[1] Prices were taken from construction bids for similar work in recent years. Double track guideway construction costs per mile were estimated to range from $687,000 using spread footings to $847,000 using long piles with 20′ clearances in both cases. Right-of-way costs are based on current real estate values. Estimated capital costs for a double-track system on the preliminary Corridor alignment are itemized in Table 2.2.

The Aerotrain capital costs were used in conjunction with costs provided by Bertin and Cie to develop the total costs per passenger-mile shown in Figure 2.8. The cost per passenger-mile decreases from 7.5¢ to 5.5¢ as passenger volumes increase as summarized in Chapter 6, from an initial 1,200 million passenger-miles a year in 1981 to 2,400 in 1991. A load factor of 0.75 is used. As the I-80 system use single vehicles on frequent headways,

[1] A CTC Research Branch Report "Tracked Air Cushion Vehicles in the Canadian Corridor" is available containing details of TACV operation and costs for the Montreal-Toronto line and including the 1970 De Leuw Cather report "Evaluation of the Aerotrain Guideway".

(1) Costs based on CTC estimates with guideway costs from the De Leuw Cather Report.
(2) Costs based on data provided by Tracked Hovercraft Limited for North American construction.
(3) This total was used in the TACV evaluation in this report.
(4) 60 80-seat vehicles at $600,000 each.
(5) 50 100-seat vehicles at $690,000 each.

this relatively high load factor should be attainable. Figure 2.9 shows the sensitivity of passenger-mile costs to change in load factor. Figure 2.8 has indicated the predominance of capital costs in the total operating costs; an indication of the sensitivity of total operating costs to changes in capital costs is shown in Figure 2.10.

**Second Generation TACV**—When the Bertin I-80 system costs were prepared in 1969, the development of second generation TACV's had not yet reached a position where equally reliable estimates of construction and operating costs could be made. However, the advantages provided by the second-generation system appear to be considerable and recent cost estimates have been provided by Tracked Hovercraft Limited for construction and operation of their TACV system in North America. These construction costs are shown in the right hand column of Table 2.2, and while not directly comparable with the I-80 costs, they permit certain general statements:

— The cost of the THL box-beam guideway is of the same order as the I-80 inverted-T guideway. (Indications are that the box-beam should cost up to 20% lower than the inverted-T, but this is not demonstrated in these figures.)

— The cost of the vehicles, on a per-passenger basis, is almost identical.

— The use of linear motor propulsion adds 35% to the cost of the guideway; 15% for the linear motor reaction rail and 20% for the power distribution system.

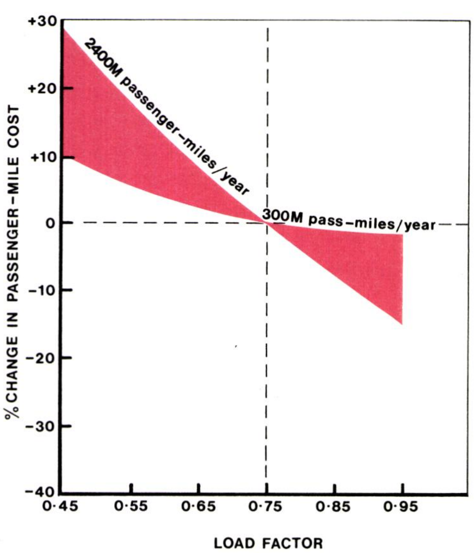



**Figure 2.9** **Sensitivity of passenger-mile costs to load factor for the Aerotrain I-80 TACV.**

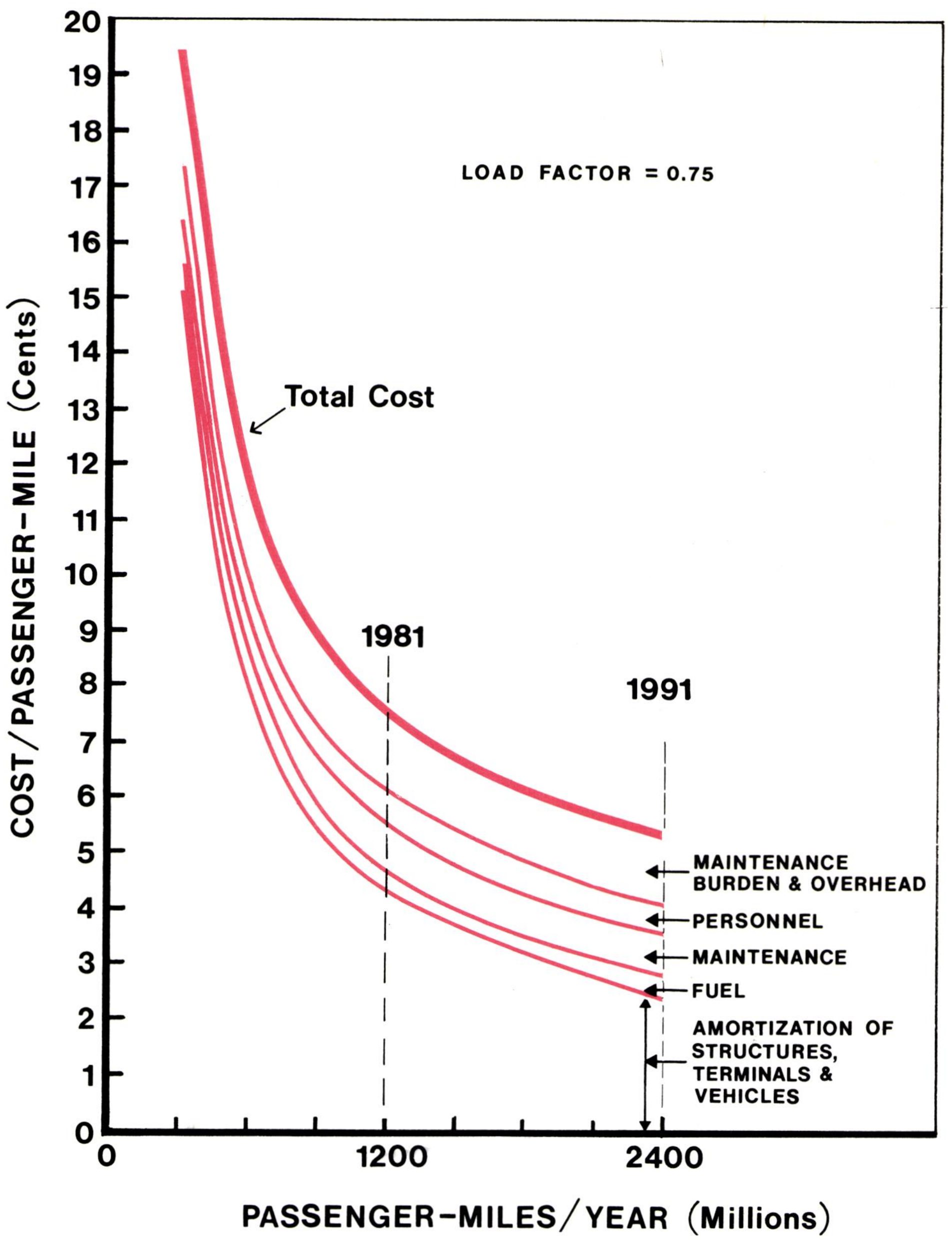



**Figure 2.8** **Composite operating costs versus passenger volumes for the Aerotrain I-80 TACV.**

Detailed operating costs have not been calculated for the second generation system. However, certain differences between the systems can be generalized:

— The introduction of multiple-unit operation will substantially reduce labour costs while still permitting adequate frequency of operation.

— Electric power costs should be lower than fuel costs for the I-80 system.

— Maintenance of the linear motor vehicles should be less than for turbine-equipped vehicles.

Total operating cost data provided by Tracked Hovercraft Limited suggest that the above reductions almost fully compensate for the increased capital costs introduced by linear motor propulsion. Hence, over the range of passenger volumes applicable to a Montreal-Ottawa-Toronto line, total operating costs for either system appear similar. At lower volumes the second-generation system becomes more expensive on a passenger-mile basis.

If this operating cost similarity can be verified, the second generation system becomes particularly advantageous. Not only is the linear motor a far quieter means of propulsion (a significant factor in urban areas) but it also has higher speed capabilities. Higher speed should result in a more attractive service and higher passenger volumes. With the increased capacity provided by multiple-unit operation, regional and airport services can be superimposed on the intercity service with significant savings in the capital costs of providing separate high speed access to an airport. Both of these effects will increase the revenue of the system and hence improve the overall system economics.

It should be noted that linear motor propulsion is being incorporated in British, French and U.S. designs. The advantages inherent in the linear motor will apply equally to all systems, not just to the THL system discussed above.

## 2.6 Air Transport Technology

In the 20-year period of this study air transport technology is represented by 'present technology' aircraft (conventional takeoff and landing (CTOL) aircraft) and a competitive air mode (short take-off and landing (STOL) aircraft). In this analysis, little change is anticipated in the performance or economics of present or 'next generation' widebodied CTOL jets. STOL airliners capable of operations from short runways are currently in the design stage and could be available in 1974 if demand warrants their early development. The concept of STOL operations would improve terminal access by locating STOL ports close to the origin and/or destination of potential air travellers. In addition, by diverting travel from conventional air services, a STOL system may alleviate air and ground congestion at conventional air terminals. Aircraft capable of vertical take-off and landing may find specialized application within the Corridor in the 20-year period of interest but are not expected to make a significant contribution to intercity travel.

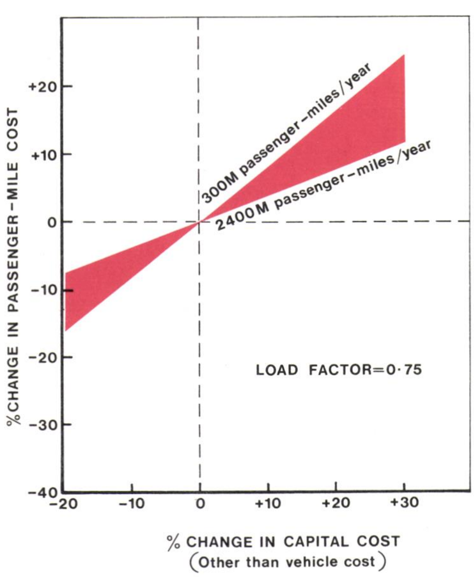



**Figure 2.10 Sensitivity of passenger-mile costs to load factor for the Aerotrain I-80 TACV.**

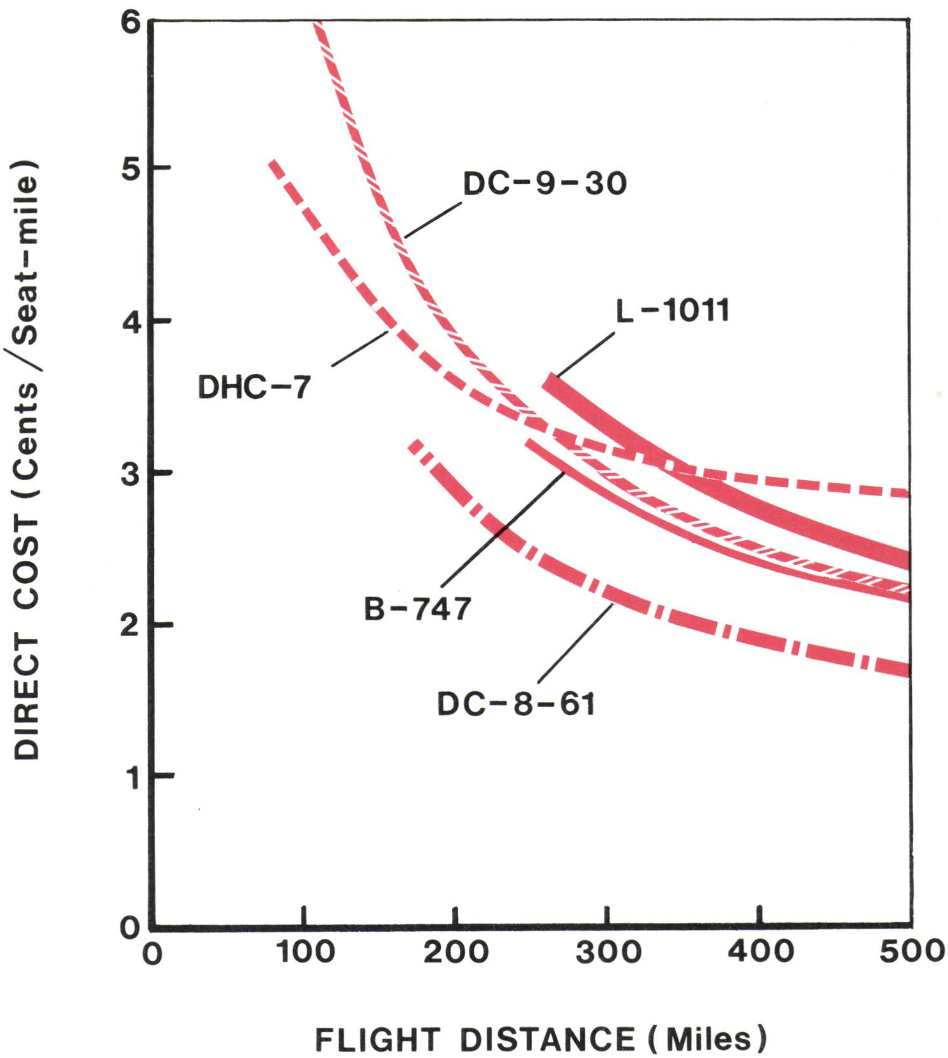



**Figure 2.11 Aircraft direct operating cost versus flight distance.**

1. **Conventional Take-Off and Landing (CTOL) Aircraft**—Most of current air travel in the Corridor is accommodated on conventional jet aircraft seating approximately 100 passengers (e.g. DC-9). The Montreal-Toronto link is also served by 200-seat aircraft (e.g. DC-8) on the initial or final segment of trans-Atlantic or trans-Continental flights. In the near future, conventional turbo-prop aircraft will be completely phased out of service on the major Corridor links and replaced with jet aeroplanes. Starting in 1971, wide-bodied jet aircraft (B-747 and L-1011) will be brought into service in Air Canada's operation. Like the DC-8, the initial contribution of these aircraft to the Corridor network will undoubtedly be limited to the Montreal-Toronto link as a continuation of longer flights.

Figure 2.11 shows estimated direct operating costs (DOC's) of the "stretched" version of DC-9 and DC-8 as representative of aircraft currently serving the main Corridor links.[1] The DOC curves start at the expected minimum stage lengths operated by each type. DOC's decrease with increasing trip distance as the effect of the fixed cost involved in non-productive operations such as taxiing and take-off diminishes. As shown, costs for B-747 and L-1011 are estimated to lie close to costs for DC-9 operations (the DHC-7 curve is referred to in later paragraphs).

"Direct operating cost" accounts for those costs which relate directly to the transport function of an air service and includes the following elements of cost: fuel, flying crew, aircraft maintenance, maintenance burden, and depreciation and interest charges relating to the aircraft itself. DOC's are estimated using the 1967

[1] A CTC Research Report "Operating Costs for Conventional and STOL Aircraft" gives details of the aircraft costing used in this Study.

ATA method[1](*6*) with the exception of depreciation which, calculated on a replacement basis, includes interest and inflation costs. In addition to direct costs, total operating cost includes those indirect operating costs (IOC's) associated with aircraft servicing, and the processing and servicing of passengers and baggage. IOC's are calculated using the RAC formulæ[2](*7*). Combining direct costs with these indirect cost items, total operating costs for a load factor of 50 percent are shown in Figure 2.12 on a seat-mile basis. Certain elements of indirect cost (such as passenger food and passenger handling) are dependent on the number of passengers carried and consequently total operating cost is dependent on load factor. As was the case with direct operating costs, total operating cost for the B-747 and L-1011 are essentially the same as for the "stretched" DC-9.

Unit operating costs in themselves are an inadequate basis for comparing the economic performance of various aircraft. As illustrated in Figure 2.13 capacity and productivity vary rather significantly from one aircraft to another and the full effect of these factors is not reflected in unit costs such as those of Figures 2.11 and 2.12. In moving to a larger aircraft which offers lower unit cost on a particular route or network, service frequency must be reduced in order to maintain load factors at the same level. This reduction in level of service may result in a considerable loss in patronage and a less profitable operation.

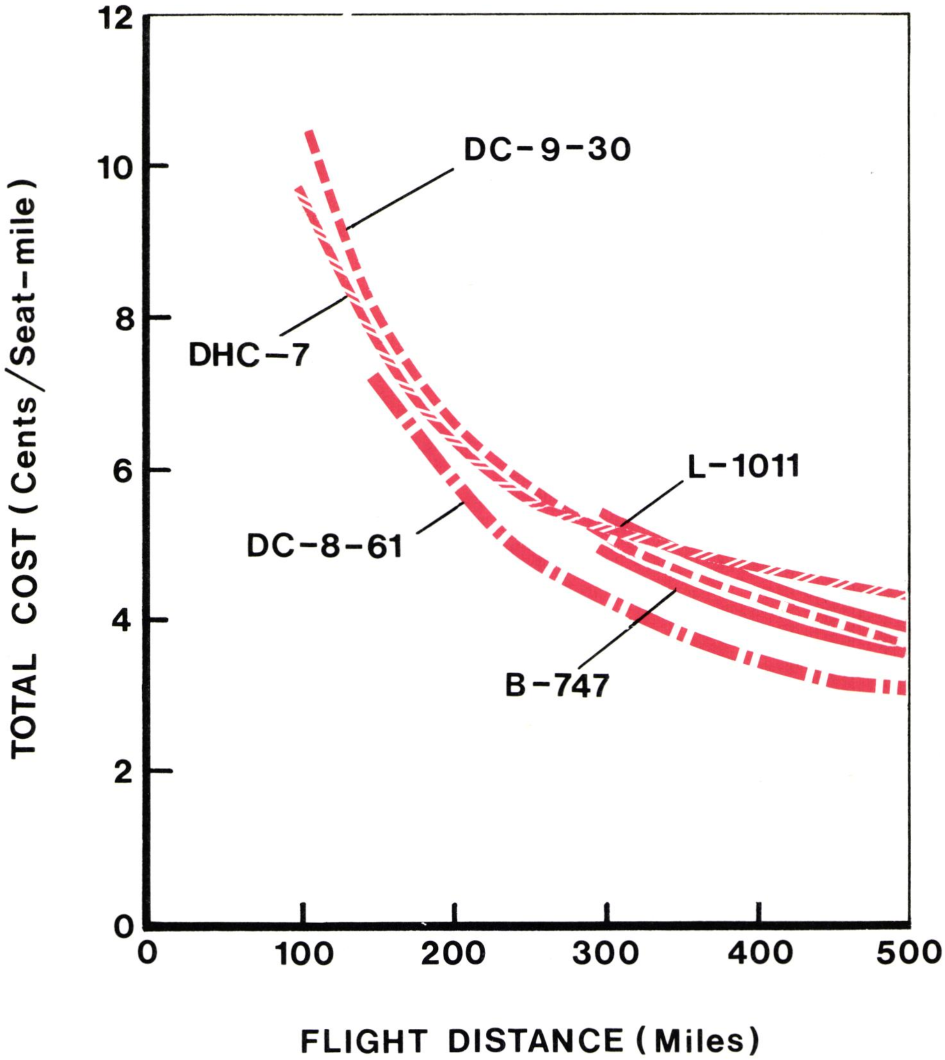



**Figure 2.12 Aircraft total operating cost versus flight distance with a 50 percent load factor.**

As an example of a first-generation STOL airliner, the turbo-prop DHC-7 possesses a small seating capacity and a low cruising speed compared to its contemporary CTOL airliners in Figure 2.13. As discussed in the following section, other factors in the STOL operation may compensate for these deficiencies.

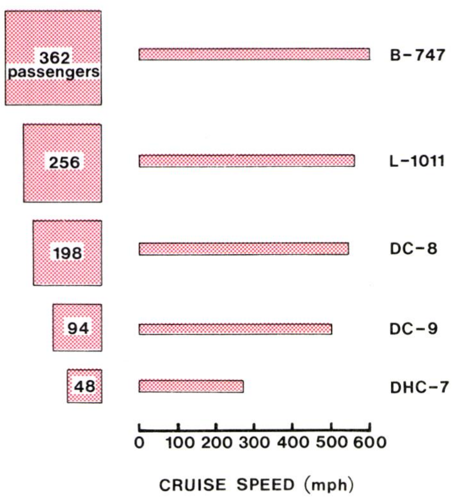



**Figure 2.13 A diagrammatic comparison of aircraft capacity and speed.**

2. **Short Take-Off and Landing** (STOL) **Aircraft**—The STOL strategy is based upon the idea that aircraft will become available which possess suitable low-noise and short take-off and landing characteristics, thereby enabling them to operate from small airfields located within developed urban areas.

The argument favouring STOL is that the total trip time by a STOL flight can be less than by a CTOL flight because of savings in access and terminal processing time. As an example, the following table illustrates the components of total trip time between two representative central areas of Montreal and Toronto for a jet CTOL flight and a turboprop STOL flight. Although the STOL flight phase is longer than that of CTOL, there is enough saving in the estimated STOL access, egress and terminal processing times to make the STOL journey shorter.

**Table 2.3 Total Montreal-Toronto Trip Time STOL vs. CTOL**

| | Turbo-Prop STOL | Jet CTOL |
|---|---|---|
| Access | .25 | .45 |
| Terminal Processing | .67 | 1.40 |
| Flight | 1.47 | 1.08 |
| Egress | .33 | .57 |
| Total Trip Time | 2.72 hrs. | 3.50 hrs. |

This effect may not apply to entire cities and certainly not to areas of a city located near to the CTOL airport. Nevertheless, it is expected that there will be sufficiently high volumes generated between city area-pairs where this relationship does exist to justify a STOL service.

[1] These costing procedures involve sets of formulae for elements of operating cost derived from reported airline costs by the Air Transport Association.

[2] Research Analysis Corporation.

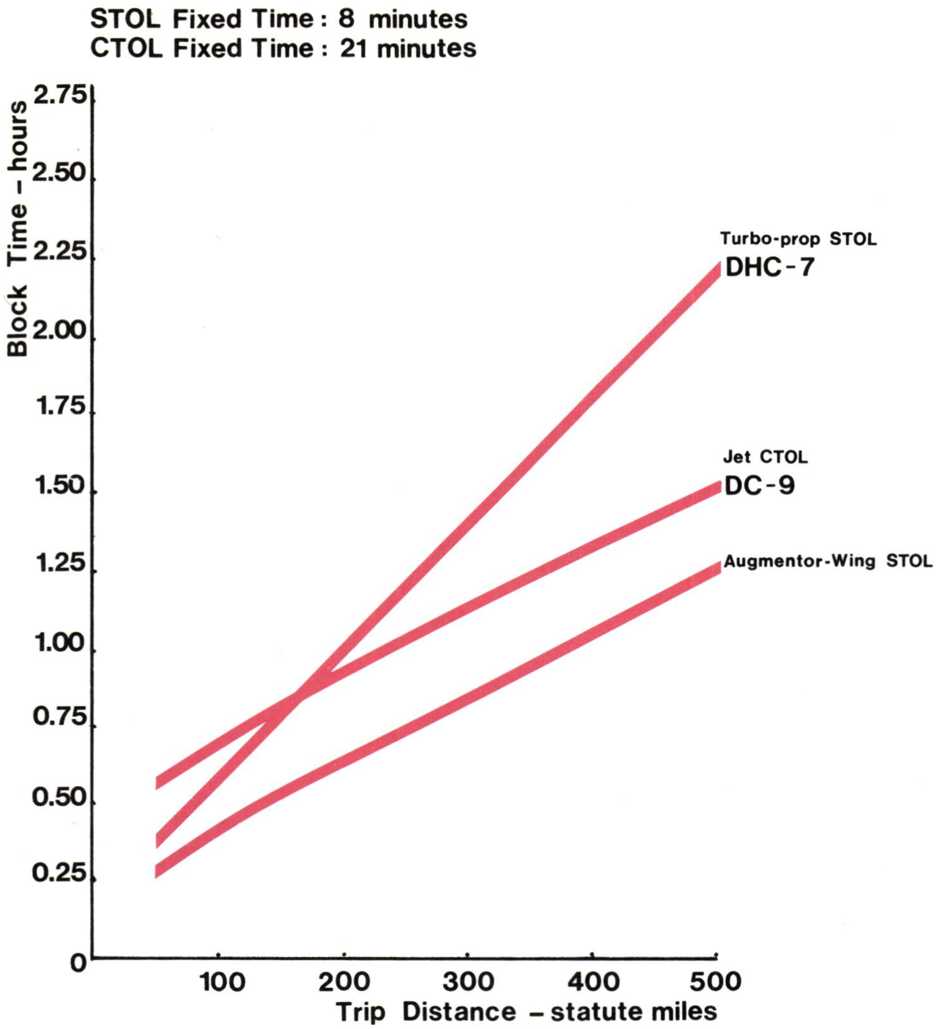



**Figure 2.14 Block times for STOL and CTOL aircraft.**

**STOL Aircraft Types**— Much of the STOL system's market share and profitability will depend upon the economics and performance of the vehicle itself. Since the time period of this study spans the years 1970-1990, two future generations of STOL aircraft are examined. The first is a turbo-prop and the example used is the de Havilland DHC-7. Its successor is assumed to be a turbo-fan STOL aircraft. Many designs already exist for advanced-technology turbo-fan STOL types and an augmentor-wing type such as that proposed by de Havilland is chosen as a representative example. That both generation aircraft are de Havilland designs is mainly due to the ready availability of details of these aircraft characteristics and performances. They are typical of many similar proposals and their highlights appear in Table 2.4.

Both types are designed to operate from a field length of 2000′, using take-off and approach paths steeper than those of CTOL aircraft. In addition, these aircraft possess low approach speeds enabling them to be highly manoeuvrable in restricted terminal airspaces. The DHC-7 is termed a C/STOL aircraft and relies upon slower approach speeds, lower wing loadings, slightly higher power/weight ratios than its turbo-prop CTOL counterpart. Being a turbo-prop, the DHC-7 will cruise at lower speeds and is expected to have a less comfortable ride than conventional jet airliners. The DHC-7's low seating capacity should permit it to offer intercity services with reasonable frequencies yet allow it to be used on 'regional' or 'feeder' routes.

The augmentor-wing arrangement, very simply, permits 'cold' air from a bypass of fan engine to be ducted into the wing where it is blown out through spanwise ducts and highly deflected by a double flap system. Among other things this scheme produces the high lift coefficients necessary during the take-off and approach. During cruise this system is shut down and the air switched to a conventional jetpipe. One of the augmentor-wing's chief appeals is that it will possess the high cruise speeds (with a significant further reduction in total trip time) and comfortable smooth ride of the conventional jet.

**Table 2.4 Comparison of 1st and 2nd Generation STOL Aircraft**

| Type | Year Available | Maximum Seating Capacity | TOGW max. lbs. | Max. Cruise speed, mph. | Engine Power | Estimated Price 1969 $ |
|---|---|---|---|---|---|---|
| DHC-7 | 1973-74 | 48 | 38,500 | 276 | 4 x 1,161 eshp. | 1.84 M |
| A-W | 1980 | 100 (88[1]) | 90,000 | 506 | 4 x 10,000 lb. thrust | 5.75 M |

[1] For this analysis, a seating capacity of 88 was used for the augmentor-wing proposal to give a seating configuration comparable to the DC-9.

**STOL Operating Costs**—are calculated in the same manner as those of CTOL. Both formulae (References *6* and *7*) are slightly modified to reflect differences that can be expected between STOL and CTOL operations.

1. Air traffic control systems designed for STOL operations are expected to permit STOL aircraft to fly a more 'efficient' mission profile (Figure 2.15). Part of the mission profile is non-productive or fixed time when the aircraft is taxiing and landing and no contribution is made to trip distance. The total non-productive time is reduced from the present ATA value of 21 minutes to 8 minutes.

2. ATA air traffic allowance of 20 miles is omitted.

3. Annual utilization is held constant at 3000 hours.

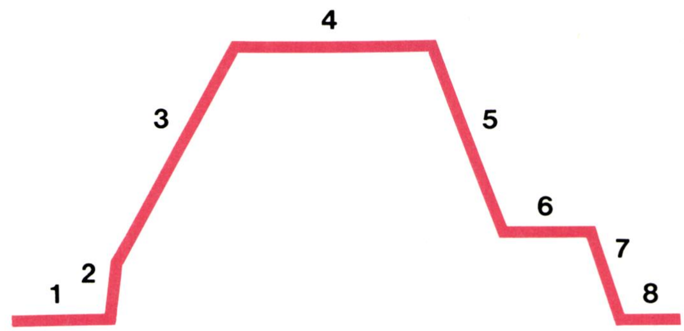
Block time (or speed) has an important effect in the calculations of operating costs and the STOL mission profile permits the block times to be kept to a minimum. Figure 2.14 illustrates the variation of block time with trip distance for the DHC-7, augmentor-wing and a CTOL jet airliner (DC-9).

DOC's and TOC's for the DHC-7 can be compared directly with those of CTOL aircraft in Figures 2.11 and 2.12. Operating costs of the augmentor-wing are not shown. Details of this aircraft's characteristics permitted only parts of its DOC to be calculated directly. Several remaining items, such as the direct maintenance cost of the augmentor-wing system, could only be estimated. The results of these estimates produced DOC's and TOC's for the augmentor-wing which are very slightly lower than those of the DHC-7. For the Toronto-Montreal stage length the costs are shown in Table 2.5.

**Table 2.5 Cost Comparison for STOL/CTOL Aircraft—Montreal-Toronto**

| Type | DOC, ¢/ASM | TOC, ¢/ASM |
|---|---|---|
| DHC-7 | 3.0 | 5.3 |
| A-W | 2.9 | 5.2 |
| DC-9 | 2.6 | 5.1 |

Trip distance = 340 s.m.
Load Factor = 70%
ASM = Aircraft Seat Mile




FIXED TIME:

| | |
|---|---|
| 1. Taxi out | 2 mins. |
| 2. Take off | 1 " |
| 3. Climb | – " |
| 4. Cruise | – " |
| 5. Descent | – " |
| 6. Air Manoeuvre | 2 " |
| 7. Landing | 2 " |
| 8. Taxi in | 1 " |

Total Non-Productive or Fixed Time 8 minutes

**Figure 2.15 Mission profile for a STOL aircraft.**

**STOLports**—A key part of the STOL system is the STOLport itself. That STOLports be located within easy access of passengers' origins/destinations does not imply exclusively downtown sites. Although STOL operators may obviously begin from downtown STOLports, there may exist a need for a number of STOLports serving scattered suburban or industrial districts within a large metropolitan area. Despite the promise of low-noise aircraft capable of manoeuvering within confined airspaces, STOL/CTOL air traffic compatibility and community consideration as well as ready access requirements will pose serious difficulties in establishing metropolitan STOLport systems. In this analysis single STOLports for Montreal and Toronto are assumed to be located only in the waterfront areas adjacent to the central business districts. A commonly proposed site for Montreal is the present Victoria Auto Park; the exact siting of a Toronto STOLport has not been determined.

To minimize STOLport costs, the design of a STOLport ideally should be as simple as possible—permitting the swift handling of both the expected passenger volumes and aircraft movements. Proposed STOLport configurations have produced facilities of varying sizes, complexity and cost and many are considered unsuitable for handling the expected Toronto and Montreal traffic levels. The STOLport costs used in this study are based upon those produced by the Montreal STOLport Study (*8*). That study estimated the costs of a facility at the Victoria Auto Park capable of handling upwards of one million passengers per year as approximately $13.5 million.[1] No such detailed cost exists for a Toronto STOLport so its cost is assumed to be of the same order. The Montreal STOLport estimates included no allowance for land acquisition. Although the specific site considered in the study is the property of the National Harbours Board, the "opportunity cost" of that land must be accounted for. For purposes of this study, the combined capital cost of the two STOLports is estimated as $30 million.

[1] More recent studies conducted by the Ministry of Transport have estimated STOLport costs as $4.5 million for a facility designed to handle one million passengers per year. This estimate includes no allowance for the cost of land.

# 3 PRESENT TRANSPORT CHARACTERISTICS

Chapters Three and Four (Urban Structure and Demographic Trends) detail the information obtained for the development and calibration of the demand models described in Chapter Five. Much of this information is derived from the Common Carrier Origin-Destination Survey carried out in summer 1969. Details of the survey with selected data tabulations are contained in Appendix One.

## 3.1 Common Carrier Performance

The Canadian Corridor is both narrow and linear so that travel by any mode between most major city pairs has no choice of route and is often via other cities in the Corridor, particularly the key cities of Montreal and Toronto. Exceptions such as the competing rail service between Montreal and Ottawa or Quebec City are not significant as the distances and schedule times are comparable. Figures 3.1, 3.2 and 3.21 show the rail, air and highway networks respectively, while Tables 3.1, 3.2 and 3.3 contain a summary of the common carrier schedules during the O-D survey in summer 1969 together with the appropriate fates. Inevitably there is some discrepancy between scheduled and actual performance. Figures 3.3, 3.4 and 3.5 show the distribution of common carrier arrivals relative to their scheduled time. Note that while the standard deviation of the bus arrivals (Figure 3.5) is greater than the other modes, many more arrive early, partly because buses do not have the same degree of control over their paths as aircraft and trains. These tables are derived from the O-D Survey under summer conditions, greater deviations from published schedules will occur in winter.

The time and cost of trips by common carriers play a dominant part in the demand analysis. However, the time and cost for a trip is not simply the scheduled time or cost but rather a passenger's total trip time and trip cost including access and egress to and from the common carrier terminal and any time spent waiting in terminals. Section 3.2 describes access and egress information for terminals as obtained from the O-D survey.

Along with these major factors of time and cost, other characteristics such as comfort, convenience and safety affect modal choice and are applied in the demand analysis. The relative safety of competitive travel modes is a controversial area and the study limitations pro-

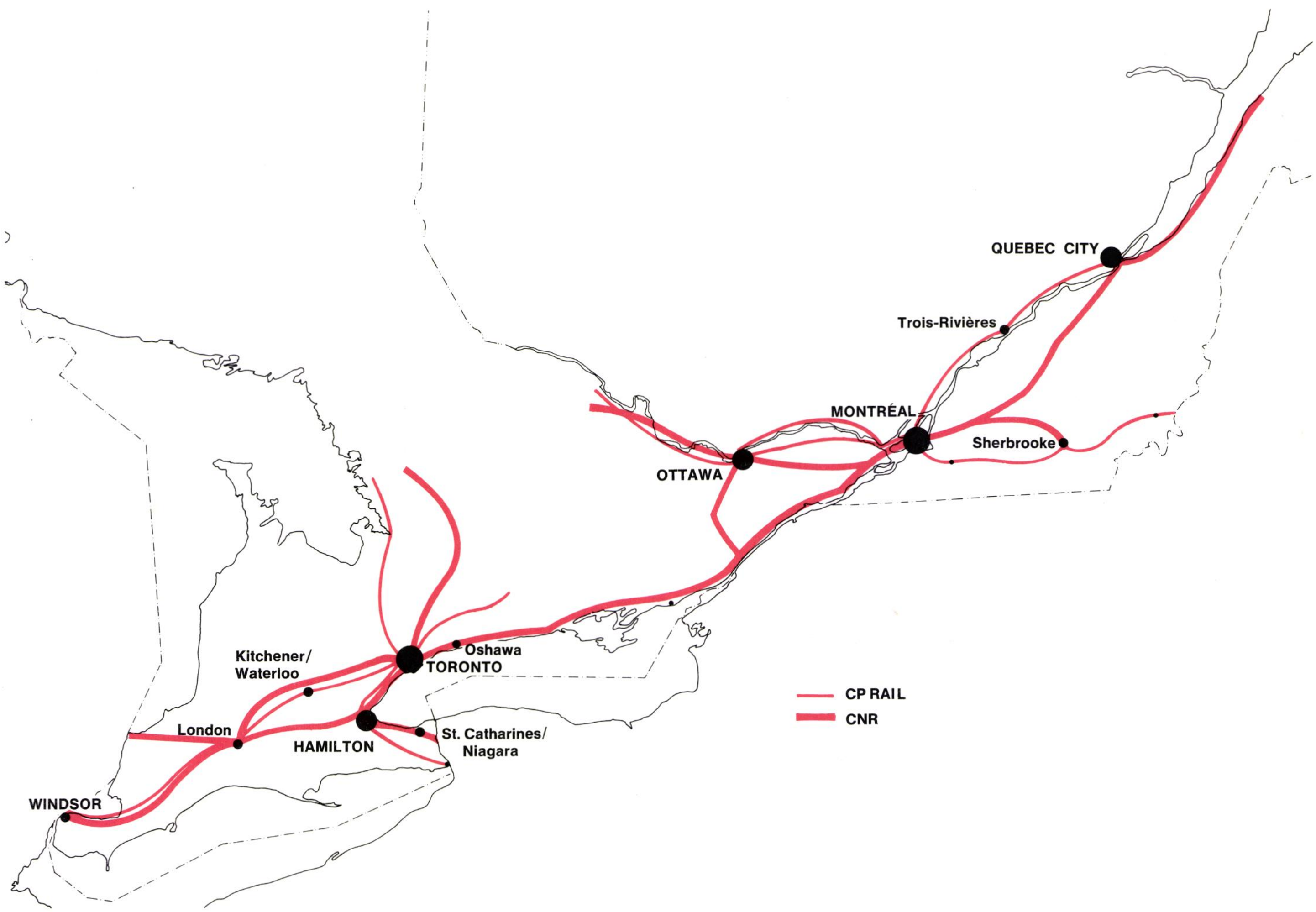



**Figure 3.1 Principal intercity railroad passenger routes.**

**Table 3.1 Intercity Schedule Times and Fares—AIR**

Note: Add road times for cities shown. Fares are by air only.
*Road times unnecessary.

| | Quebec | Sherbrooke | Trois Rivières | Montreal | Ottawa | Toronto | Hamilton | London | Windsor | St. Catharines | Niagara Falls |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Quebec | — | | | | | | | | | | |
| Sherbrooke | — | 1h 35m Road | | | | | | | | | |
| Trois Rivières | 0h 30m $11 | — | — | | | | | | | | |
| Montreal | 0h 35m $15 | — | 0h 30m $11 | — | | | | | | | |
| Ottawa | 1h 10m $24 | 0h 30m $11 | — | 0h 30m $11 | — | | | | | | |
| Toronto | 2h 20m $40 | 1h 05m $25 | — | 1h 05m $25 | 0h 55m $21 | — | | | | | |
| Hamilton | 2h 20m $40 | 1h 05m $25 | — | 1h 00m* $25 | 0h 55m $21 | — | 0h 46m Road | | | | |
| London | 3h 35m $50 | 1h 50m $35 | — | 1h 50m $35 | 1h 25m $31 | 0h 35m $11 | — | — | | | |
| Windsor | 3h 40m $58 | 2h 20m $44 | — | 2h 20m $44 | 2h 10m $39 | 0h 35m $19 | 0h 35m $19 | 0h 40m $12 | — | | |
| St. Catharines | 2h 20m $40 | 1h 05m $25 | — | 1h 00m $25 | 0h 55m $21 | 0h 25m* $ 9 | — | — | 0h 35m $19 | 1h 10m Road | |
| Niagara Falls | 2h 20m $40 | 1h 05m $25 | — | 1h 00m $25 | 0h 55m $21 | — | — | — | 0h 35m $19 | — | 1h 20m Road |

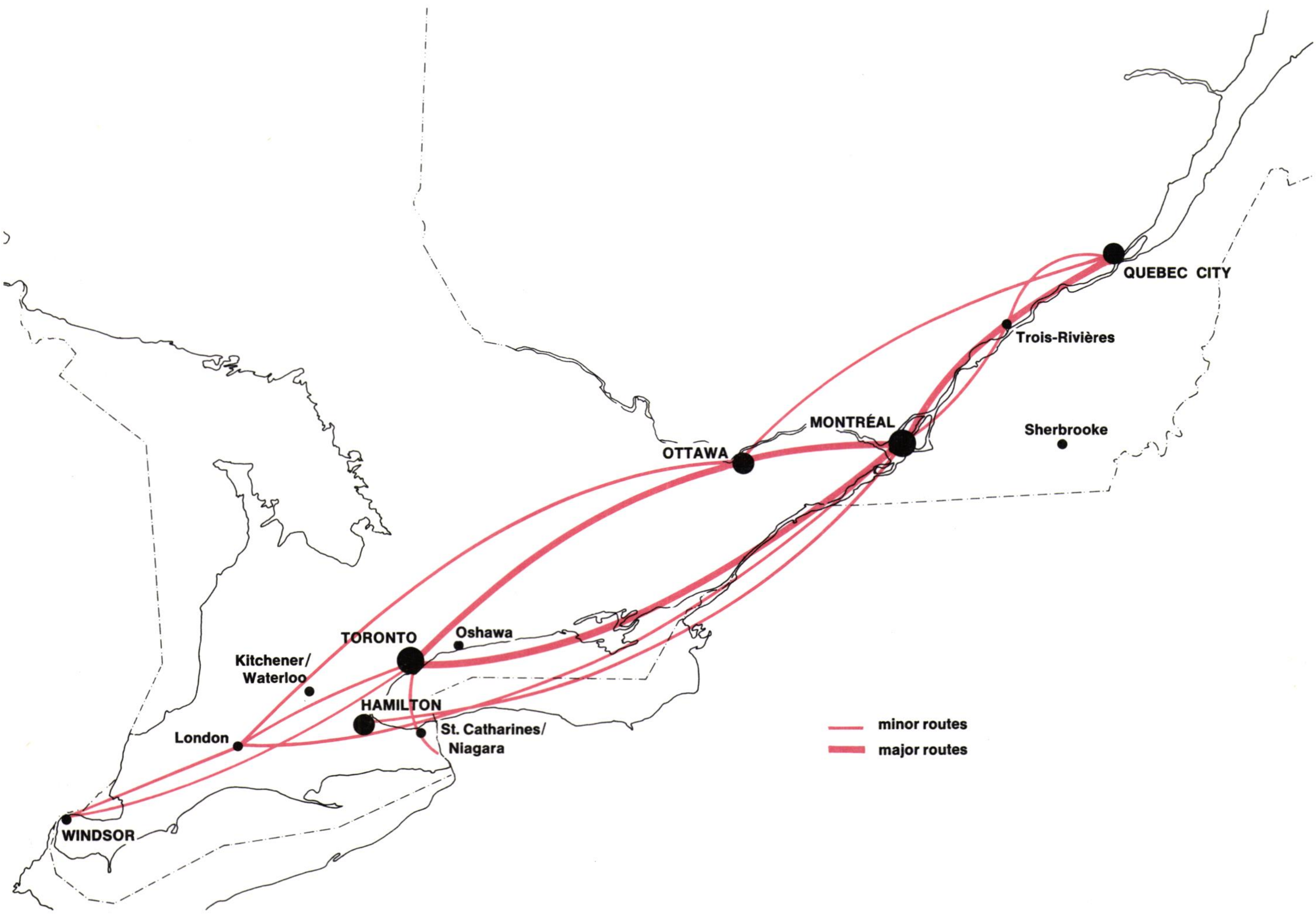



**Figure 3.2 Principal intercity airline routes.**

**Table 3.2 Intercity Schedule Times and Fares—RAIL**

Note: Fares shown are 'White Fares' where applicable.
*24 mile drive to Richmond P.Q. not included.

| | Quebec | Sherbrooke | Trois Rivières | Montreal | Ottawa | Toronto | Hamilton | London | Windsor | St. Catharines | Niagara Falls |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Quebec | — | | | | | | | | | | |
| Sherbrooke | 2h 45m<br>*$ 4.10 | — | | | | | | | | | |
| Trois Rivières | 1h 50m<br>$ 3.00 | — | — | | | | | | | | |
| Montreal | 2h 59m<br>$ 6.20 | 2h 35m<br>$ 3.80 | 1h 47m<br>$ 3.90 | — | | | | | | | |
| Ottawa | 5h 55m<br>$10.10 | 5h 05m<br>$ 8.20 | 4h 07m<br>$ 8.00 | 1h 59m<br>$ 4.10 | — | | | | | | |
| Toronto | 9h 19m<br>$15.00 | 9h 20m<br>$12.40 | 10h 17m<br>$15.80 | 4h 59m<br>$11.90 | 4h 59m<br>$ 8.90 | — | | | | | |
| Hamilton | 11h 17m<br>$15.70 | 10h 20m<br>$13.00 | 11h 17m<br>$21.10 | 7h 57m<br>$12.90 | 6h 37m<br>$10.50 | 1h 00m<br>$ 2.00 | — | | | | |
| London | 12h 52m<br>$17.00 | — | — | 9h 32m<br>$16.10 | 8h 12m<br>$12.90 | 2h 25m<br>$ 4.20 | 1h 38m<br>$ 3.40 | — | | | |
| Windsor | 16h 45m<br>$19.50 | — | — | 12h 10m<br>$15.90 | 11h 55m<br>$14.80 | 4h 15m<br>$ 8.10 | 3h 28m<br>$ 7.10 | 1h 50m<br>$ 4.10 | — | | |
| St. Catharines | 12h 00m<br>$16.50 | — | — | 8h 40m<br>$15.30 | 7h 02m<br>$12.20 | 1h 30m<br>$ 3.00 | 0h 40m<br>$ 1.60 | — | — | — | |
| Niagara Falls | 12h 20m<br>$16.50 | — | — | 9h 00m<br>$15.30 | 7h 22m<br>$12.20 | 1h 50m<br>$ 3.40 | 1h 00m<br>$ 2.15 | — | — | 0h 20m<br>$ 0.55 | — |

hibited work in this area. However, Table 3.4 has been derived from the US Northeast Corridor Transportation Project (Reference *1* page 1-33) and is included as an item of interest. The Northeast Corridor report on "External Costs and Benefits Analyses" (see section 8.2) places a value on accidents to be used in evaluating alternate transport strategies. Such cost-benefit analysis has not been performed for the Canadian Corridor but would be desirable for inclusion in any extension of this study.

## 3.2 Terminal Interface

One objective of the passenger survey was to obtain distribution of trip origins within the four main cities. A series of questions was asked relating to the location of the passengers' origin and destination, the modes of transportation used, and the time and cost associated with terminal access. Observations received from these queries were coded according to census tracts of each city. As there are 500 census tracts in each city, (census metropolitan area) the census tracts were aggregated into contiguous groups, or areas.

In Toronto and Montreal, 24 areas were formed, while Ottawa and Quebec being smaller cities had 12 areas. An attempt was made to equalize these areas with respect to space and population and to relate them to the city's planning zones.

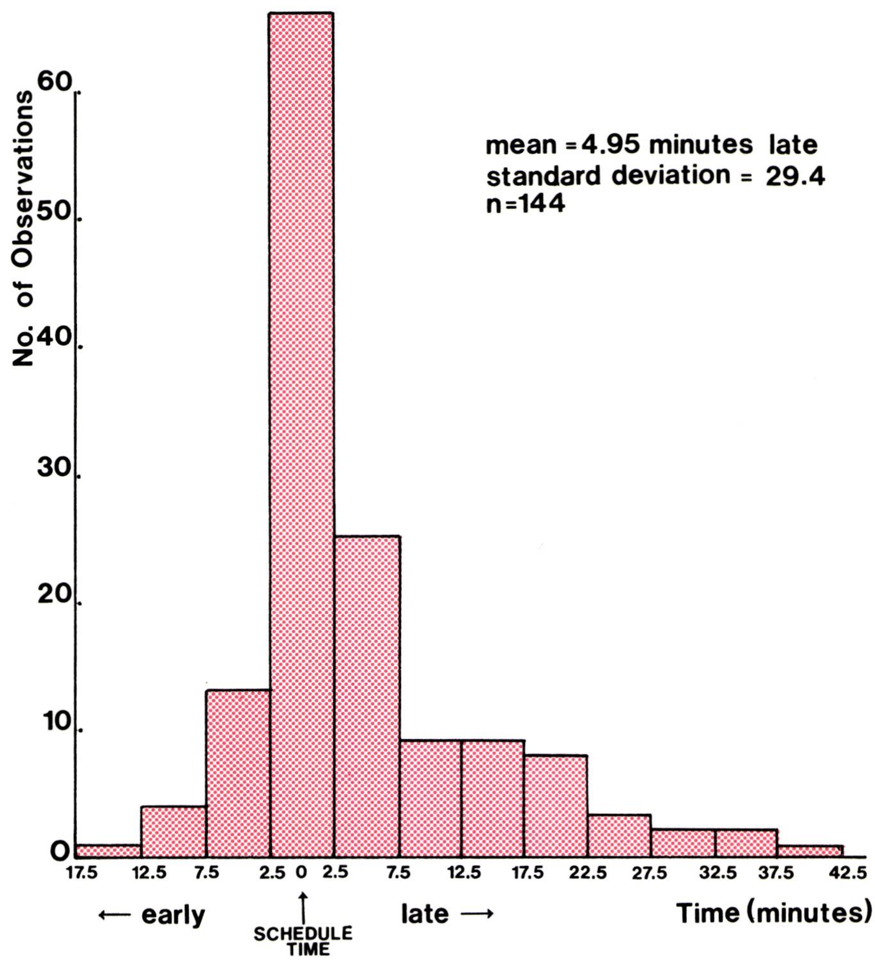



**Figure 3.3 Distribution of air arrivals (Toronto, Ottawa, Montreal and Quebec City during O-D survey in Summer 1969).**

**Table 3.3 Intercity Schedule Times and Fares—BUS**

| | Quebec | Sherbrooke | Trois Rivières | Montreal | Ottawa | Toronto | Hamilton | London | Windsor | St. Catharines | Niagara Falls |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Quebec | — | | | | | | | | | | |
| Sherbrooke | 3h 10m<br>$ 9.35 | — | | | | | | | | | |
| Trois Rivières | 2h 30m<br>$ 3.05 | — | — | | | | | | | | |
| Montreal | 2h 50m<br>$ 5.80 | 1h 45m<br>$ 3.55 | 1h 59m<br>$ 3.35 | — | | | | | | | |
| Ottawa | 5h 45m<br>$10.30 | 4h 05m<br>$ 8.00 | 4h 30m<br>$ 6.85 | 2h 14m<br>$ 4.50 | — | | | | | | |
| Toronto | 9h 10m<br>$17.95 | 9h 55m<br>$15.65 | 9h 15m<br>$12.10 | 6h 10m<br>$12.15 | 4h 45m<br>$ 9.60 | — | | | | | |
| Hamilton | 11h 30m<br>$19.70 | — | — | 7h 55m<br>$13.90 | 7h 20m<br>$11.35 | 2h 00m<br>$ 1.75 | — | | | | |
| London | 12h 25m<br>$21.90 | — | — | 9h 25m<br>$16.10 | 8h 25m<br>$13.55 | 2h 24m<br>$ 3.95 | 2h 15m<br>$ 2.60 | — | | | |
| Windsor | 13h 55m<br>$25.60 | — | — | 11h 09m<br>$19.80 | 10h 24m<br>$17.25 | 4h 59m<br>$ 7.65 | 5h 15m<br>$12.00 | 3h 00m<br>$ 3.70 | — | | |
| St. Catharines | 12h 15m<br>$20.95 | — | — | 7h 45m<br>$15.15 | 7h 20m<br>$12.60 | 1h 20m<br>$ 3.00 | 1h 15m<br>$ 1.85 | — | — | — | |
| Niagara Falls | 12h 40m<br>$21.25 | — | — | 8h 10m<br>$15.45 | 7h 45m<br>$12.90 | 1h 45m<br>$ 3.30 | 1h 50m<br>$ 2.50 | — | — | 0h 25m<br>$ 0.70 | — |

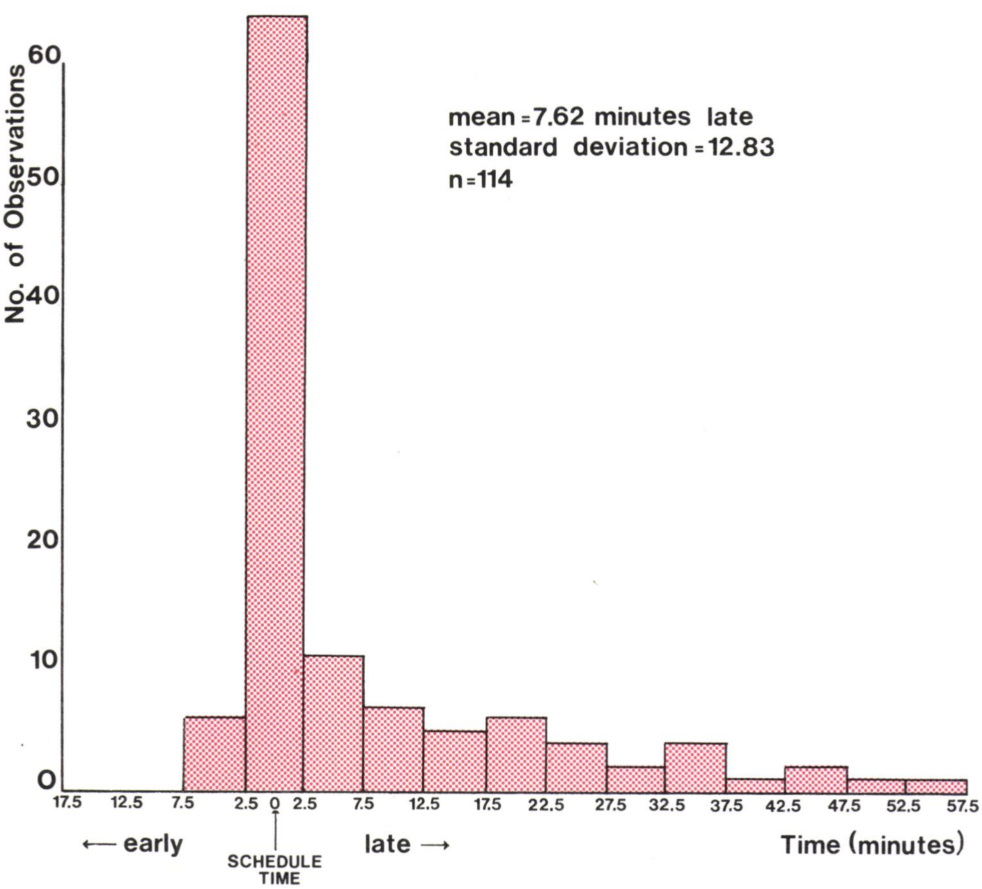



**Figure 3.4** **Distribution of rail arrivals (Toronto, Ottawa, Montreal and Quebec City during O-D survey in Summer 1969).**

In order to generalize this information, distributions of trip origins were described in terms of distance from the respective terminals.

In Figure 3.6 accumulated percentages were taken from the resident population and the resident and non-resident traffic of each area. Points representing areas as described above are placed at their estimated road distance from the terminal. In most cases a logistic curve was fitted to the data. In the cases where a good fit

**Table 3.4 Expected Rates of Passenger Accidents for 1975**

| Mode | 1975 rate per 100 million passenger miles: Fatalities | Injuries |
|---|---|---|
| Auto (1) | 2.40 | 85.4 |
| Bus (2) | 0.24 | 6.6 |
| CTOL (3) | 0.30 | 2.4 |
| STOL (4) | 0.60 | 4.9 |
| Rail (All) (5) | 0.10 | 0.9 |
| TACV (5) | 0.08 | 0.4 |

(1) Based on US 1967 adjusted national data.
(2) Based on US 1964-1969 intercity bus data.
(3) Based on US 1967 Certified Route Air Carriers.
(4) Scaled upwards from (3).
(5) Adjusted from 1967 US passenger rail experience.

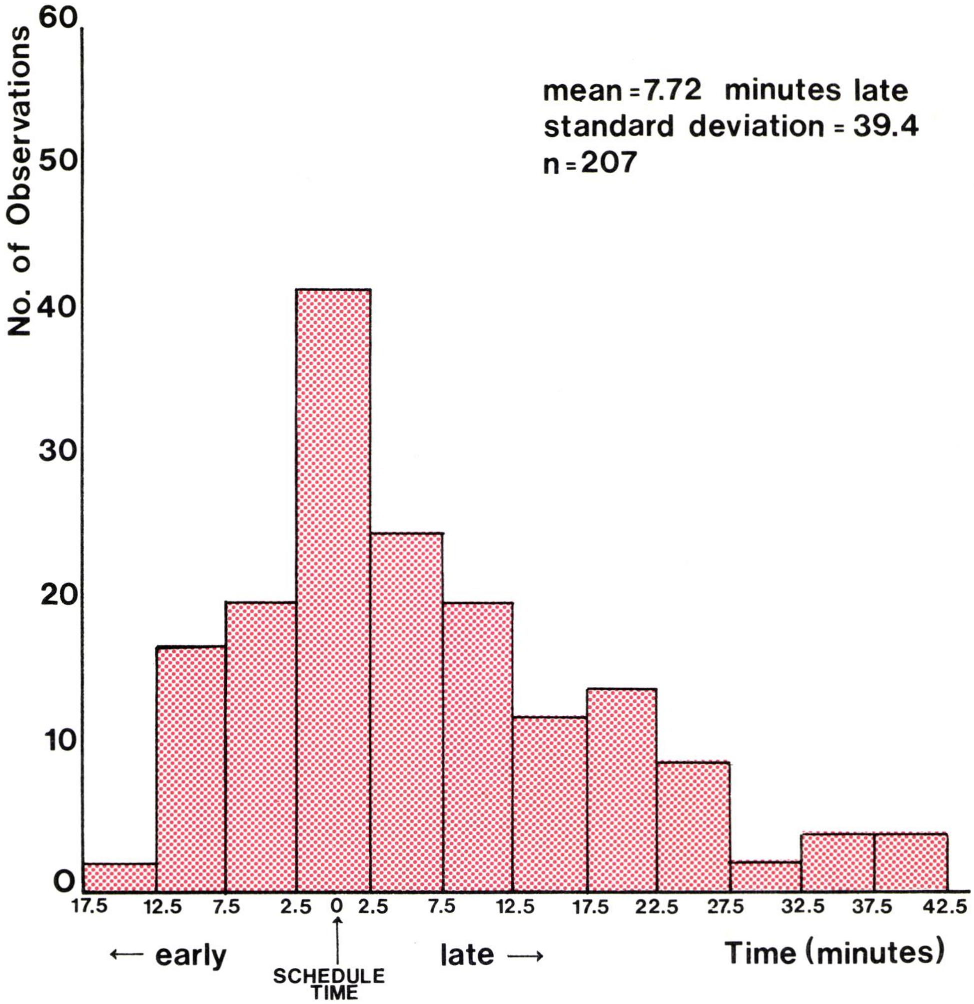



Figure 3.5 Distribution of bus arrivals (Toronto, Ottawa, Montreal and Quebec City—Summer 1969).

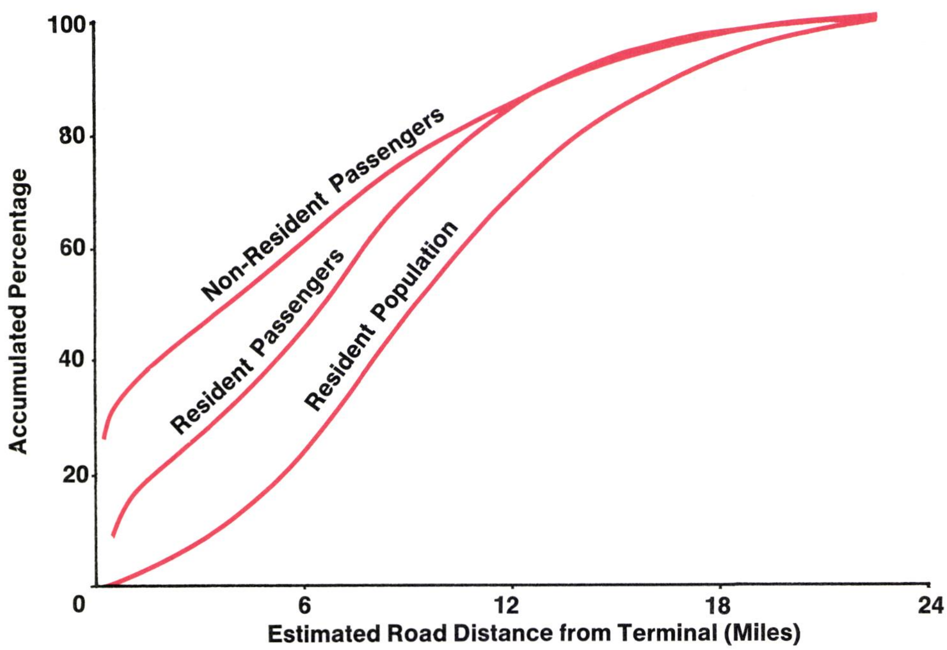



Figure 3.6 An example of the cumulative distribution of population and departing passengers by distance from a common carrier terminal.

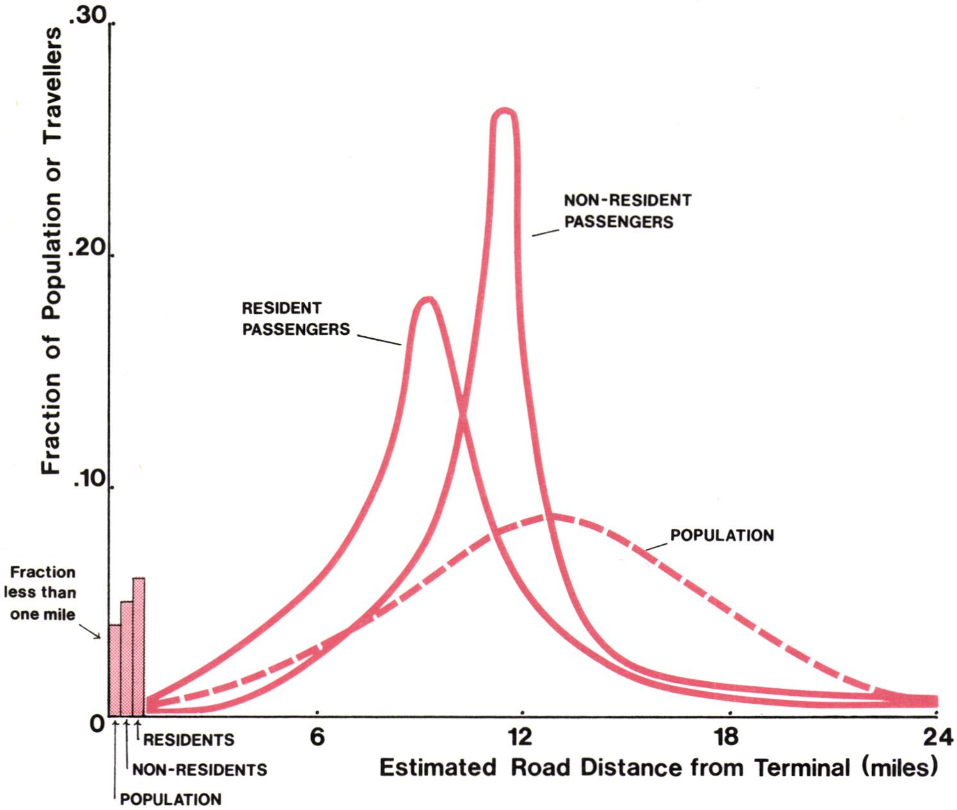



**Figure 3.7** **Distribution of population and trip origins of departing passengers by distance from Montreal airport.**

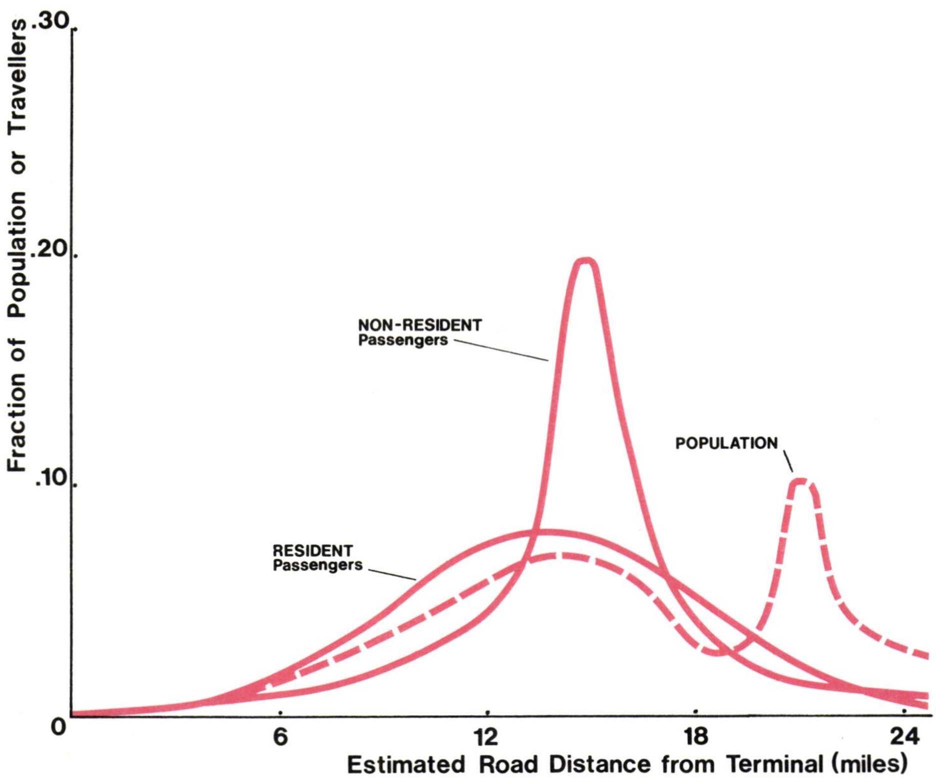



**Figure 3.8** **Distribution of population and trip origins of departing passengers by distance from Toronto airport.**

was not possible, an empirical curve was drawn through the points. Based on these cumulative distribution curves, density functions of trip origins were derived with respect to distance from the terminal.

## Observations

(1) **Air Passenger Distribution**—Figures 3.7 to 3.9 — The highest density of traffic for non-residents is found within the city centre. The resident traffic is spread over a larger area and closely follows the population curve with its highest peak at the city centre. Montreal is the exception with the peak of resident traffic being closer to the terminal, indicating that a substantial percentage of air travellers live in the western part of the city.

(2) **Downtown Terminals**—Figure 3.10 and 3.11 — Terminals for both Toronto and Montreal downtown areas are located near the centre of trip origins. In Toronto, there are two peaks of traffic for resident passengers. One at less than one mile, while another lower peak approximates the population curve. In contrast, Montreal has only one area of high density at two miles indicating a more centralized populace. The decrease in resident traffic at less than one mile in Montreal is due in part to the diversion of some traffic outside the city centre to Dorval rail terminal.

The peak of resident traffic is nearer to the terminal than is the peak of population for all terminals, indicating that the farther a resident is from any specified terminal, the less likely he is to make use of that terminal and that specific mode.

(3) **Distribution by Access Mode**—Figures 3.12 to 3.14 — The automobile is the most widely-used access mode. For airports, automobile usage is greater at shorter distances with taxi-limousine usage at further distances.

For distances less than 10 miles from downtown terminals, bus-subway usage is greatest and tends to limit automobile use. For greater distances, bus-subway usage is either too time-consuming or services become too sparse to be of great use. Walking is limited to one to two miles. In Montreal, the dense downtown population encourages more walking and this reduces use of other modes. Walking in Toronto is less significant.

Using the density function and the passenger distributions for Toronto downtown and airport terminals, a more illustrative view can be given of the modal splits and their relationships to the re-

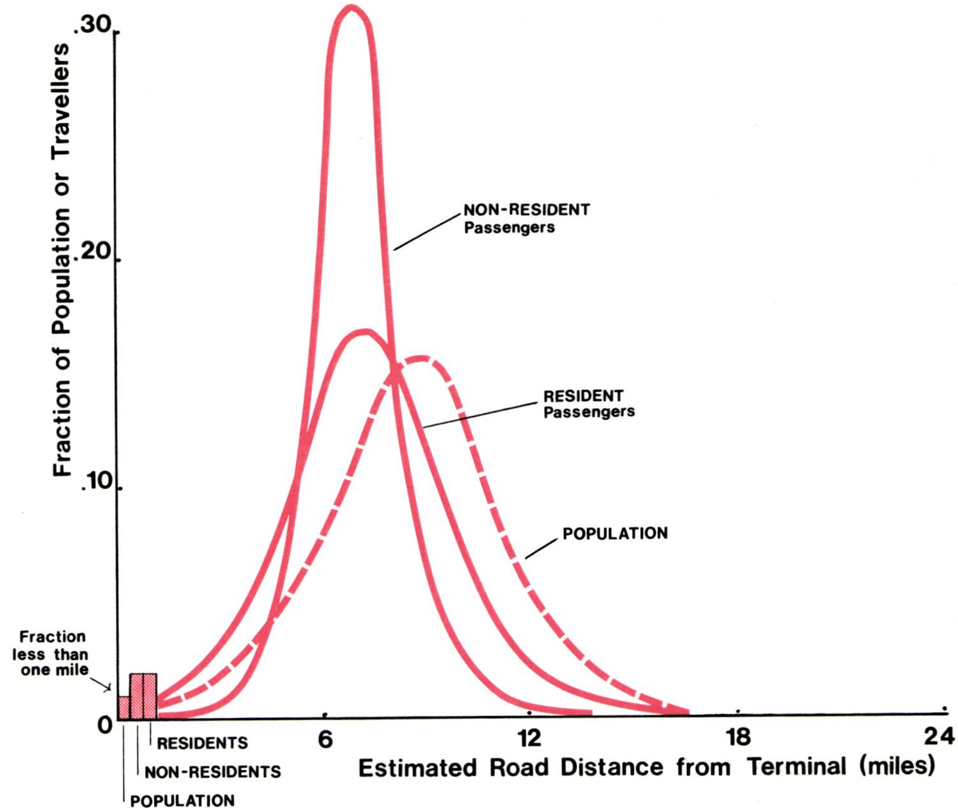



**Figure 3.9** **Distribution of population and trip origins of departing passengers by distance from Ottawa airport.**

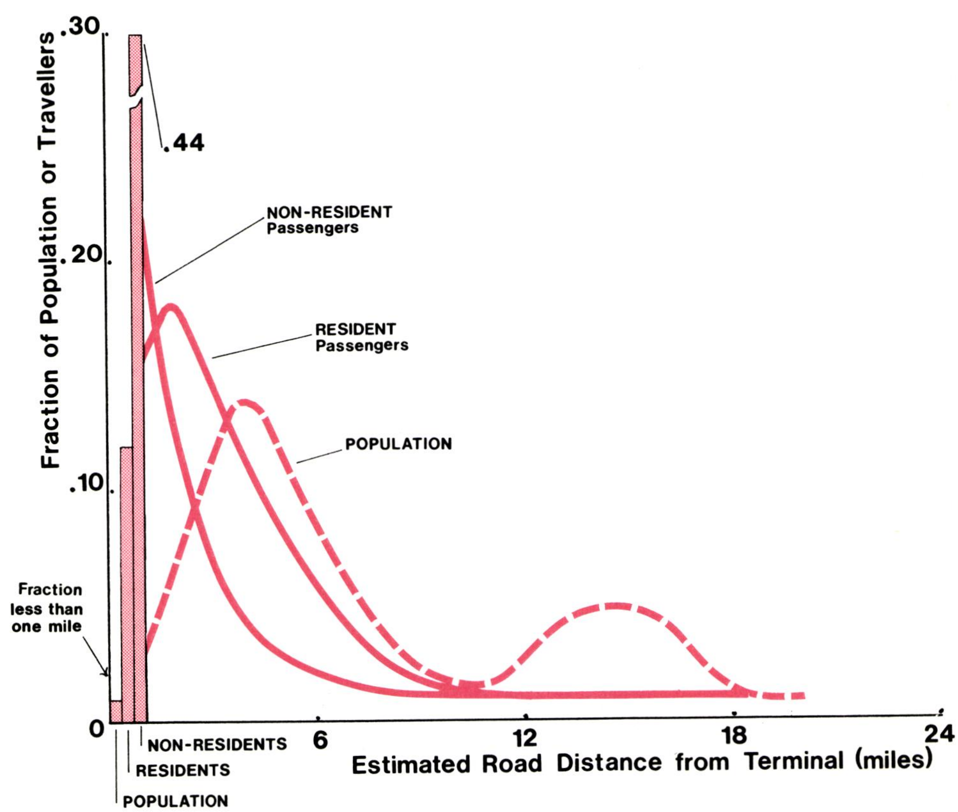



**Figure 3.10** **Distribution of population and trip origins of departing passengers by distance from Montreal downtown.**

**Table 3.5 Average Terminal Waiting Times (minutes)**

| City | Routes | Air Business | Air Non-business | Rail Business | Rail Non-business |
|---|---|---|---|---|---|
| Montreal— | Toronto Dep. | 42.50 | 62.23 | | |
| Toronto— | Montreal Dep. | 39.90 | 43.41 | | |
| Ottawa— | Toronto Dep. | 30.32 | 38.55 | | |
| | Montreal Dep. | | | 21.18 | 23.89 |
| Quebec— | Quebec Dep. | 31.89 | 36.69 | 28.02 | 34.46 |

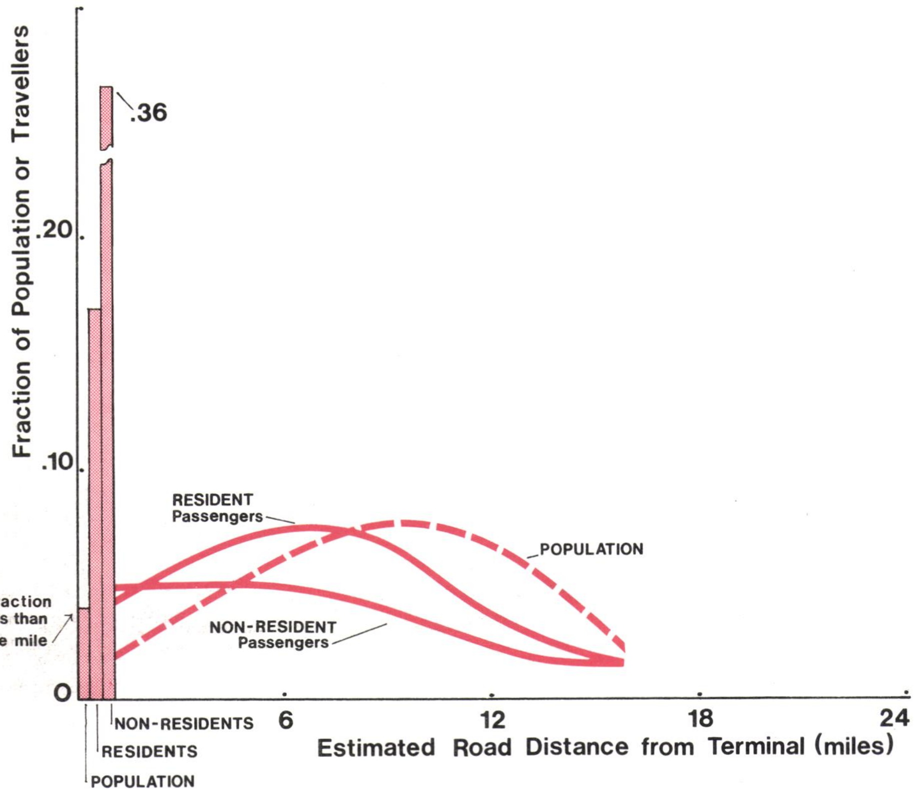



**Figure 3.11 Distribution of population and trip origins of departing passengers by distance from Toronto downtown.**

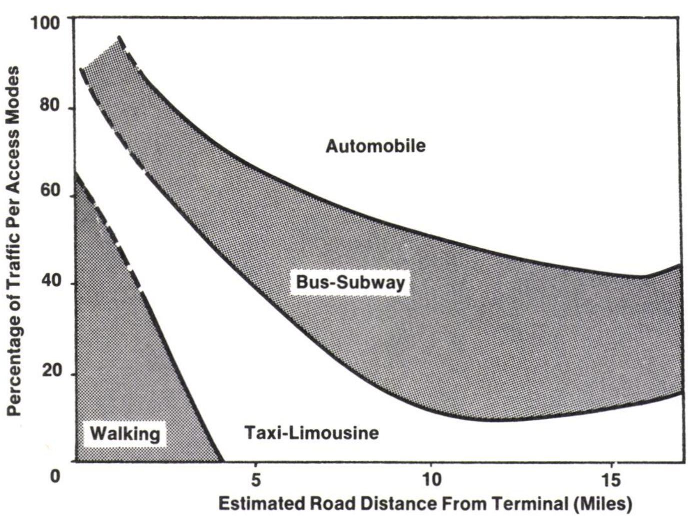



**Figure 3.12 Modal split for access to Toronto Union Station.**

sident and non-resident traffic. These distributions are shown in Figures 3.15 and 3.16.

(4) **Access Time**—In Figure 3.17, each point indicates time taken from a specific area to the terminal, distance travelled and access mode used. Regression lines were fitted to these points as shown.

Due to parking, traffic congestion for automobiles, and waiting and transfer times for public transit, walking is the fastest access mode for under two miles as seen in Figure 3.17. Despite parking problems and congestion, automobile travel is the fastest access mode at distances greater than two miles.

Figure 3.18 shows automobile access times for Montreal and Toronto airports using modified exponential curves fitted by regression. Similar speeds are obtained up to ten miles from the terminals in both cities. Because Montreal is a more compact city, speeds increase at shorter distances than in Toronto. However, in both cases, speeds increase relative to distance from the downtown areas due to expressways and the lack of congestion.

**Terminal Waiting Times**—Average waiting times in the terminals were determined for business and non-business travellers. These are presented in Tables 3.5 and 3.6 for departing and arriving passengers. They represent the answers to questions 10 and 15 of the survey.[1]

The waiting times are partially the consequence of traveller's behaviour and thus are not determined wholly by the nature of the terminal. They include a time allowance the traveller gives himself in order to make certain that he catches the departing train, plane, or bus. There is always some uncertainty about the time it will take to get to the terminal and the time it will take to negotiate the terminal which is reflected in this time allowance. In addition, the frequency of the service and the length of the trip will have an effect on the waiting time. Generally, the experienced business traveller allows a shorter waiting time than the non-business traveller.

[1] Question 10: How long were you at the terminal before this vehicle departed? (If still waiting, how long do you think the wait will be?)

Question 15: How long do you think it will take you to get from the terminal to your final destination?

**Table 3.6 Average Terminal Waiting Times (minutes)**

| City | Routes to | | Air | Rail | Bus |
|---|---|---|---|---|---|
| Montreal— | Toronto | Dep. | 51.64 | 44.08 | |
| | Ottawa | Dep. | | 34.16 | 27.28 |
| | Quebec | Dep. | | 39.12 | |
| Toronto— | Montreal | Dep. | 40.64 | 35.51 | 34.88 |
| Ottawa— | Toronto | Dep. | 32.85 | | |
| | Montreal | Dep. | | 23.02 | 21.93 |
| Quebec— | Quebec | Dep. | 33.63 | 33.03 | 28.99 |

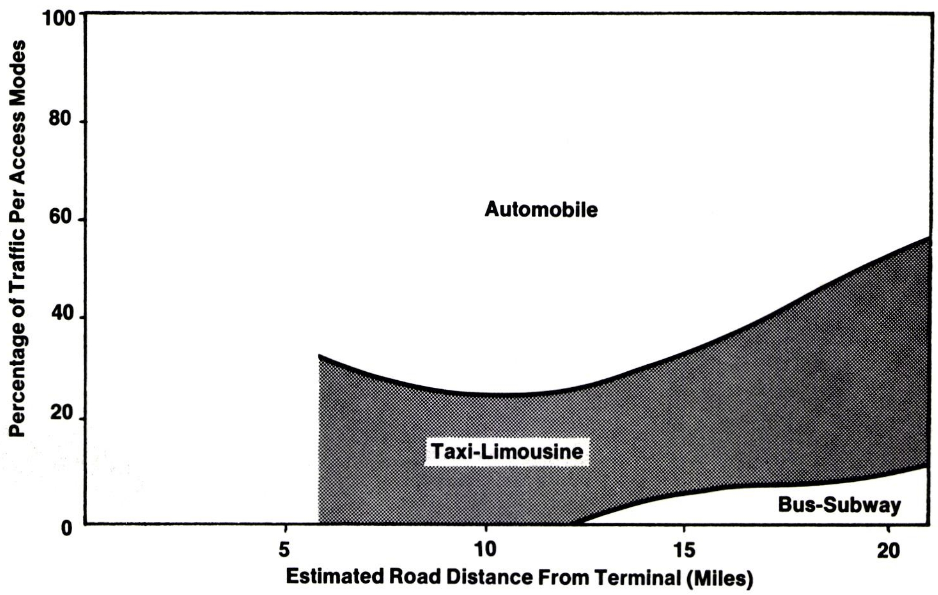



**Figure 3.13 Modal split for access to Malton Airport, Toronto.**

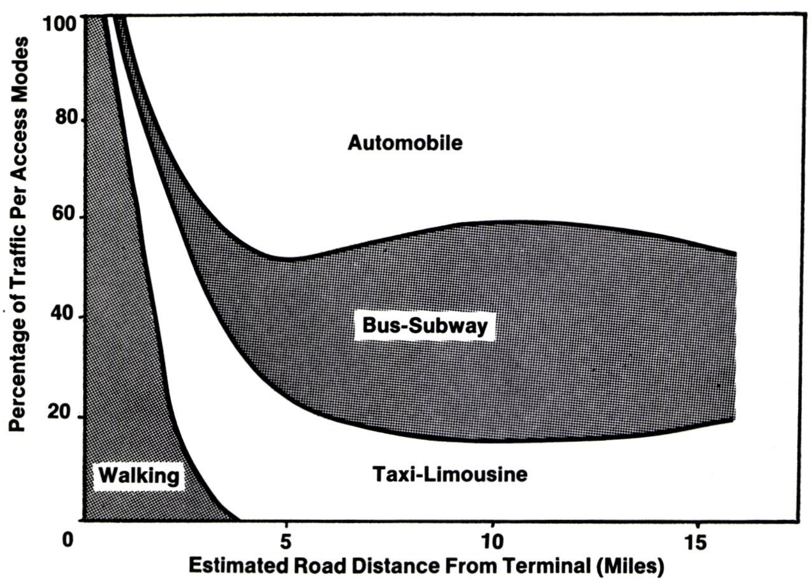



**Figure 3.14 Modal split for access to Montreal rail stations.**

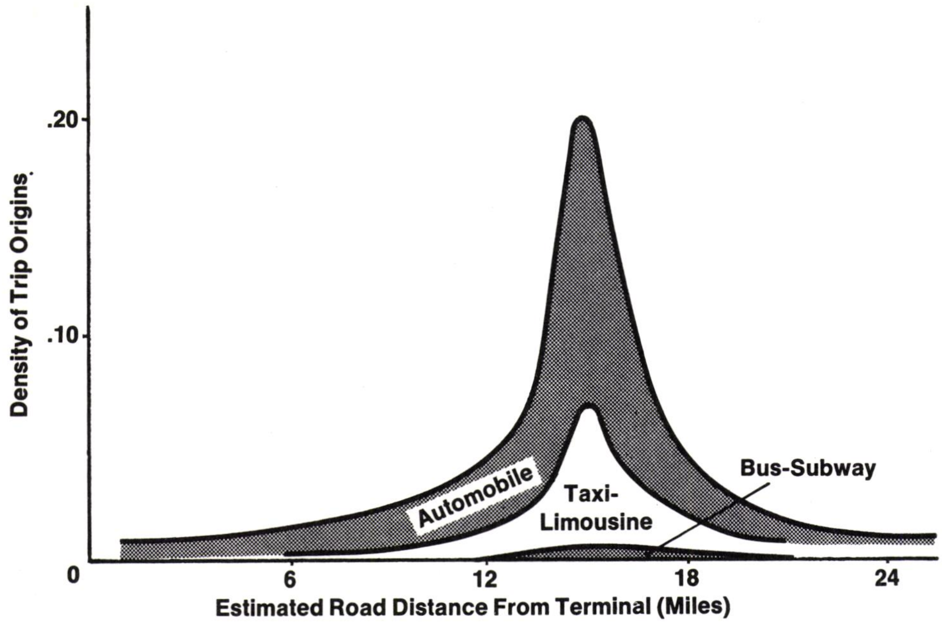



**Figure 3.15 Density of trip origins by mode and distance for non-resident departures from Malton Airport, Toronto. Note that the area under each curve represents the percentage of non-resident departures using that access mode for any distance range from the airport**

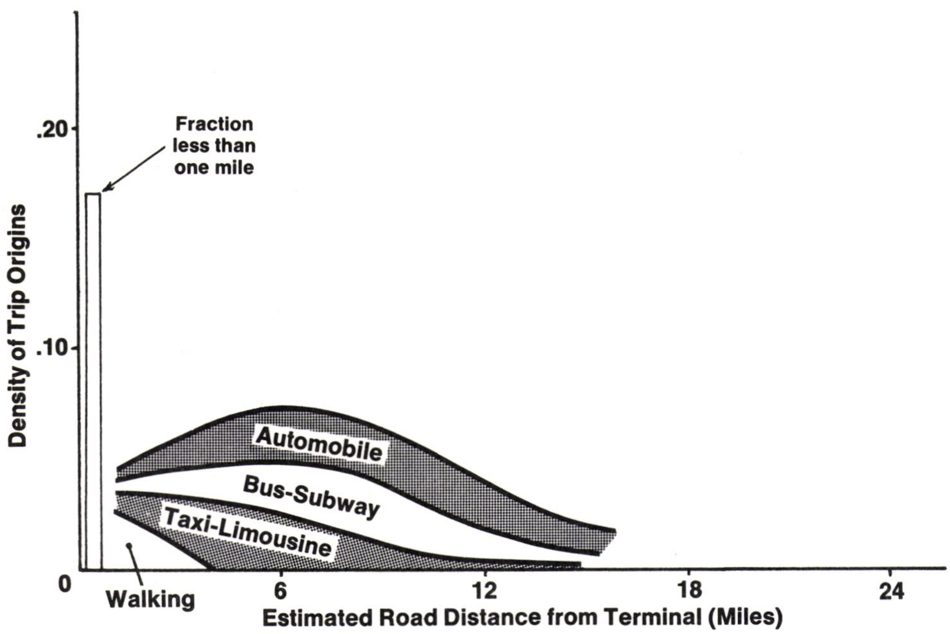



**Figure 3.16 Density of trip origins by mode and distance for resident departures from downtown Toronto bus and rail terminals (see note on Figure 3.15).**

## 3.3 Common Carrier Flows

The pattern of common carrier flows in the Corridor is shown in Figure 3.19. The pattern is distinctly different from that of automobile traffic in Figure 3.25 and is clearly dominated by the Montreal-Ottawa-Toronto links.

The flows and modal splits for certain intercity links are given in Figure 3.20 and Table 3.7. These are preliminary results based on unedited survey data.

## 3.4 Automobile Travel Characteristics

The automobile, with its inherent privacy, comfort, and high mobility continues to play a large role in intercity travel. Data of the type collected by the common carrier survey is difficult to accumulate for automobile travellers, and for the purposes of this study it was decided that available data would be utilized.

**Table 3.7 Estimated Intercity Traffic Flows by Common Carrier in 1969**

| | | | |
|---|---|---|---|
| Quebec | — | | |
| Montreal | **620**<br>.30<br>.56<br>.14 | | |
| Ottawa | **48**<br>.26<br>.33<br>.41 | **705**<br>.36<br>.57<br>.07 | |
| Toronto | **56**<br>.06<br>.33<br>.61 | **1164**<br>.05<br>.36<br>.59 | **416**<br>.21<br>.19<br>.61 |
| Hamilton | **4**<br>.12<br>.41<br>.47 | **57**<br>.10<br>.55<br>.35 | **35**<br>.31<br>.17<br>.52 |
| London | —<br>—<br>—<br>— | **40**<br>.04<br>.40<br>.56 | **26**<br>.09<br>.27<br>.64 |
| Windsor | —<br>—<br>—<br>— | **41**<br>.07<br>.34<br>.59 | **14**<br>.08<br>.27<br>.65 |

*Key:* **620**—Estimated Annual Volume (Origin Destination) (2 way person trips—thousands)
.30—Modal Split: Bus
.56 Rail
.14 Air

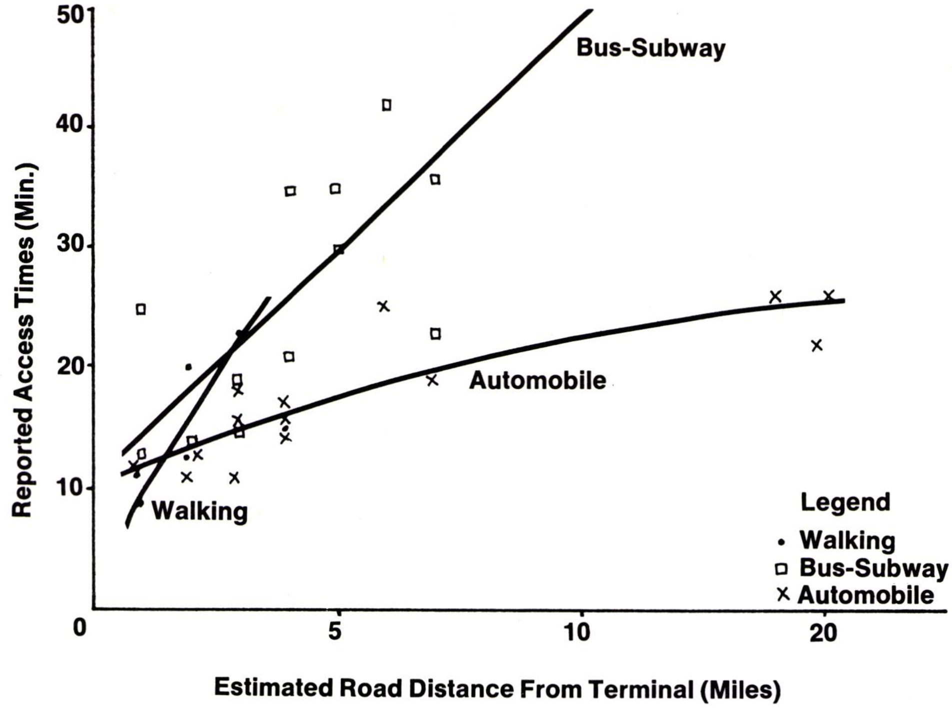



Figure 3.17 Reported access time for each access mode to bus and rail terminals in downtown Montreal.

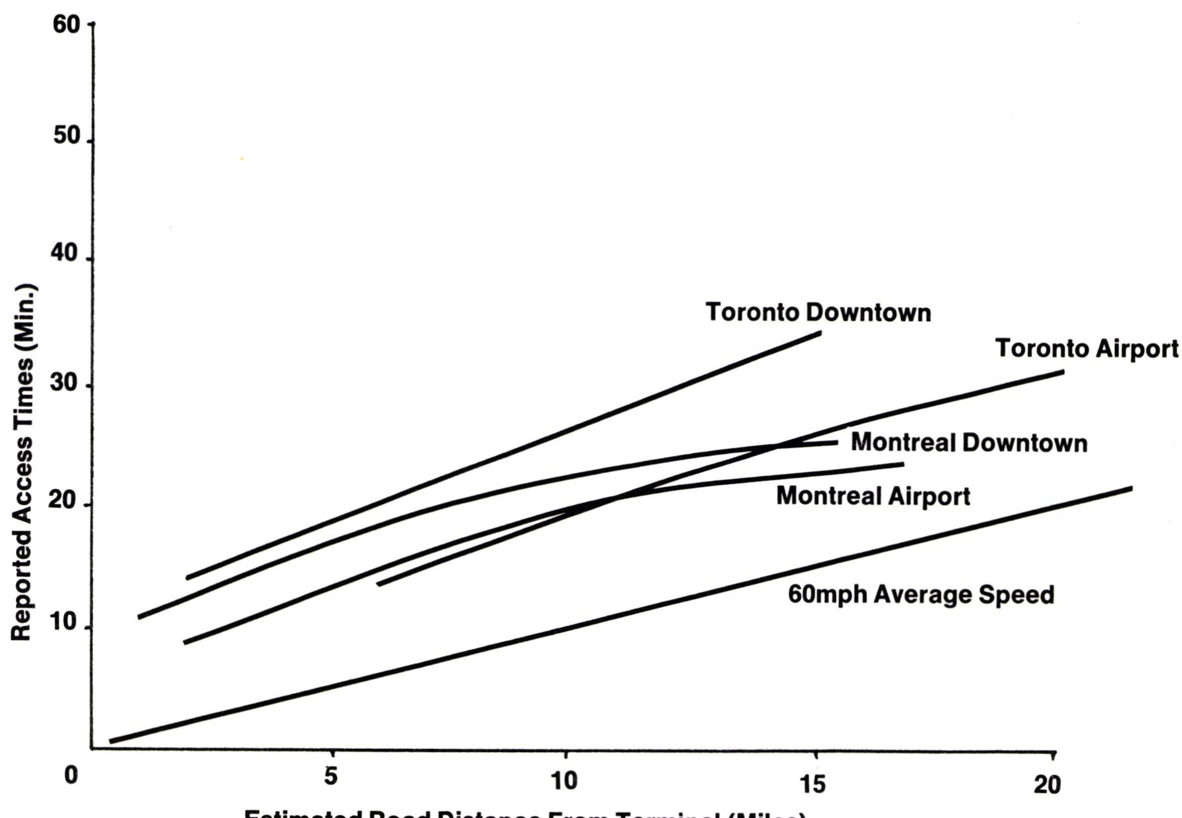



Figure 3.18 Reported access times by automobile to Montreal and Toronto terminals.

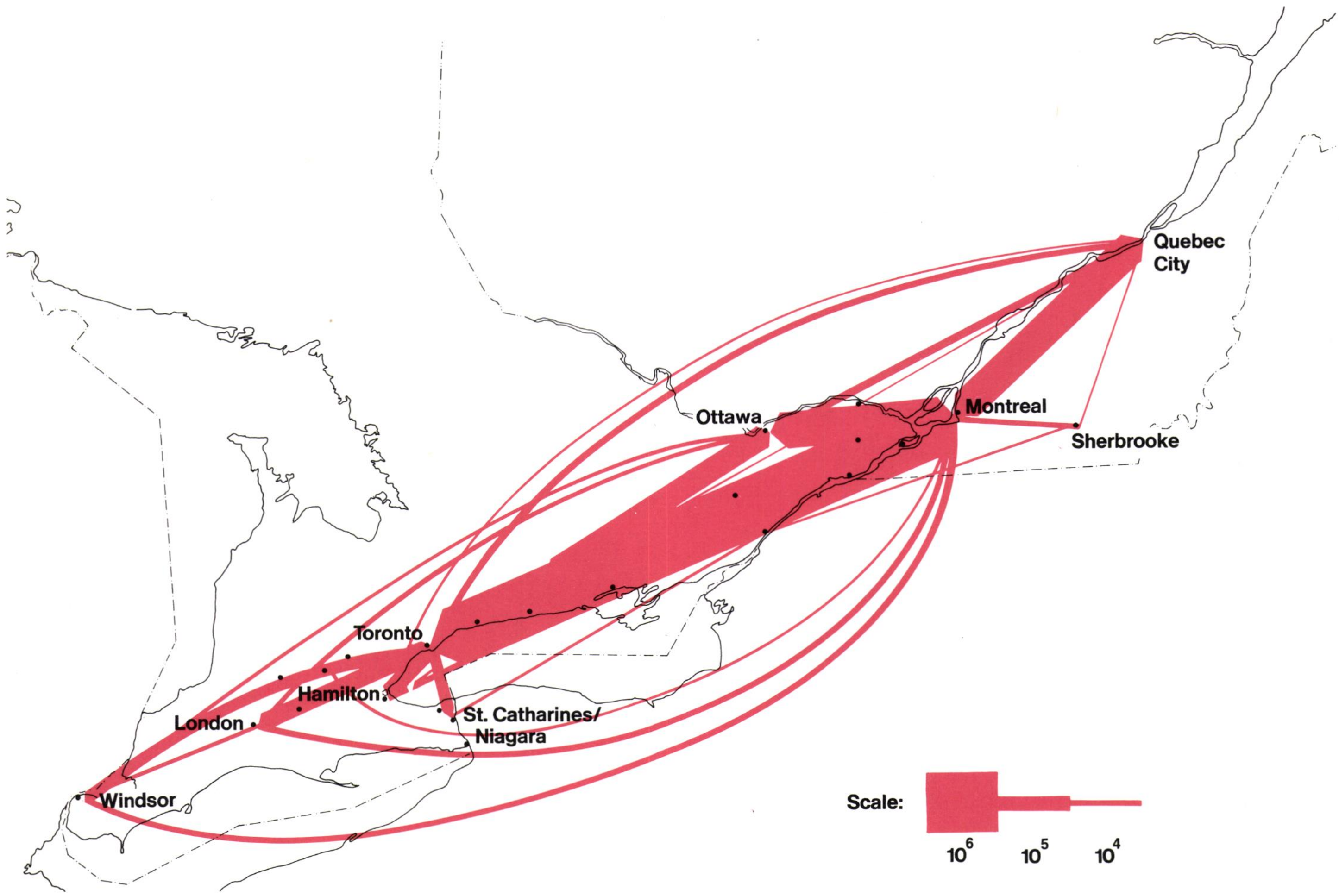



**Figure 3.19 Common carrier origin-destination flows.**

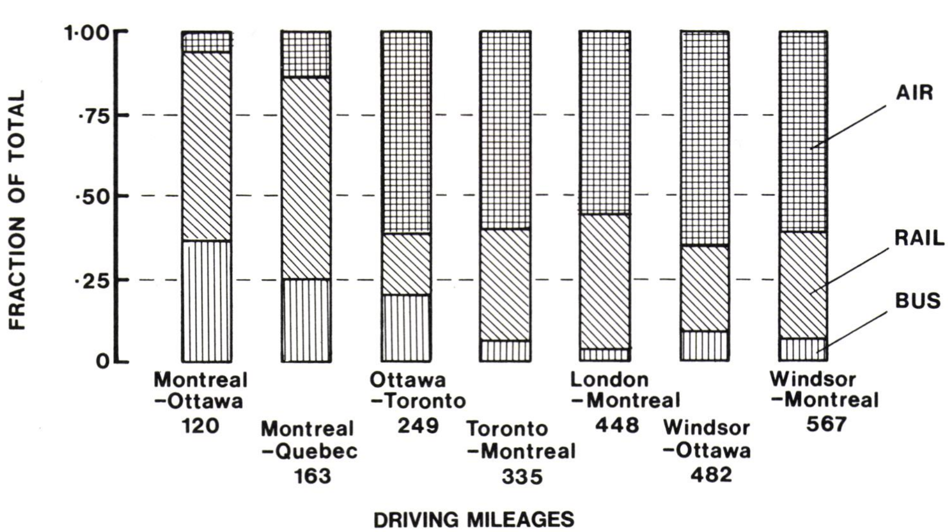



**Figure 3.20 Existing common carrier modal splits for selected city pairs.**

All the major cities, with the exception of Ottawa, are served by limited access four lane highways (Figure 3.21). The distances from Ottawa to the limited access links are small in comparison to most link lengths and therefore the effect on interaction will be minimal. Distances for all major links are less than 500 miles and Figure 3.22 shows that the automobile maintains a competitive time advantage over the common carriers within the greater part of this range. The broad band representing average total trip time by common carriers has city pairs with good common carrier service such as Montreal-Toronto at the bottom and city pairs with poor service such as Sherbrooke-London at the top.

In making an automobile trip, the average person considers only his direct trip expenses, such as fuel, oil and tires, neglecting to take into account the costs of depreciation, maintenance and ownership costs. This results in perceived costs lower than the total costs as shown in Figure 3.23. The costs here are based on average running speeds with slightly congested

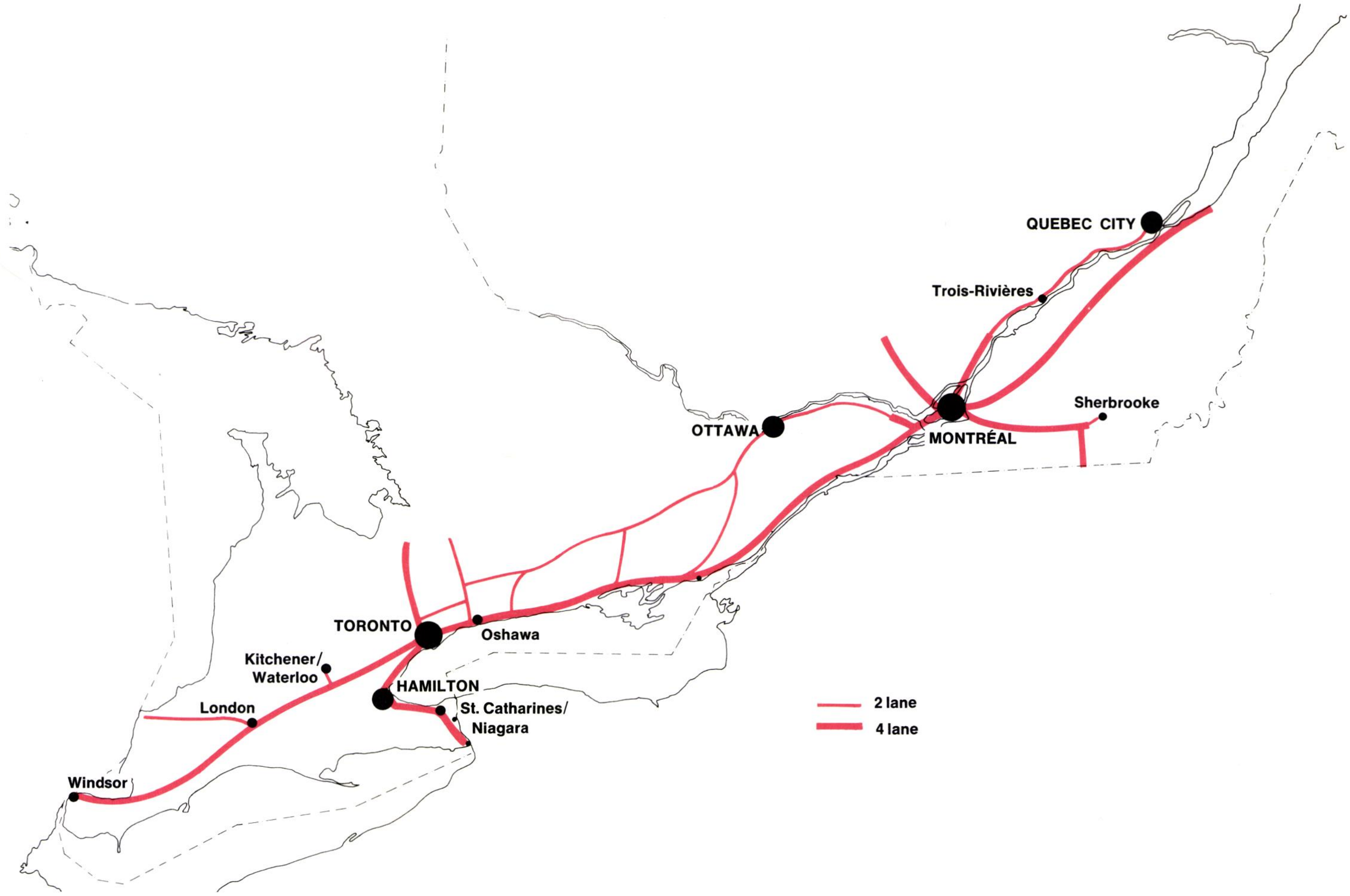



**Figure 3.21 Principal intercity highway network.**

highway conditions (Level of Service "B") and reflect maximum speeds in the order of 10 mile/h higher.

The ownership statistics in Figure 3.24 indicates that the percentage of households operating automobiles is tending towards saturation at about 80 percent This means that the percentage of people with access to automobiles is approaching saturation, while the number of cars per family continues to rise. Growth of traffic volumes can then be attributed to four sources:

(1) increases in population
(2) increased interaction between the cities
(3) diversion from other modes
(4) changes in behavioural patterns

Relative to this latter point, a 1967 Canadian National Survey (*4*) found that of those travelling by air, 4 percent were doing so due to no access to a car, while for rail the figure was 34 percent and for bus 62 percent. As might be expected, most of these people were in the lower income brackets.

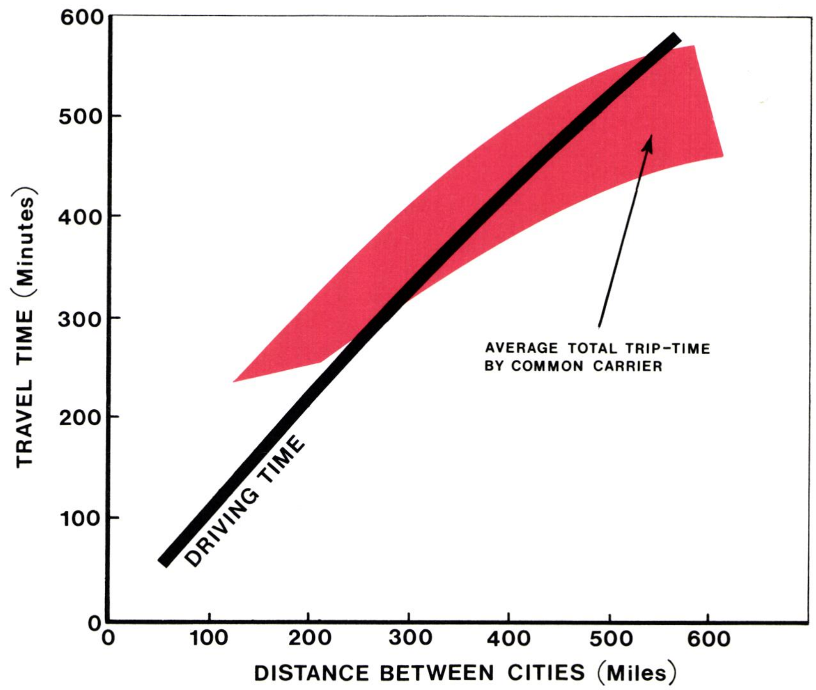



**Figure 3.22 Comparison of travel times between automobiles and common carriers against trip distance.**

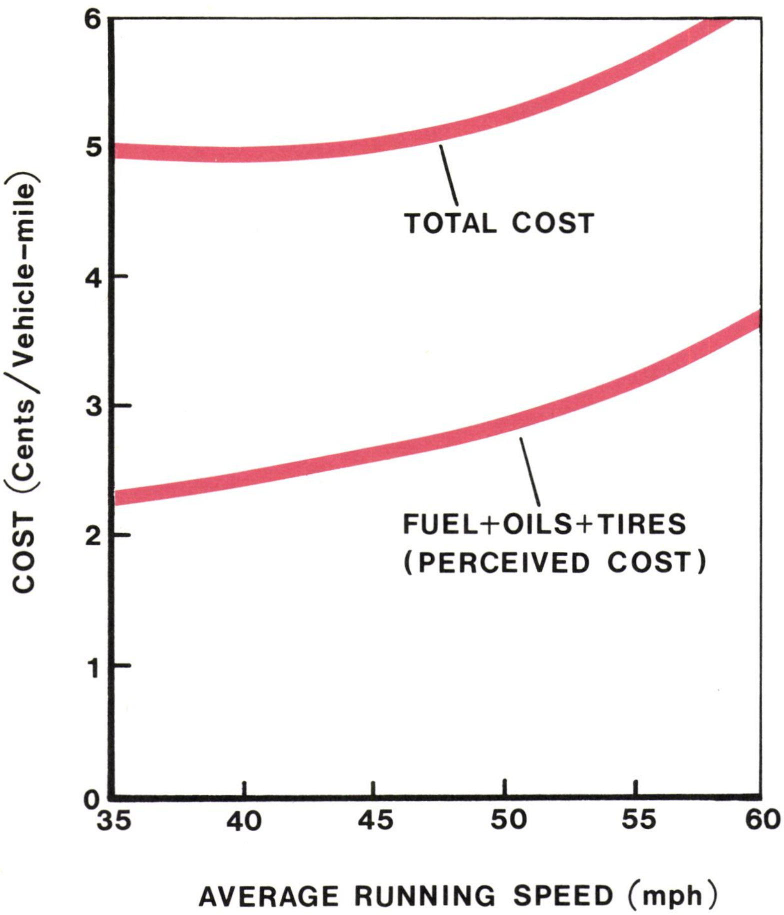



**Figure 3.23 Typical automobile operating costs on rural freeways.**

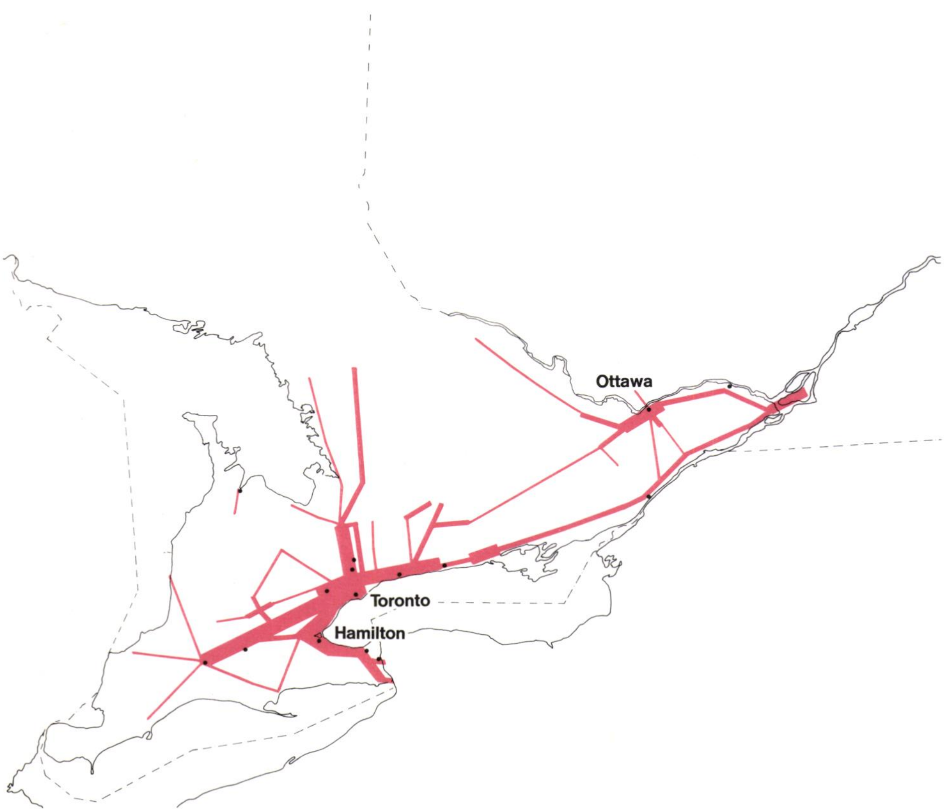



**Figure 3.25 Road flows on selected Ontario highways.**

Table 3.8 lists driving distances and typical driving times based on information from the Ontario Motor League. The table can be compared with Tables 3.1, 3.2 and 3.3 listing times for the common carriers. The time differences between automobile and common carrier travel are shown graphically in Figure 3.22.

Representative intercity automobile volumes based on data from the Department of Highways, Ontario are shown in Table 3.9. These volumes are approximately represented in Figure 3.25. Note the relative dominance of local traffic compared with long distance flows.

## 3.5 User Characteristics Introduction

The purpose of this section is to identify the segments of the urban population which are under-served or are under-utilizing the existing transport network. The characteristics of those who use the network are outlined in relation to the resident population of the cities in which they live. The data has been obtained from the CTC O-D Survey of Summer 1969 and the Canada Census.

Cities are consistently defined as census Metropolitan Areas for the collection of both resident and sample data. A traveller is said to be a resident of a given city if he responded that that city was his *permanent* residence rather than one he visited.

A relationship is shown as directly as possible within the limitations of the data. For example, the particular age/sex distribution of travellers residing in Toronto is related to the general age/sex distribution from the Census of Canada for all Toronto residents. It was not feasible to estimate family income distribution for each city; hence, these particular statistics are related to the provincial estimates.

Automobile travel was not included in the survey. An indication of people without direct access to automobiles can be deduced from car ownership and driver's licence statistics. However, it is not possible to determine the degree of secondary access to an automobile (i.e. travelling as a passenger with family or friends).

In the interpretation of the available data, it should be remembered that each completed questionnaire does not, as in a census, necessarily represent a single individual. A frequent traveller may have been sampled more than once.

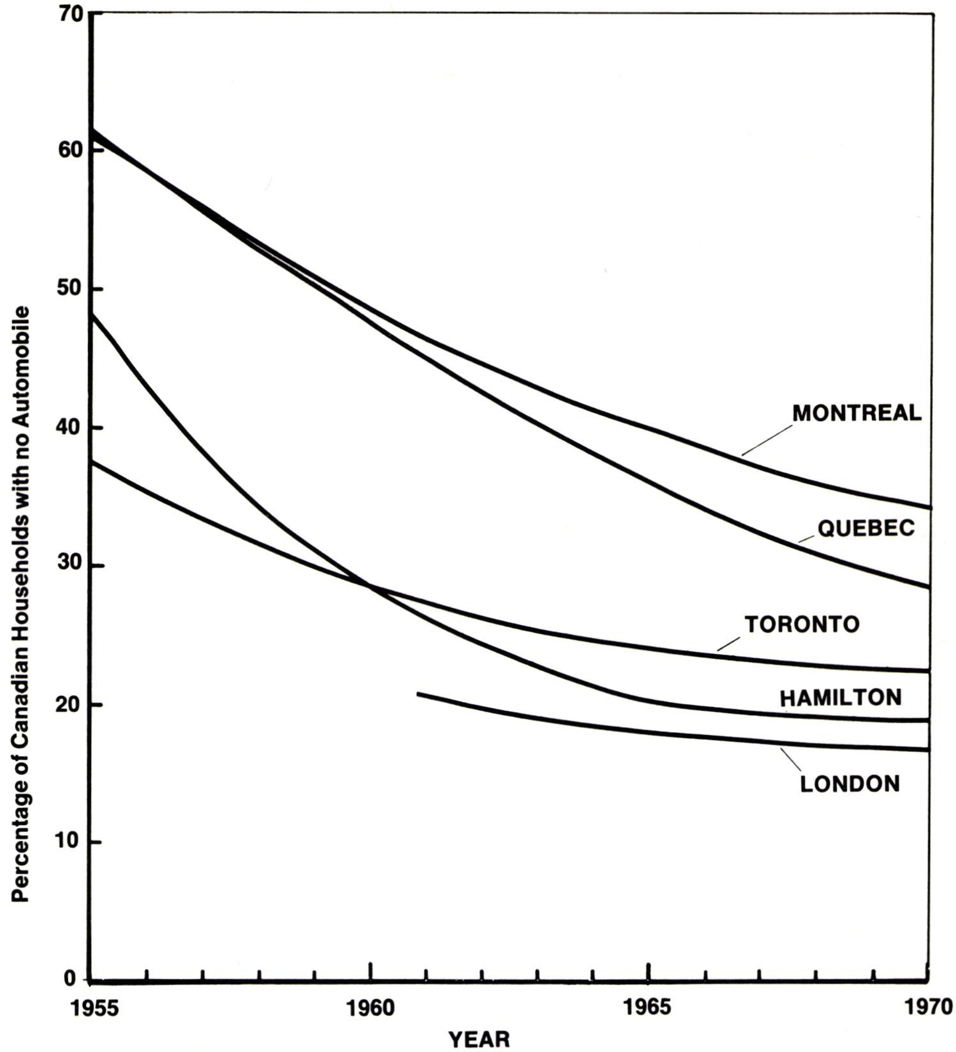



**Figure 3.24** Percentage of households without automobiles in selected Canadian cities.

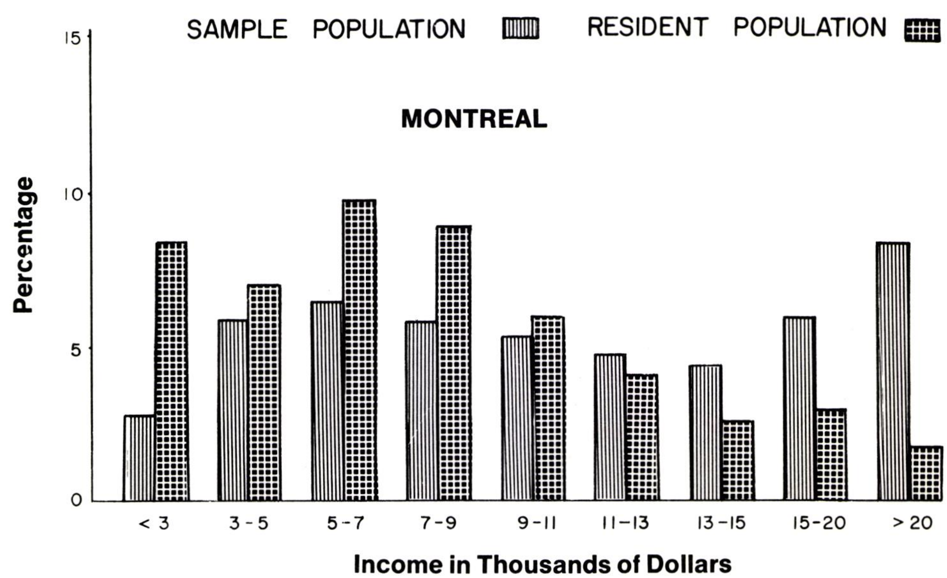



**Figure 3.26** Distribution of travelling Montreal residents by family income.

**Table 3.8 Distances and Times by Automobile from City Centre to City Centre in 1969**

*Key* | 0h52<br>41 | — Time (hours and minutes)<br>— Distance (miles)

Notes: Fastest route listed.
Average speeds used:
60 mile/h-limited access
50 mile/h-2 lane rural
40 mile/h-urban roads

| | Toronto | Three Rivers | Sherbrooke | St. Catharines | Québec | Ottawa | Oshawa | Niagara Falls | Montreal | London | Kitchener | Hamilton |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kitchener | | | | | | | | | | | | 0h52<br>41 |
| London | | | | | | | | | | | 1h10<br>60 | 1h44<br>82 |
| Montreal | | | | | | | | | | 7h40<br>448 | 6h55<br>396 | 6h31<br>375 |
| Niagara Falls | | | | | | | | | 7h05<br>413 | 2h40<br>126 | 1h36<br>87 | 0h56<br>44 |
| Oshawa | | | | | | | | 1h55<br>113 | 5h10<br>300 | 2h37<br>155 | 1h51<br>103 | 1h21<br>75 |
| Ottawa | | | | | | | 4h05<br>214 | 6h<br>327 | 2h15<br>120 | 6h35<br>362 | 5h50<br>310 | 5h26<br>289 |
| Québec | | | | | | 5h<br>280 | 8h05<br>462 | 10h<br>575 | 3h<br>163 | 10h35<br>610 | 9h49<br>558 | 9h26<br>537 |
| St. Catharines | | | | | 9h50<br>565 | 5h50<br>317 | 1h45<br>103 | 0h10<br>10 | 6h55<br>403 | 2h30<br>116 | 1h26<br>77 | 0h46<br>34 |
| Sherbrooke | | | | 8h30<br>498 | 2h52<br>133 | 3h46<br>213 | 6h45<br>395 | 8h40<br>508 | 1h35<br>95 | 9h15<br>543 | 8h29<br>991 | 8h06<br>470 |
| Three Rivers | | | 1h42<br>90 | 8h25<br>486 | 1h41<br>81 | 3h42<br>201 | 6h40<br>383 | 8h35<br>496 | 1h31<br>91 | 9h10<br>531 | 8h31<br>479 | 8h01<br>458 |
| Toronto | | 7h15<br>418 | 7h20<br>430 | 1h10<br>68 | 8h40<br>497 | 4h40<br>249 | 0h35<br>35 | 1h20<br>78 | 5h45<br>335 | 2h02<br>120 | 1h16<br>68 | 0h46<br>40 |
| | 4h13<br>236 | 10h53<br>645 | 11h01<br>661 | 4h30<br>232 | 12h18<br>724 | 8h44<br>482 | 4h34<br>264 | 4h46<br>242 | 9h45<br>567 | 2h22<br>124 | 3h28<br>188 | 3h46<br>198 |

**Table 3.9 Representative Intercity Volumes**

| City Pairs | Year | Annual Passengers (x 1000) Business | Recreation | Total |
|---|---|---|---|---|
| Ottawa-Montreal | 1963 | 222 | 1,023 | 1,245 |
| London-Windsor | 1964 | 272 | 79 | 351 |
| London-Sarnia | 1964 | 176 | 181 | 357 |
| Toronto-St. Catharines | 1963 | 171 | 138 | 309 |
| Toronto-Niagara | 1963 | 203 | 277 | 480 |
| Toronto-London | 1963 | 276 | 18 | 294 |
| Toronto-Windsor | 1964 | 122 | 102 | 223 |
| Toronto-Sarnia | 1964 | 31 | 49 | 80 |
| Toronto-Kingston | 1965 | 54 | 261 | 315 |
| Toronto-Belleville | 1965 | 71 | 99 | 171 |
| Toronto-Port Credit | 1965 | 178 | 208 | 386 |
| Toronto-Brockville | 1965 | 17 | 44 | 61 |
| Toronto-Montreal | 1965 | 77 | 584 | 661 |
| Toronto-Ottawa | 1965 | 65 | 276 | 341 |
| Hamilton-Port Credit | 1965 | 14 | 8 | 22 |
| Hamilton-Montreal | 1965 | 4 | 62 | 66 |
| Hamilton-Ottawa | 1965 | — | 55 | 55 |

### 3.5.1 Aggregate Data

A. **Family Income Data**—The aggregated data for travellers resident in Montreal and Toronto (Figures 3.26 and 3.27) show high utilization by high-income family members and low utilization by low-income family members. The use of public transportation within the middle income group is lower than might be expected, possibly reflecting an automobile orientation, particularly in Toronto. In Montreal, a somewhat greater percentage of the middle income group preferred to use public facilities, possibly due to the lower number of households owning cars (64% in Montreal, 78% in Toronto in 1968).

B. **Age/Sex Data**—From the age/sex distribution data in Toronto and Montreal (Figures 3.28 and 3.29) the disproportionate number of travelling males age 25 to 55 is immediately obvious. To a large extent this is a ramification of the male 'business' role in society generating intercity, rather than intracity or urban-rural travel. In addition, both the Montreal and Toronto distributions show the larger number of 21-25 year old males and females who travel. This indicates the

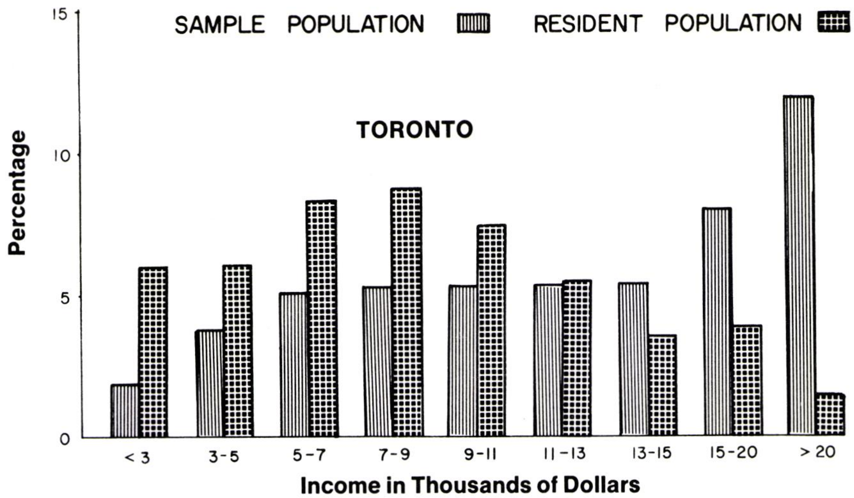



Figure 3.27 Distribution of travelling Toronto residents by family income.

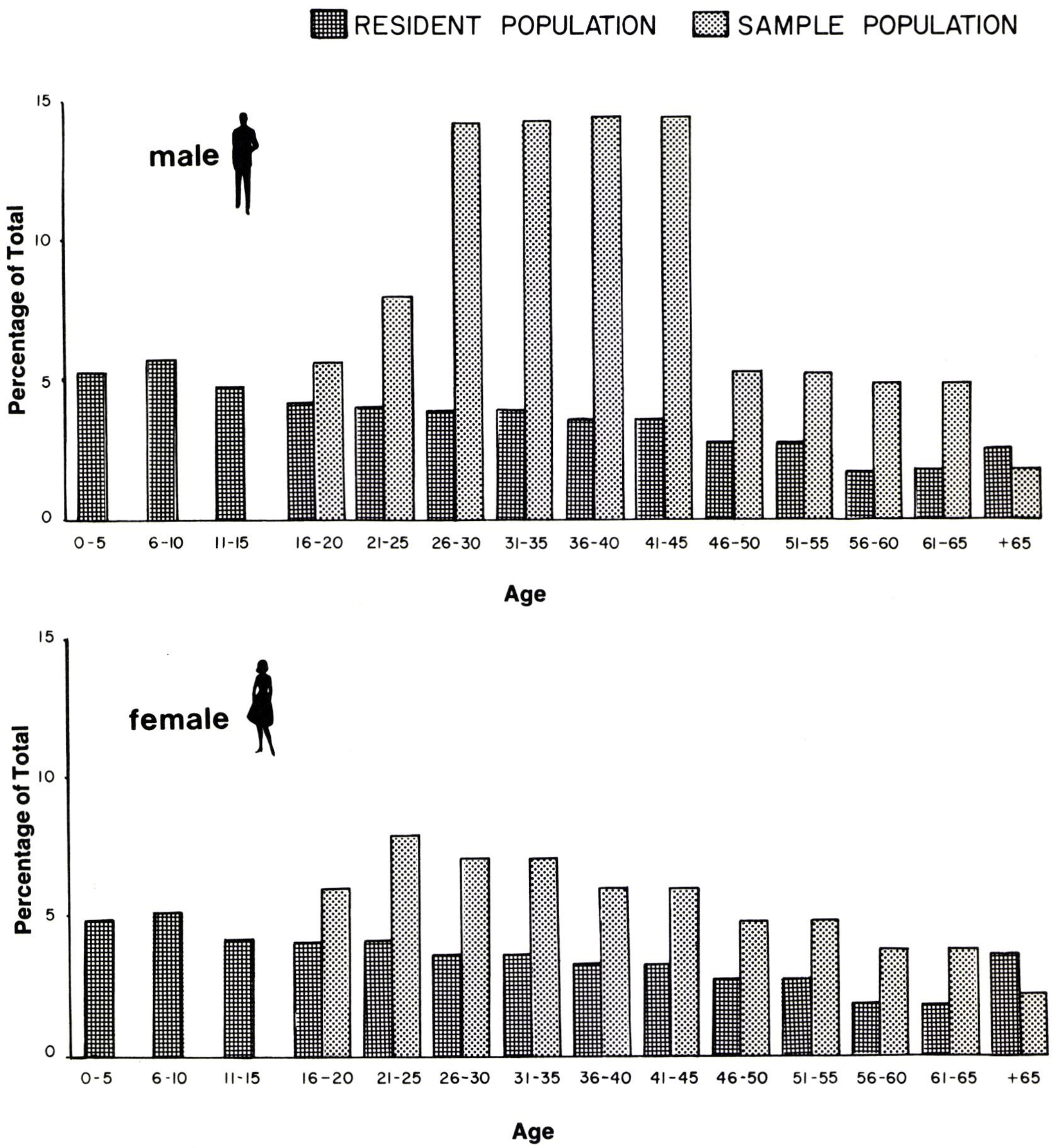



Figure 3.28 Distribution of Montreal travellers by age and sex.

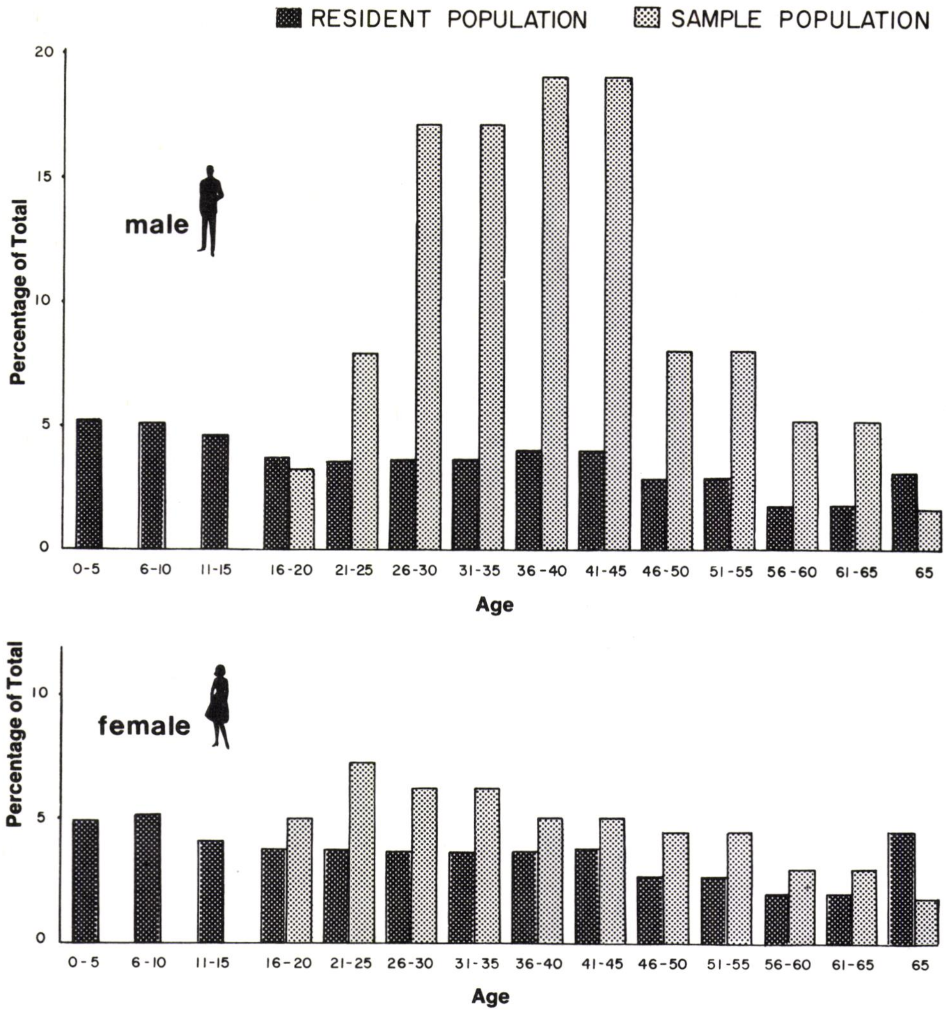



**Figure 3.29 Distribution of Toronto travellers by age and sex.**

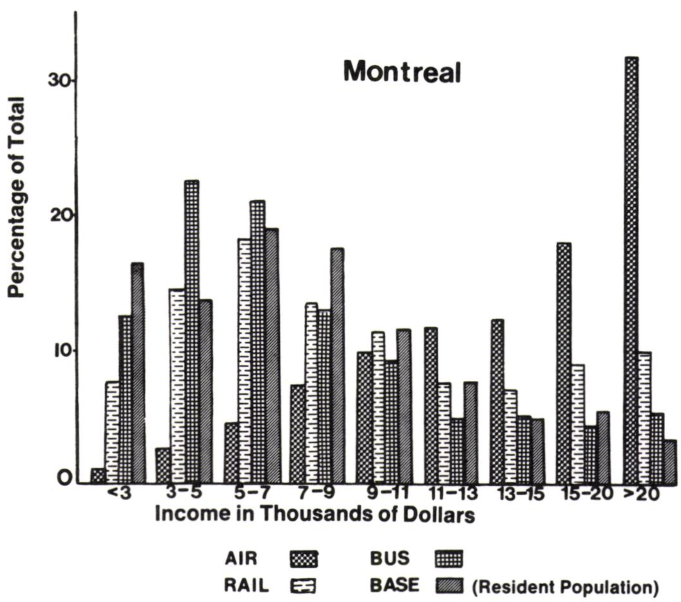



**Figure 3.31 Distribution of travelling Montreal residents by family income and mode.**

mobility of the urban young and represents an important aspect in the growth of intercity travel.

C. **Linguistic Ability Data**—The difference between linguistic ability of the survey respondents and that of the metropolitan resident population may partly be explained by the different format of the bilingualism question on the survey and the Canada Census. Combining questionnaire responses of moderate and fluent bilingualism it appears that bilingual people predominate in travel emanating from each major city in the network (Table 3.10). Their linguistic ability permits the greatest freedom of circulation.

## 3.5.2 Disaggregated Data — by Mode

A. **Family Income Data**—The relationship between income and mode of travel is evident from Figures 3.31 and 3.32. The family income of bus travellers more nearly approximates the distribution of the general population. Airline travel, however, is a function of income. In both Toronto and Montreal, over 50% of the airline passengers surveyed belonged to families earning over $15,000 annually. The annual income of bus travellers was predominantly within the $3,000—$5,000 category; and the rail travellers within the $5,000—$7,000 category (Refer also to Figures 3.26 and 3.27).

B. **Age/Sex Data**—Distinctions between the modes of travel appear when the data displayed in Figure 3.29 (Toronto age/sex) is disaggregated. Air was particularly the mode of the middle-aged male. Rail was the mode of all age groups but with more females (56 percent). But was the mode of younger people (under 35) of both sexes and of older females (refer to Figures 3.33, 3.34 and 3.35).

## 3.5.3 Disaggregated Data — by Purpose

A. **Age/Sex Data**—The variation of users age and sex according to trip purpose is shown in Figures 3.36, 3.37 and 3.38. As expected, business travel dominated the air mode with 68.7 percent of all air travel within the study area by Montreal residents. The comparable figure for business travel by rail is 14 percent, by bus, 5.4 percent.

This analysis shows both rail and bus having a very high proportion of 16-25 year-olds travelling for pleasure. People within this age group are almost twice as

**Table 3.10 Linguistic Characteristics of Travellers**

| | Percentage English | | Percentage Bilingual | | | Percentage French | |
|---|---|---|---|---|---|---|---|
| | Resident | Sample | Resident | Sample Moderate | Sample Fluent | Resident | Sample |
| Montreal | 22.4 | 19.8 | 37.6 | 33.2 | 27.3 | 40.0 | 5.5 |
| Toronto | 95.4 | 57.9 | 4.4 | 31.6 | 7.7 | 0.2 | 0.4 |
| Ottawa | 55.6 | 38.4 | 31.1 | 34.7 | 21.8 | 13.3 | 1.7 |
| Quebec | 1.4 | 1.2 | 24.2 | 45.9 | 30.3 | 74.3 | 20.0 |

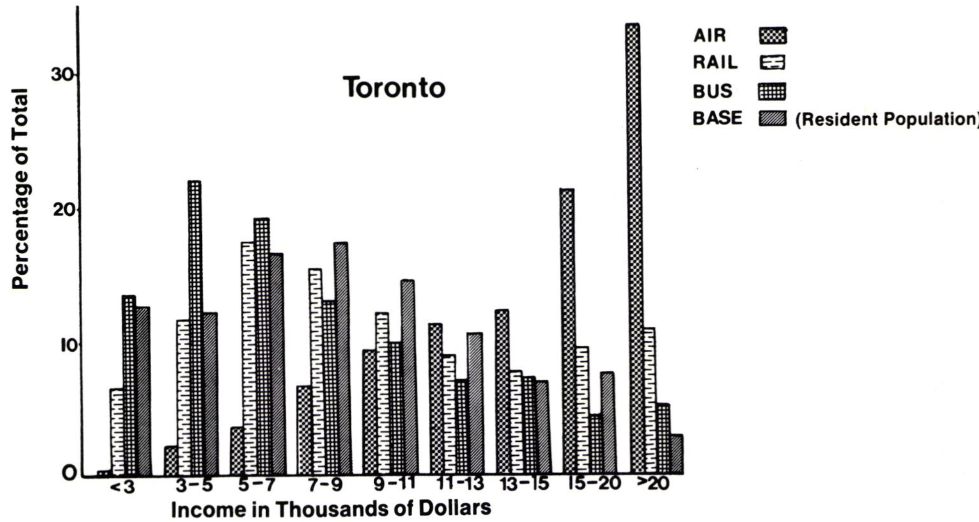



**Figure 3.32 Distribution of travelling Toronto residents by family income and mode.**

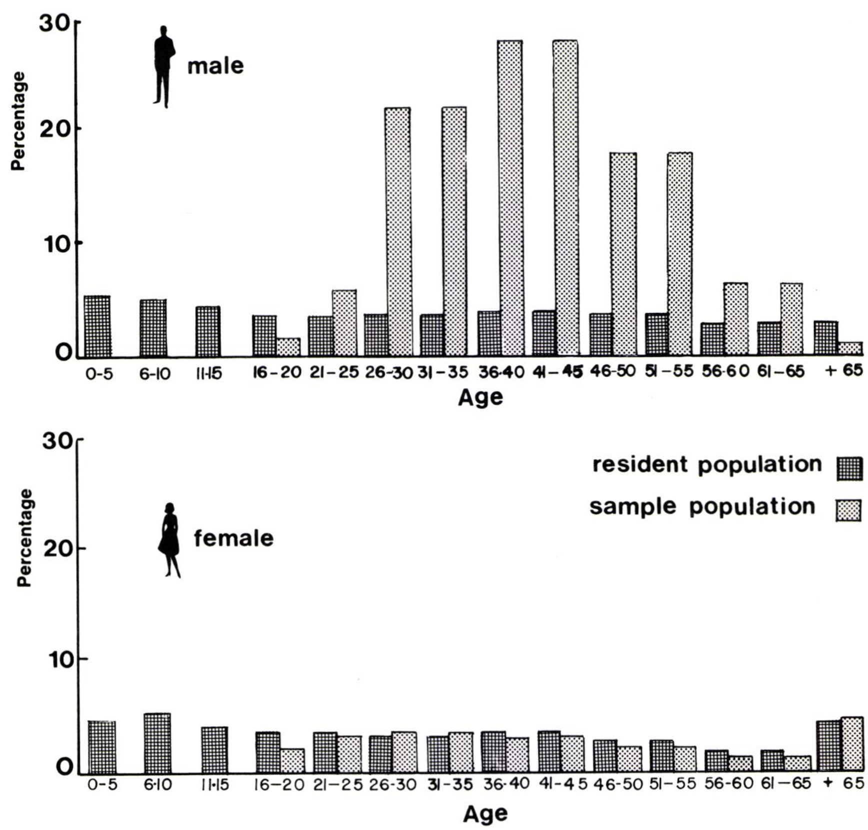



**Figure 3.33 Age and sex distribution of Toronto residents travelling by air.**

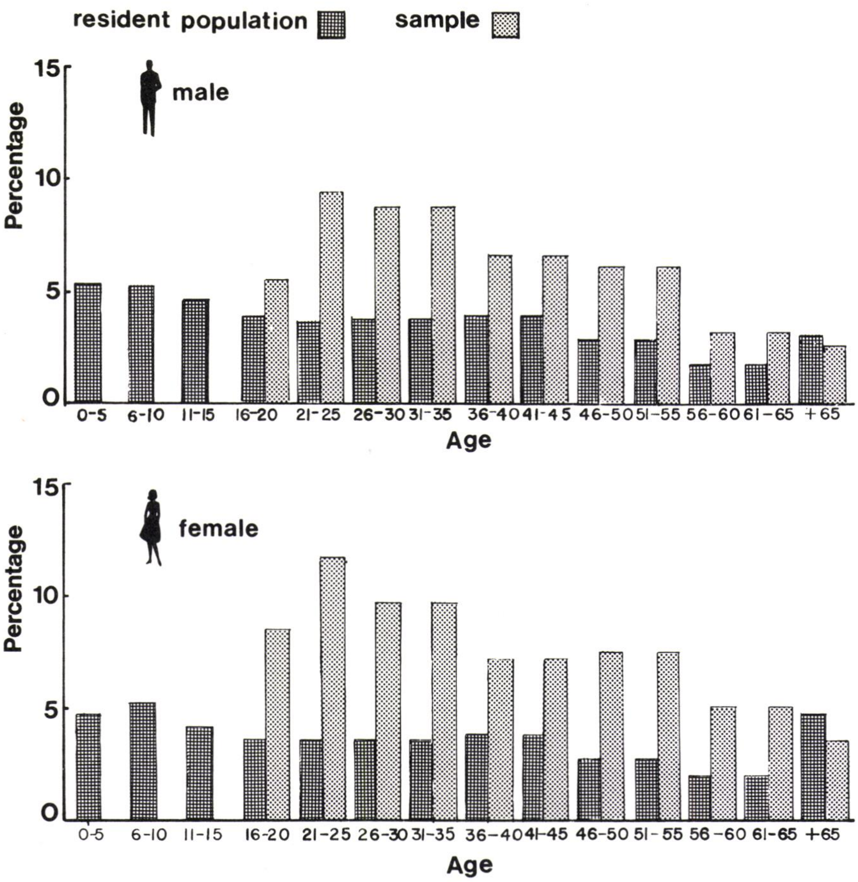



**Figure 3.34 Age and sex distribution of Toronto residents travelling by rail.**

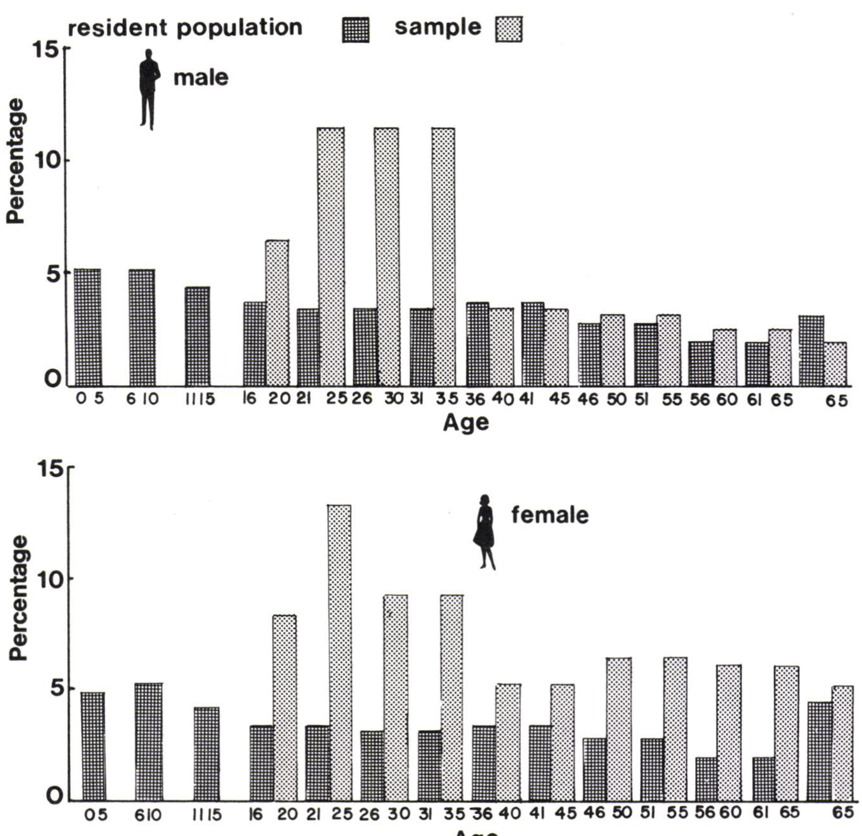



**Figure 3.35 Age and sex distribution of Toronto residents travelling by bus.**

numerous on buses as might be expected from the resident, population of Montreal. Pleasure travel is seasonable and as the survey was conducted during the summer a lower proportion of pleasure travel can be expected in winter.

### 3.5.4 Explanations

There are four principal ways to explain the above variations:

(1) People who possess the characteristics under-represented in the sample may not desire or need to make intercity journeys.

(2) Those under-represented may not be able to afford such journeys.

(3) Those under-represented may be using private automobiles.

(4) The data may have appreciable inaccuracies.

1. **Lack of desire or need**—Even a complete lack of constraints does not necessarily mean that most people will travel, as need and desire to travel are closely related to perceived possibilities of travelling (shaped by cost).

Still, inter-city mobility opens a far greater range of options to an individual. The business segment of society has realized this, as has the federal government, which represently has a Manpower program to aid those who undertake inter-regional travel in search of work.

2. **Income Deterrent**—Those having low family incomes are significantly underpresented in all the surveyed modes of travel. Airline service definitely shows the effect of income constraints.

3. **Automobile Travel**—It is unlikely that the distribution of user characteristics would resemble the total resident population even if automobile travellers were included. The age/sex distribution of Ontario Driver's Licence holders (Figure 3.39) shows a marked similarity to the age/sex distribution of Toronto residents travelling by common carrier (Figure 3.29).

There is inadequate information to further pursue a study of automobile user characteristics.

**Table 3.11 Travel Purpose (%) for Air & City Pair**

| | Ottawa-Hamilton | Ottawa-Toronto | Ottawa-Montreal | Ottawa-Quebec | Montreal-Hamilton | Montreal-Toronto | Montreal-Quebec | Toronto-Quebec |
|---|---|---|---|---|---|---|---|---|
| Vacationing/Sightseeing | 4.88 | 3.08 | 8.21 | 1.60 | 7.65 | 3.68 | 11.88 | 17.08 |
| Visit Friends and Relatives | 24.63 | 11.30 | 7.08 | 18.40 | 10.10 | 8.16 | 7.89 | 7.95 |
| Shopping, Entertainment or Sports Events | — | .53 | .23 | — | 1.82 | .90 | .35 | — |
| To or From Place of Work (commuting) | 1.93 | 3.10 | 3.50 | .63 | 3.75 | 1.88 | .70 | — |
| Travelling on Company Business | 57.13 | 70.03 | 71.53 | 60.70 | 69.90 | 75.65 | 66.60 | 52.30 |
| Travelling on Personal Business | 5.00 | 8.18 | 7.60 | 18.67 | 2.88 | 6.20 | 8.05 | 17.04 |
| Other | 5.88 | 3.58 | 1.85 | — | 3.90 | 3.08 | 4.18 | 5.63 |
| No Response | .55 | .20 | — | — | — | .45 | .35 | — |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

**Table 3.12 Travel Purpose (%) for Rail & City Pair**

| | Ottawa-Hamilton | Ottawa-Toronto | Ottawa-Montreal | Ottawa-Quebec | Montreal-Hamilton | Montreal-Toronto | Montreal-Quebec | Toronto-Quebec |
|---|---|---|---|---|---|---|---|---|
| Vacationing/Sightseeing | 12.03 | 13.40 | 13.58 | 17.48 | 22.23 | 17.65 | 26.15 | 34.43 |
| Visit Friends and Relatives | 71.13 | 43.80 | 34.43 | 57.05 | 44.30 | 38.58 | 35.87 | 36.45 |
| Shopping, Entertainment or Sports Events | — | 4.35 | 6.03 | 3.83 | 1.70 | 2.13 | 3.35 | 1.43 |
| To or From Place of Work (commuting) | — | 2.52 | 3.00 | — | — | 1.58 | 1.85 | 1.63 |
| Travelling on Company Business | 4.00 | 10.30 | 21.83 | 8.05 | 6.28 | 15.15 | 14.85 | 2.43 |
| Travelling on Personal Business | 9.75 | 14.83 | 13.50 | 7.83 | 7.29 | 11.46 | 8.85 | 7.40 |
| Other | 3.09 | 10.25 | 6.98 | 5.18 | 16.90 | 12.70 | 8.05 | 15.95 |
| No Response | — | .55 | .65 | .58 | 1.30 | .75 | 1.03 | .28 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

**Table 3.13 Travel Purpose (%) for Bus & City Pair**

| | Ottawa-Hamilton | Ottawa-Toronto | Ottawa-Montreal | Ottawa-Quebec | Montreal-Hamilton | Montreal-Toronto | Montreal-Quebec | Toronto-Quebec |
|---|---|---|---|---|---|---|---|---|
| Vacationing/Sightseeing | 20.10 | 16.23 | 22.01 | 16.08 | 18.35 | 21.23 | 21.25 | 58.03 |
| Visit Friends and Relatives | 53.92 | 47.98 | 38.28 | 52.20 | 66.95 | 48.25 | 39.15 | 14.43 |
| Shopping, Entertainment or Sports Events | 4.25 | .98 | 5.03 | .48 | — | 2.70 | 3.75 | — |
| To or From Place of Work (commuting) | 1.35 | 3.50 | 4.70 | 10.05 | 2.58 | 2.63 | 2.03 | 1.45 |
| Travelling on Company Business | — | 2.05 | 5.55 | 11.65 | — | 1.38 | 6.15 | 2.63 |
| Travelling on Personal Business | 8.10 | 11.03 | 16.05 | 6.28 | 6.74 | 12.95 | 16.68 | 9.63 |
| Other | 11.68 | 17.30 | 7.75 | 3.26 | 3.48 | 8.18 | 10.60 | 13.83 |
| No Response | .60 | .60 | .63 | — | 1.90 | 2.68 | .39 | — |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

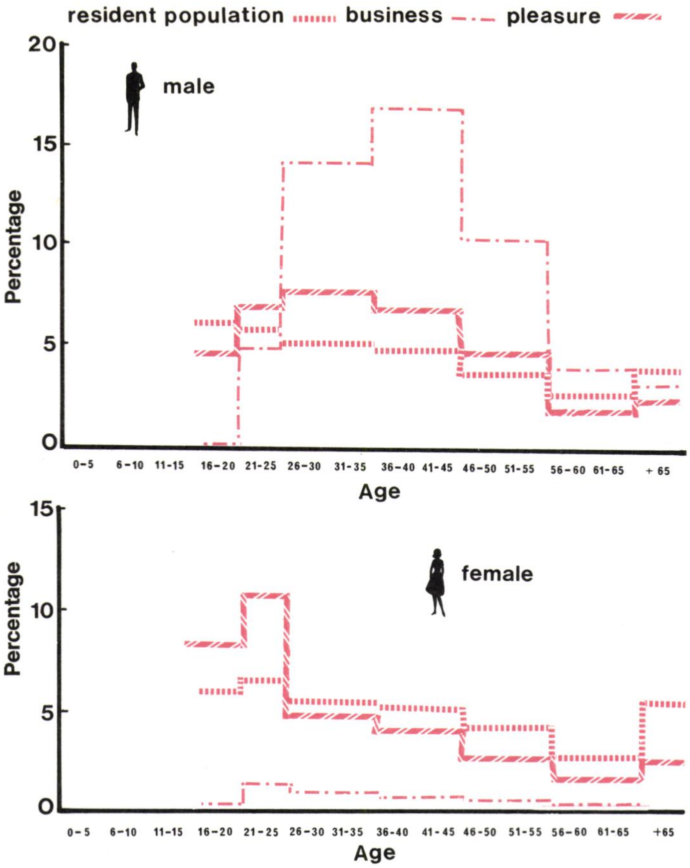



**Figure 3.36** Distribution by age, sex and travel purpose of air travellers resident in Montreal.

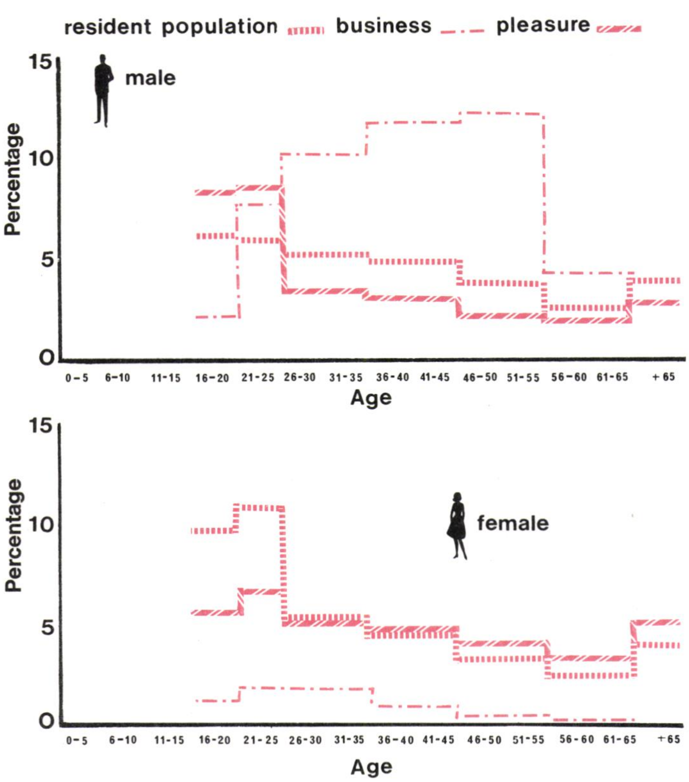



**Figure 3.37** Distribution by age, sex and travel purpose for rail travellers resident in Montreal.

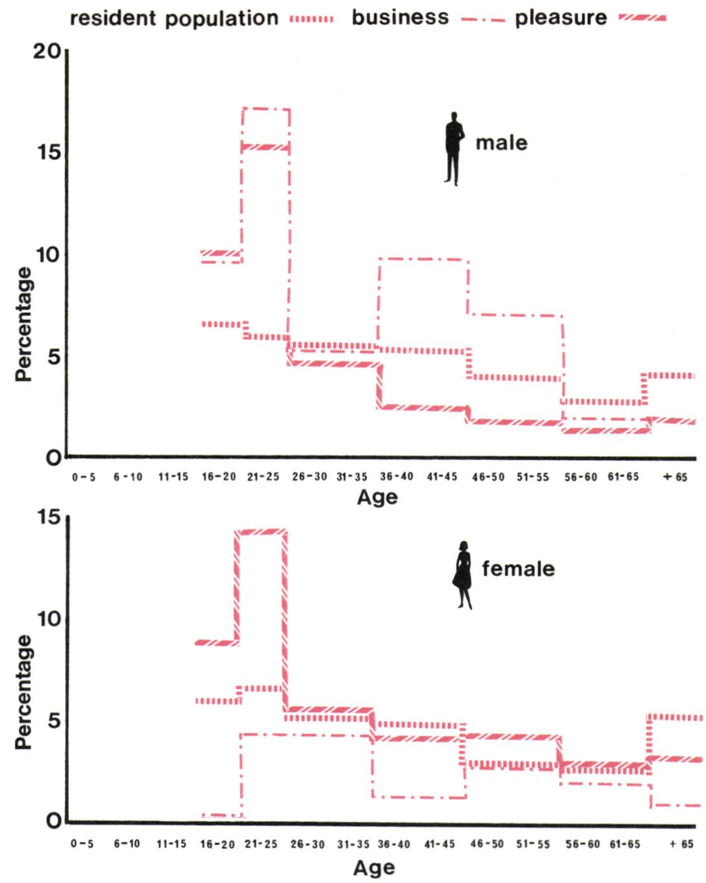



**Figure 3.38** Distribution by age, sex and travel purpose for bus travellers resident in Montreal.

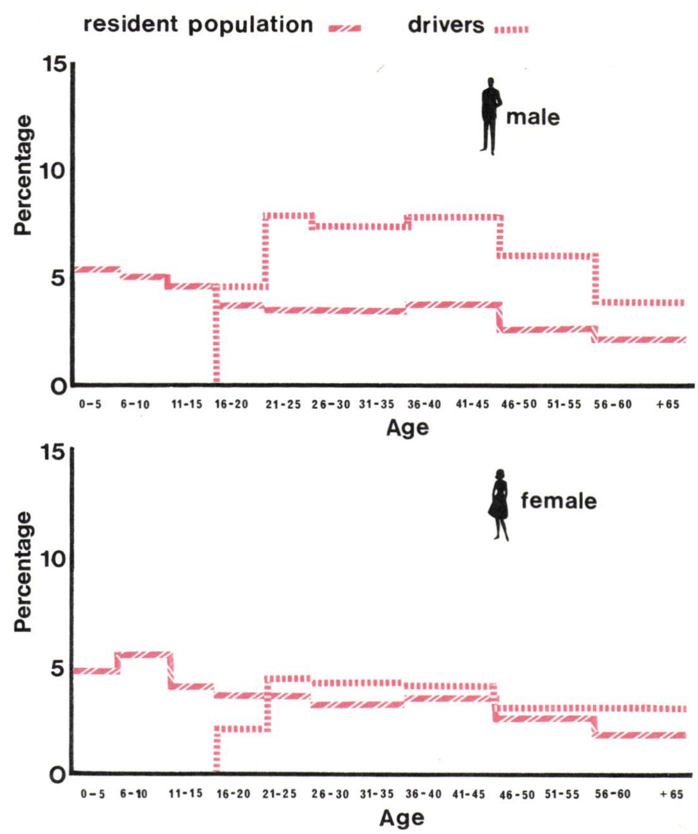



**Figure 3.39** Distribution by age and sex of licenced Ontario drivers.

# 4 URBAN STRUCTURE AND DEMOGRAPHIC TRENDS

"In broad generalization it may be said that Canadian urbanization has partly resulted from and determined the concentration of economic advances at a relatively few specific points in geographical space . . . Important among the factors that have influenced the spatial concentration of economic changes and opportunities are . . . a sequence of technological developments in the fields of transportation and communication.

"Population centres provide goods and services for each other. Thus they may be said to perform economic functions for each other."(*9*)

Historically the population of Ontario and Quebec has been distributed through a sparsely populated hinterland, which obtained its goods and services from a number of supply points. However, the pattern is changing as the population becomes concentrated in these original growth points and in new complexes. This means that analysis can be concentrated on transport between centres, rather than on rural/urban connections.

Population has been growing faster in the Ontario/Quebec Corridor than in the rest of the country—and this pattern is predicted to continue. The Economic Council of Canada predictions for 1971-81 indicate an Ontario rate somewhat higher than the national rate with Quebec growing at the national rate. (Median predictions are 1.7 percent per annum for Canada and Quebec and 1.9 percent for Ontario, with Ontario government projections within the same range).

More important, for the purposes of this study, is the fact that urbanization is proceeding faster than population growth. Using the Census definition of 'urban', 73.6 percent of Canada, 78.3 percent of Quebec, and 80.4 percent of Ontario were urbanized in 1966. Restricting consideration to centres over 30,000, the comparable percentages are lower, but the pattern is the same, as is shown graphically in Figure 4.1. Thus the Corridor area can be increasingly regarded as comprising an interlocked set of distinct urban centres, rather than a rural hinterland served by a set of centres. This increasing importance of major areas is illustrated in Figure 4.2.

"In its historical context, the emergence of metropolitan areas represents the growth

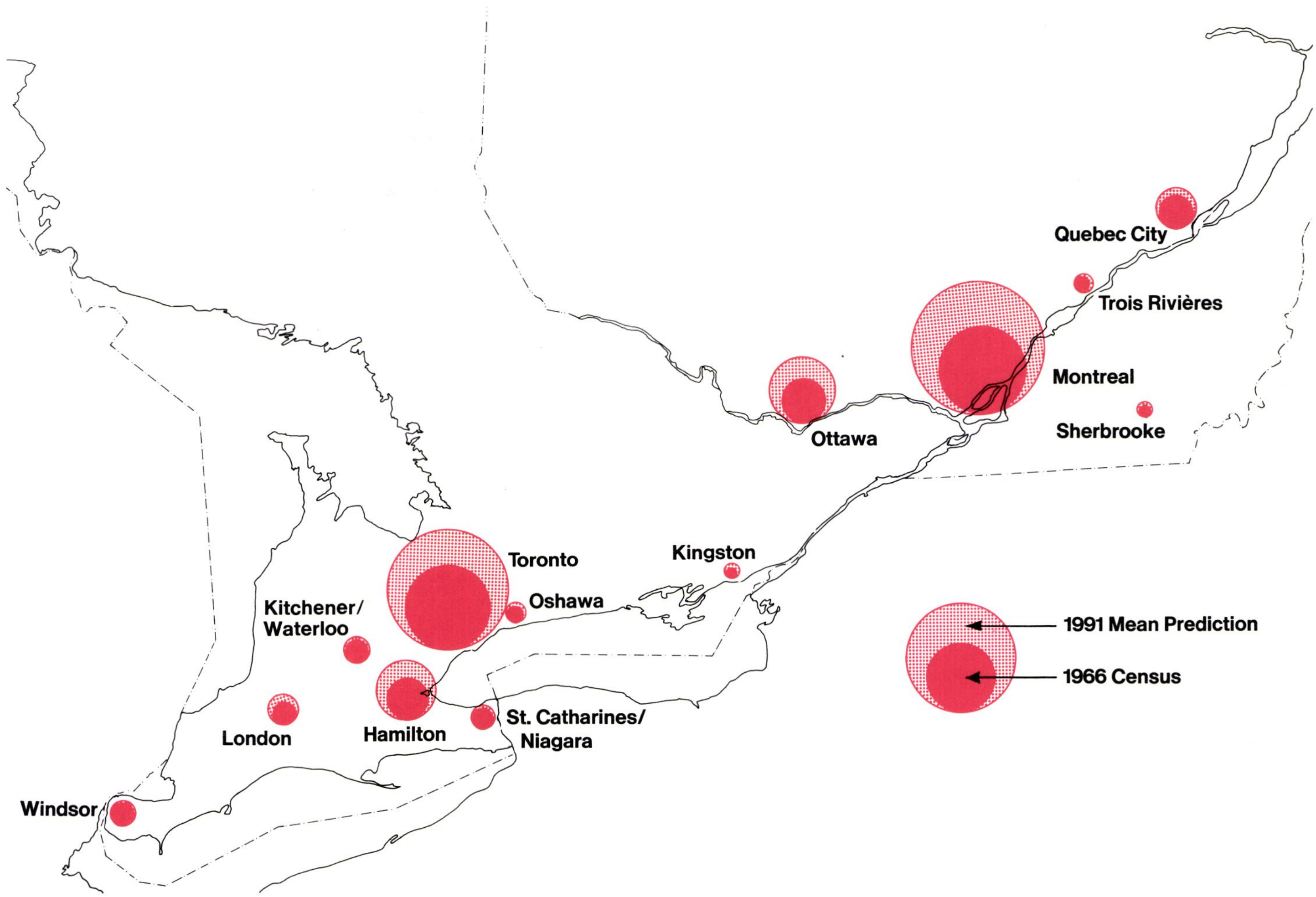



**Figure 4.2 Population growth in the Canadian Corridor.**

of a relatively new pattern of organization among population centres in the performance of economic functions. In this organization the economies of a number of centres are oriented toward that of a 'dominant' central city, and through the linkages among the centres, some real specialization tends to develop and persist. As the number of these metropolitan regions increases in a country, and as the linkages among these regions become strengthened, there is an increase in the complexity of the patterns of flows of people, goods, and communication within the country. This means that the 'spatial structure' of the country's economy becomes more advanced."(9)

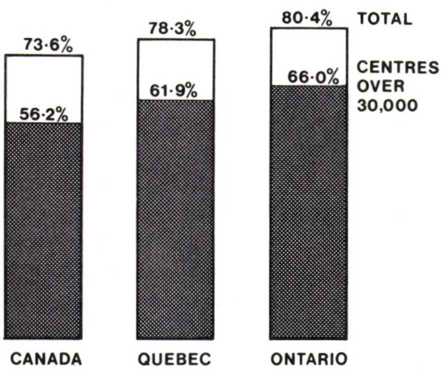



**Figure 4.1** **Percentage of population urbanized for Canada, Quebec and Ontario.**

Estimates of the future spatial distribution of population and estimates of income levels in major centres are presented in this section, together with a description of the structure of socio-economic links between these centres. This is a result of the hypothesis that two sets of characteristics determine travel volumes between any two centres. These two sets are the population in the two modes that constitute the end points for a particular journey, and the relative positions of those two centres within an overall structure of centres.

For statistical reasons, the Census definition of a Census Metropolitan Area (or major metropolitan area, for smaller centres) is used. This includes the incorporated centre plus contiguous residential areas.

## 4.1 Population Distribution

A tool frequently used by social scientists is the so-called rank-size rule, which states that the population of any centre in an urban system depends on the size of the largest centre and on its position in the array—its rank. Thus rather than projecting populations of each centre independently, the growth of the prime centre and its changing relation to other centres are projected, and then estimates

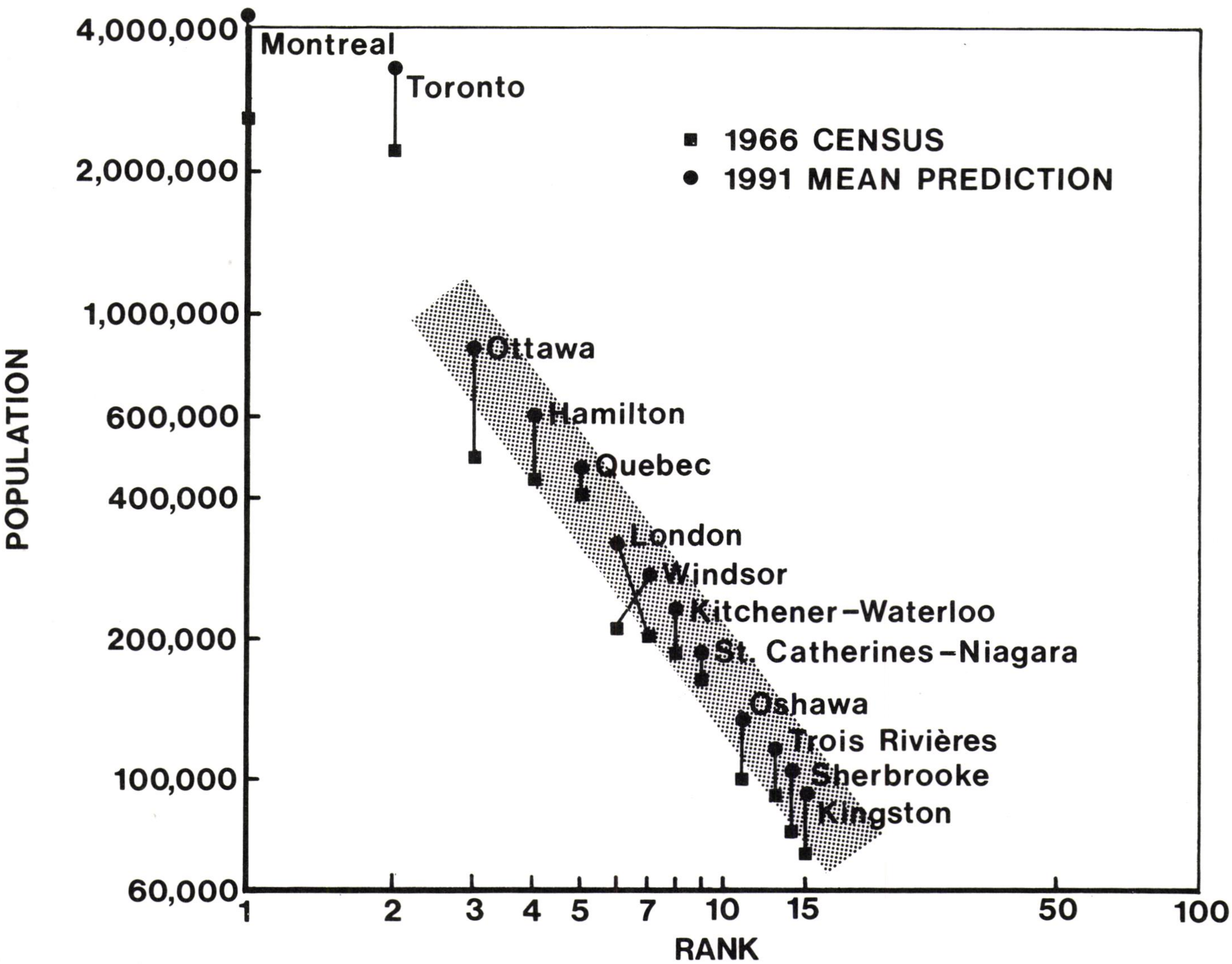



**Figure 4.3** **Size distribution of major centres.**

of these centres derived. The 1966 pattern can be seen in Figure 4.3 plotted on double-log paper.

Predictions are based on: $P_i^q = P_l / r_i$, where P is the population of the $i^{th}$ centre, $P_l$ is the population of the 'major' centre, defined to be of rank l, $r_i$ is the rank of the $i^{th}$ centre, and q is a normalizing coefficient.

A major problem in the Corridor is that Toronto and Montreal do not fit such a structure. Thus, the model is calibrated beginning with the centre of rank three (using 1951, 1961 and 1966 populations), by regressing (in log form) population and rank. The following pattern is revealed:

**Table 4.1 Rank-Size Regression**

| |
|---|
| 1951 log (pop.) = 7.21185 — 1.21267 log (rank) (r=.965) |
| 1961 log (pop.) = 7.58775 — 1.24372 log (rank) (r=.978) |
| 1966 log (pop.) = 7.75658 — 1.26652 log (rank) (r=.971) |

It can be shown that the regression coefficient is l/q and exp ($\alpha$) is the population of the 'first' centre. It is argued that the populations of Montreal and Toronto are determined exogenously (by their position in a national or continental structure), but that the population of the other centres in the system depends on the population of these two. Comparison of Census data for these two with the transformed $\alpha$ shows a consistent relationship (see Table 4.2).

**Table 4.2 Historical Comparison: Mean Toronto + Montreal Population and Estimated $\alpha$**

| | exp ($\alpha$) | Mean of Tor. & Mtl. | exp ($\alpha$) / mean |
|---|---|---|---|
| 1951 | 1355.40 | 1341.1 | 1.01 |
| 1961 | 1973.87 | 1967.0 | 1.00 |
| 1966 | 2336.90 | 2297.7 | 1.02 |

For projection purposes $P_l$ is estimated as 1.01 times the mean of the Montreal and Toronto projections. Although only three observations on l/q are available, it seems necessary to project a shift in its value—linear projection gives 1.388 for 2001 while exponential projection gives 1.397. Calculation shows a less than one percent difference in predictions as a result of the slight shift in the slope of the line predicted by the two projection methods, so the mean value of the two is used. 'High' and 'low' estimates depend on the values of Toronto and Montreal shown in Table 4.3.

**Table 4.3 Toronto and Montreal Population Estimates 1991**

| | (in thousands) | |
|---|---|---|
| | High | Low |
| Montreal | 5914.4 | 4496.7 |
| Toronto | 4716.2 | 3667.2 |
| Mean | 5315.3 | 4081.0 |

Source: City and metro planning agencies

It is not desirable to force the system to match exactly to our model at every point in time, but it is believed that it will converge over 30 years. Population projections for the years relevant to the present project are estimated by exponential interpolation between the 1966 and 2001 values (that is, by assuming a constant growth rate over the period). This ensures that at any intermediate date all points will lie closer to the line than at present.

Examination of previous growth trends suggests that London and Windsor are likely to switch rank—London is slightly smaller, but is growing faster. Accordingly, while London is rank 7 now, it is assumed that it will be rank 6 by 2001, and Windsor will be rank 7. The rank of other cities is assumed to remain unchanged over the period. The mean estimates for all centres in 1991 are shown in Figure 4.3. Growth rates are shown in Table 4.4.

Implied growth rates are somewhat lower than recently observed. This is a result of the somewhat lower rates assumed for Toronto and Montreal, where use was made of city planning group projections, adjusted through a consideration of their changing shares of provincial totals, and the relation of the predictions to Economic Council provincial population estimates.

It has proved necessary to examine one area separately—the so-called West Lake Ontario Ring, running from Oshawa to Niagara, and as far west as Kitchener-Waterloo. The procedure here has been to project population for the area, then to net out the estimates for the five centres included in the area. This method shows a fall in the 'net' ring population from 1961-66, due to a change in boundaries. Such problems over time really preclude detailed allocation of the growth to particular centres, but the ratio of the gross population of the ring to provincial population does show a steady increase. This procedure results in an implied annual growth rate of the 'net population', assuming no further boundary changes, of six to eight percent.

**Table 4.4 Growth Rates for Corridor Cities**

| | 1961-66 Actual Growth | 1966 Census Population | 1966-91 Implied Growth Rates | 1991 Mean Projection |
|---|---|---|---|---|
| Montreal | 2.9 | 2437 | 2.2 | 4182.7 |
| Toronto | 3.4 | 2158 | 1.9 | 3461.8 |
| Ottawa | 2.8 | 494.5 | 2.1 | 832.4 |
| Hamilton | 2.1 | 440 | 1.2 | 604.7 |
| Quebec | 2.9 | 413.4 | 0.5 | 475.8 |
| Windsor | 1.6 | 210 | 1.1 | 280.1 |
| London | 1.9 | 200 | 1.9 | 322.5 |
| Kitchener-Waterloo | 4.1 | 190 | 0.9 | 238.8 |
| St. Catharines-Niagara | 2.2 | 168 | 0.3 | 184.7 |
| Oshawa | 4.7 | 102 | 1.0 | 133.1 |
| Trois-Rivières-Cap de la Madeleine | 2.3 | 94 | 0.9 | 120.5 |
| Sherbrooke | 2.3 | 79 | 1.2 | 106.5 |
| Kingston | 3.0 | 70 | 1.2 | 95.6 |

**Table 4.5 Relation of Detailed Estimates to Provincial Populations**

| Major Centers (x 1000) | 1966 | | 1971 | 1976 | 1981 |
|---|---|---|---|---|---|
| Sum of 'major centers' | 7055.9 | Minimum | 7555.9 | 8098.4 | 8682.2 |
| | | Maximum | 7846.9 | 8930.3 | 9722.5 |
| Sum of Provincial Populations | 12740.9 | Minimum | 13960.0 | 15264.0 | 16679.9 |
| | | Maximum | 13960.0 | 15264.0 | 16679.9 |
| Major Centers/as % of population | 55.9 | Minimum | 54.1 | 53.1 | 52.0 |
| | | Maximum | 56.2 | 58.5 | 58.3 |

| West Lake Ontario 'Ring' (x 1000) | 1961 | 1966 | | 1971 | 1976 | 1981 | 1986 | 1991 |
|---|---|---|---|---|---|---|---|---|
| Population of Ring | 3080.5 | 3620.6 | | 4379.8 | 5254.9 | 6304.8 | 7564.4 | 9075.7 |
| Population of Ring as % of Ontario Population | 49.4 | 52.0 | | 57.1 | 62.4 | 68.1 | — | — |
| Population of Ring net of 'major centers' | 474.8 | 202.4 | Minimum | 1003.0 | 1325.3 | 2182.7 | 3006.4 | 4032.8 |
| | | | Maximum | 1124.9 | 1786.6 | 2609.4 | 3623.3 | 4872.6 |

Notes: —predicted centers are Toronto, Hamilton, St. Catharines-Niagara, Kitchener-Waterloo, Oshawa.
—1961 and 1966 values from Census of Canada.
—population of the Ring is an exponential projection based on 1951-66 growth experience.
—provincial totals 1971-81 are Economic Council of Canada median projections.

## 4.2 Income Distribution

It is apparent that travel demand in total and by mode will be sensitive not only to population totals for any pair of centres but also to the income distribution of these populations. The income variable used in the demand model is the percent of families with annual income in excess of $12,000—this can be predicted from a knowledge of the distribution function and prediction of the change in mean income.

The relationship between mean family income and per capita income is not a simple one, as it involves many aspects of the family unit: rate of information, size, number of earners, definition, etc. Thus family income is forecast directly, and this problem of relating per capita and mean income is avoided.

Time series of per capita income and mean family income for Ontario and Quebec in constant (1961) dollars are shown in Figure 4.4. Exponential growth curves were fitted by regression to the time series to determine the average growth rates. The results are shown in Table 4.6. While per capita income growths are generally higher in Quebec than Ontario, the rate of growth in family incomes is about the same. The relatively high rate of growth in recent years can be seen in the per capita figures for 1963-68.

Table 4.7 shows the estimates for 1969 that were used to calibrate the model. Also shown are the actual figures which have become available since the estimates were made. The differences between cities were estimated from the 1961 census.

**Table 4.6 Exponential Growth Rates for Income**

| | Per Capita Income | | | | Mean Family Income | | |
|---|---|---|---|---|---|---|---|
| | Current $ | | Constant 1961 $ | | Constant 1961 $ | | |
| Period | Que. | Ont. | Que. | Ont. | Que. | Ont. | Can. Metro |
| 1926-68 | .052 | .051 | — | — | — | — | — |
| 1949-68 | .051 | .045 | .032 | .027 | — | — | — |
| 1963-68 | .085 | .077 | .054 | .046 | — | — | — |
| 1951-65 | .042 | .037 | .027 | .025 | .026 | .028 | .027 |

Source: DBS publications

**Table 4.7 Income Estimates**

| | Estimated | | | | Actual | | | |
|---|---|---|---|---|---|---|---|---|
| | Provincial Per Capita | | Mean Family Metro Areas | | Provincial Per Capita | | Mean Family Metro Areas | |
| Year | Ont. | Que. | Ont. | Que. | Ont. | Que. | Ont. | Que. |
| 1965 | — | — | — | — | 2409 | 1857 | 7062 | 7774 |
| 1967 | — | — | 9250 | 8450 | 2842 | 2239 | 9087 | 8261 |
| 1969 | 3280 | 2680 | 10470 | 9470 | 3369 | 2627 | * | * |

*Available early 1971

Demand forecasts have been made on the basis of a growth rate in real family income of 0.025 per annum. This might be considered slightly conservative since the long-term growth rate is between 0.025 and 0.030. However, from Figure 5.3, it can be seen that demand is not very sensitive to this assumption.

Distribution functions for family income were derived from income survey data in 1957 and 1965. A histogram of family income is shown in Figure 4.5 while normalized cumulative distributions can be seen in Figure 4.6. A gamma distribution function gave a good fit.

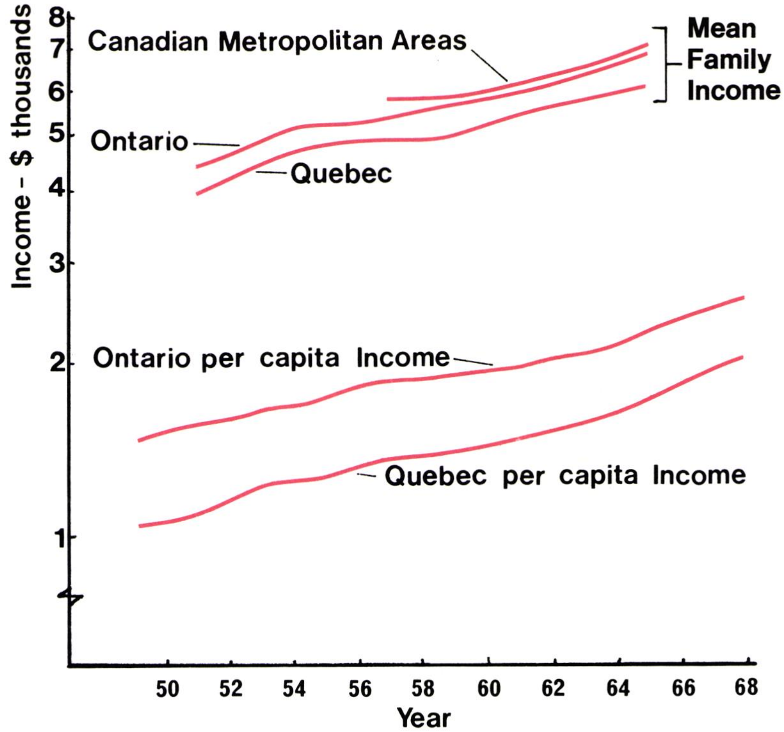



**Figure 4.4** Growth of real income in constant 1961 dollars.

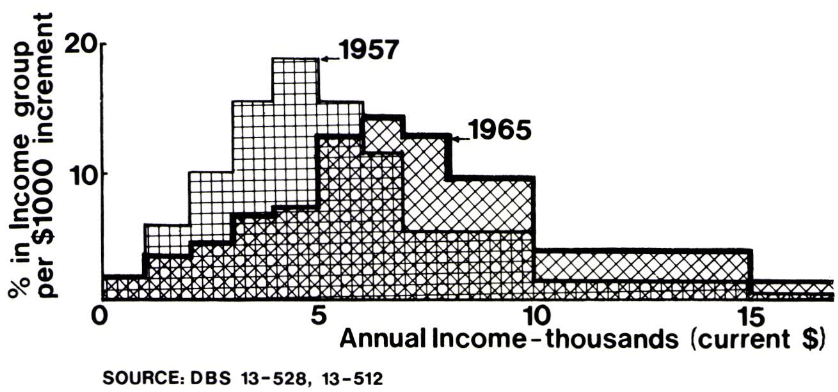



**Figure 4.5** Distribution of family income for metropolitan areas in Ontario.

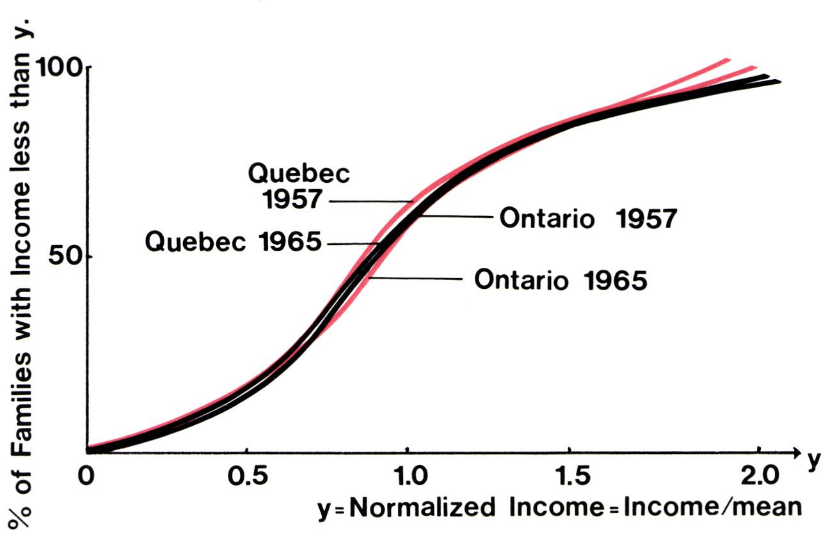



**Figure 4.6** Cumulative family income distribution for metropolitan areas in Ontario and Quebec.

## 4.3 Spatial Structure of Cities

The preceding sections have indicated the distribution of income and of population according to size of agglomeration. However, not all such aggregates interact in the same way.

It is necessary to have some idea of the spatial structure of the system of cities. If complete statistics were available on person and commodity flows, then the fraction of, say, Montreal's total traffic generation going to Toronto, to Ottawa or to Trois-Rivières could be examined. But this would not really represent the underlying pattern, because it is constrained by the topology of the transport system. Since transport involves a physical facility, not all points at equal distance from a major centre are equally served by all modes.

However, statistics are available on telephone calls (supplied by Bell Canada), where cost and convenience of access are related only to distance, not to the routing. The structure of communication should be indicative of the structure of total flows. There is, of course, a debate as to whether communication and transport are substitutes or complements, but it is now fairly clear that, although they may be substitutes for particular cases in the short run, over the long run they are complementary and thus will increase together. Details are available on outgoing calls—by type and length—to and from each of 63 centres in the study area, and from each of these centres to a number of groupings of outside points. For each of the 63 centres the centre to which it has the largest outflow is determined and whether that centre is larger or smaller than the origin (where size is measured by number of telephones, as it is difficult to match toll areas with Census areas).

This exercise generates the pattern shown in Figure 4.7, a structure of tree-like flows. Over the whole system, about 36 percent of the outgoings calls are by the largest flow from each point.The second largest flow is the reverse of the first in about 80 percent of the cases, and more than half of the total calls are represented by these two flows. This was done for total telephone usage. Separate examination of business and non-business calls derived two more flow structures, and showed that more than 80 percent of the links overlap.

Note that the structure is based on volume of flows, but that once the primary flows are established volume is no longer a concern. Regarding Toronto as the 'cen-

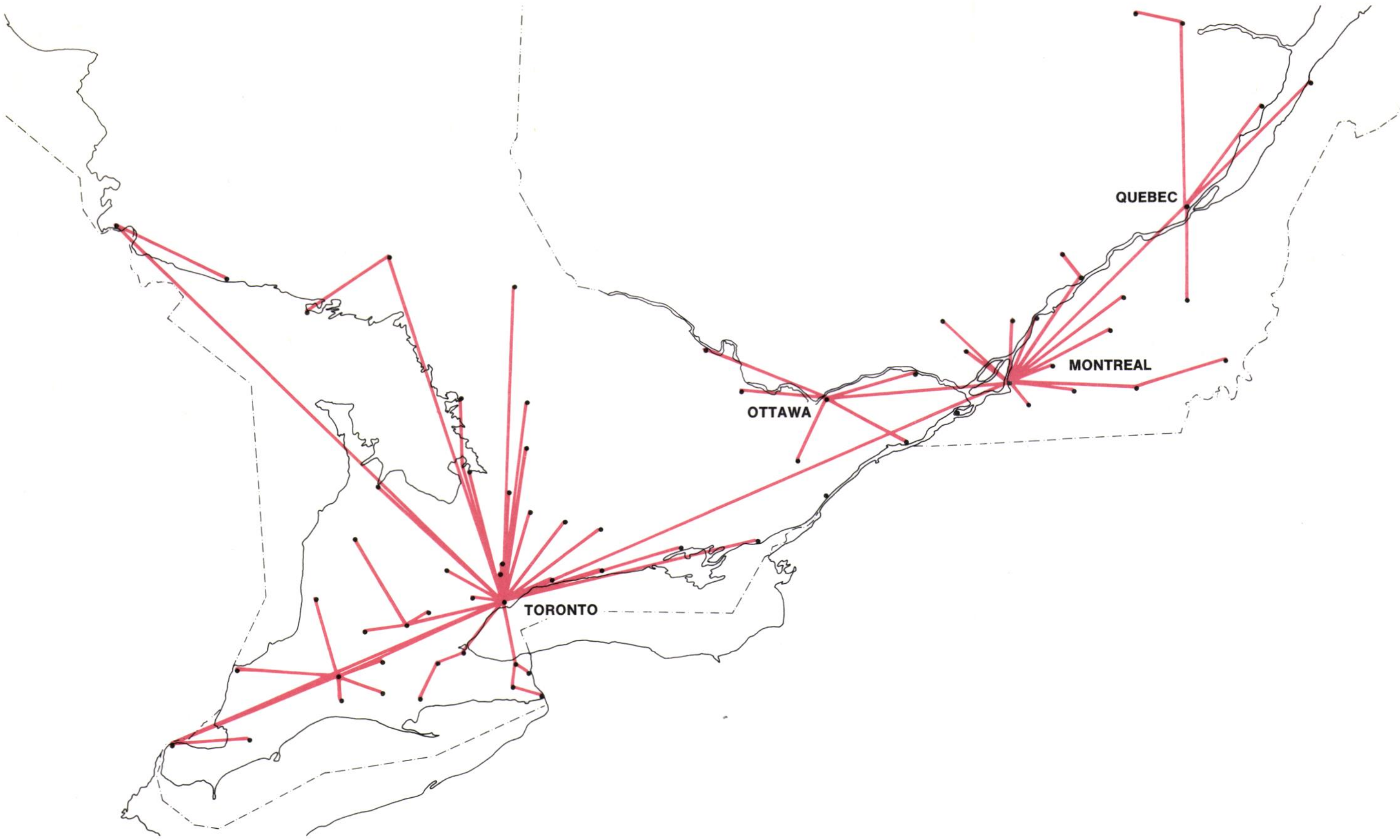



**Figure 4.7 Telephone flow hierarchy.**

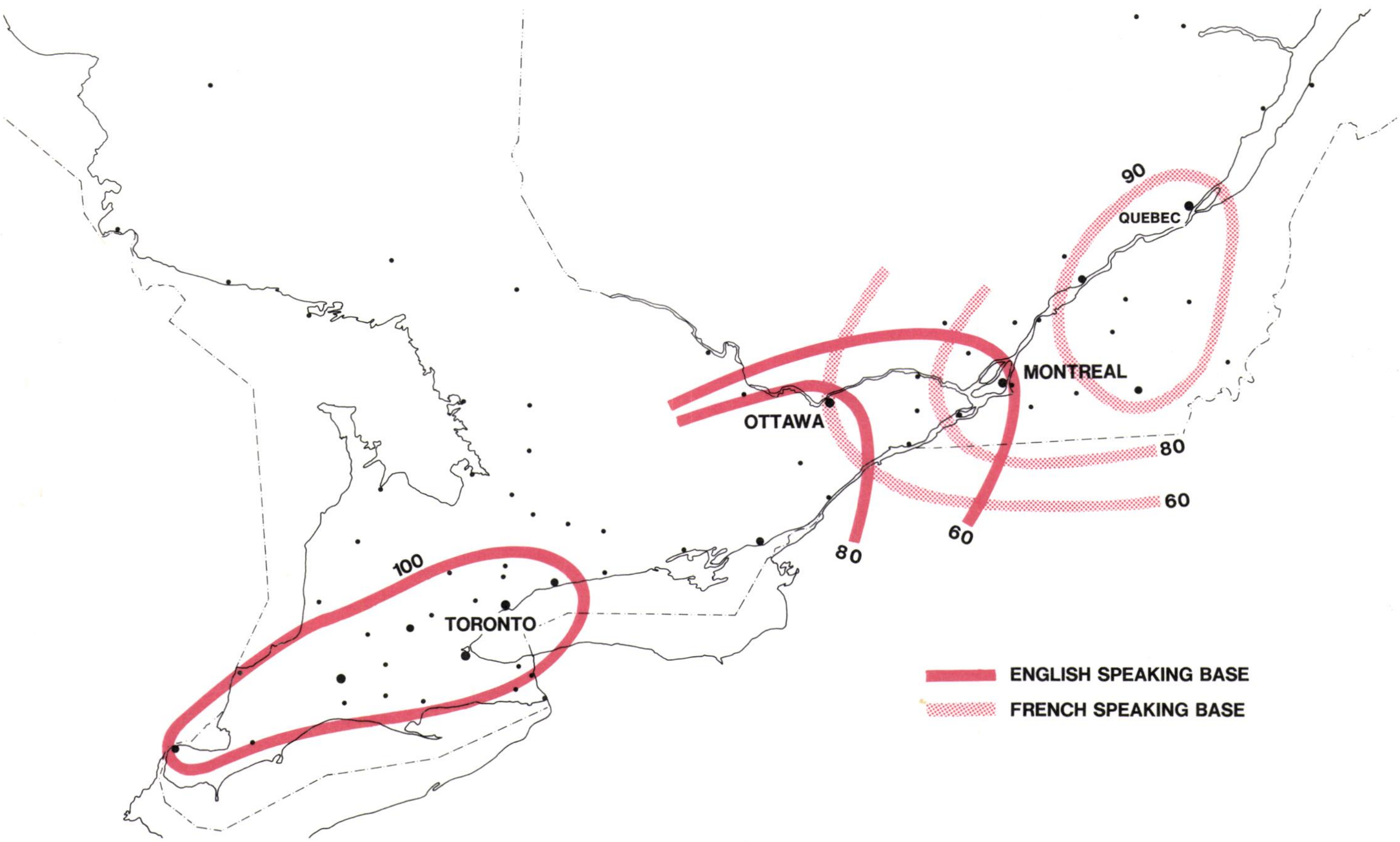



**Figure 4.8 Linguistic pairing index (see text for explanation).**

tral place' the distance to any other point in a 'functional' sense can be determined, defining the rank of the centre by the number of intervening links, rather than by 'real distance'. Smith Falls is thus of rank 4 and is further from Toronto than is Ottawa (with rank 3), despite being closer in terms of physical distance.

The basis for this hierarchical structure is economic. Its form is not unique—the pattern has been observed elsewhere: (the original study using this approach was in Washington state). (*10*) Nor is its form assured by the analytic approach, which could equally well generate some form of chain. Essentially, it arises because centres of different sizes do not supply the same grouping of goods and services—larger centres have specialized goods which the next order of centres down the list do not have, and all the surrounding centres of the next order will be within the tributary area of the larger centre for that bundle of goods. (*11*)

The index developed from this is clearly related to the index developed for linguistic pairing. Here cities were examined two at a time, and the proportions of each which were clearly primarily English-speaking, French-speaking or bilingual were compared. The index is equal to 1 (or 100) for a city pair which is perfectly matched (i.e., the predominant language in both is the same or at least one is bilingual so that all in the two cities can communicate with one another.) In the limiting case where one city is entirely English-speaking and the other is entirely French-speaking, no communication is possible and the index is equal to zero. The set of contour lines shown in Figure 4.8 was then mapped—the high index in the east end is clearly primarily French while southern Ontario is primarily English. As the value of the index is lowered, more and more points are included. The key position of Montreal and Ottawa is clear as they both lie well within the two linguistic areas. This map, like that for the telephone index, shows the clear existence of a pair of semi-independent city systems with the Montreal-Ottawa-Toronto links being of prime importance in tying the two systems together. The analytic model which utilizes this information on urban structure and population distribution thus concentrates on these three routes.

**Table 4.8 Population Estimates for Corridor Cities (x 1000)**

| | 1966 | | 1971 | 1976 | 1981 | 1986 | 1991 |
|---|---|---|---|---|---|---|---|
| Montreal | 2437 | Minimum | 2659.0 | 2903.1 | 3168.6 | 3458.4 | 3774.7 |
| | | Maximum | 2766.0 | 3139.5 | 3563.4 | 4044.5 | 4590.7 |
| Toronto | 2158 | Minimum | 2327.8 | 2511.0 | 2708.6 | 2921.7 | 3151.7 |
| | | Maximum | 2413.0 | 2898.1 | 3016.9 | 3373.4 | 3772.0 |
| Ottawa | 494.5 | Minimum | 538.0 | 585.4 | 636.0 | 693.0 | 754.1 |
| | | Maximum | 558.7 | 631.3 | 713.3 | 806.0 | 910.7 |
| Hamilton | 440 | Minimum | 459.7 | 480.3 | 501.8 | 524.3 | 547.8 |
| | | Maximum | 477.4 | 517.0 | 562.0 | 609.8 | 661.6 |
| Quebec | 413.4 | Minimum | 416.9 | 420.4 | 423.9 | 427.5 | 431.0 |
| | | Maximum | 432.9 | 453.3 | 474.7 | 497.1 | 520.6 |
| Windsor | 210 | Minimum | 218.2 | 226.7 | 235.5 | 244.6 | 254.1 |
| | | Maximum | 226.6 | 244.4 | 263.7 | 284.5 | 306.0 |
| London | 200 | Minimum | 215.8 | 232.7 | 251.1 | 270.8 | 292.2 |
| | | Maximum | 224.0 | 250.0 | 281.2 | 314.0 | 352.8 |
| Kitchener-Waterloo | 190 | Minimum | 194.0 | 200.1 | 205.4 | 210.8 | 216.3 |
| | | Maximum | 202.5 | 215.8 | 229.0 | 245.1 | 261.2 |
| St. Catharines-Niagara | 168 | Minimum | 167.9 | 167.7 | 167.6 | 167.4 | 167.3 |
| | | Maximum | 174.3 | 180.9 | 187.7 | 194.7 | 202.0 |
| Oshawa | 102 | Minimum | 105.5 | 109.2 | 112.0 | 116.9 | 120.0 |
| | | Maximum | 109.6 | 117.8 | 126.5 | 135.0 | 146.1 |
| Trois Rivières-Cap de la Madeleine | 94 | Minimum | 96.9 | 99.8 | 102.8 | 105.0 | 109.2 |
| | | Maximum | 100.6 | 107.6 | 115.1 | 123.2 | 131.8 |
| Sherbrooke | 79 | Minimum | 82.2 | 85.6 | 89.1 | 92.7 | 96.5 |
| | | Maximum | 85.4 | 92.3 | 99.7 | 107.8 | 116.5 |
| Kingston | 70 | Minimum | 73.1 | 76.4 | 79.8 | 83.3 | 86.0 |
| | | Maximum | 75.9 | 82.3 | 89.3 | 96.9 | 105.1 |

# 5 DEMAND MODEL

## 5.1 Introduction

To this point in the report transport technology, the system of cities, and the volumes and characteristics of travellers have been discussed separately. In order to assess the effects of the introduction of new methods of transport, it is necessary to relate these elements to each other. Specifically, predictions are required to estimate, a) the proportion of traffic that would be attracted to competing modes, —the modal split, b) the total volume of traffic that would be generated by a mixture of transportation services, and c) a forecast of future travel demand with respect to changes in the social environment.

The first requirement, modal split prediction, involves the concept that transport modes offer the same good (movement fron A to B), but in different combinations of time, comfort, cost, and convenience. That is, they are perfect substitutes and actively compete with each other.

As individuals choose between the current alternative modes, their aggregate behaviour can be observed with a view to determining the social preferences and values implied by their action. Thus, a prediction of modal split is fundamentally one of social and economic behaviour and, of necessity, is based on the existing situation with respect to technology and social preferences.

In the same way, a relationship between the volume of traffic between cities and the level of service of the transportation system is a behavioural model of the social interaction between urban centres. The social interaction is viewed as a "travel market" which responds to changes in price and quality. Estimation of the degree of elasticity in these relationships is an objective of the analysis.

**Quantitative Problems**—At this point, it may be appropriate to point out that the models do not specify the precise causal mechanisms involved in these two phenomena. The problem is analogous to one of a black box in which it is known what the input and output signals are but it is not clear exactly what is going on inside. By studying the inputs and outputs, it is possible to determine general relationships which describe the output signals in terms of the input. Of course, the specification of the boundaries of the black box is completely arbitrary and it is in this aspect of the analysis, that the formulation of the model is crucial.

The precise causal mechanism involved in modal choice involves the psychological perception of a transportation service by the users. The perception of the service depends on the socio-economic group to which an individual belongs, his purpose for travel, past experience, the manner in which he uses the system and many other factors that may or may not be directly related to the physical system itself. This area is a fruitful field for study and has drawn the attention of many researchers. In this study, we have internalized much of this decision process and have attempted to model the choices of mode (the output of the "black box") in terms of the performance of the transportation system (the input) as measured by travel time, user costs and departure frequency. These attributes are both direct outputs of the physical system (schedule times) and the behaviour of the user (terminal waiting times and access costs.)

Probably the greatest difficulty encountered in deriving a mathematical expression lies in the form that the data takes. The observations of the input variables are the result of many, interrelated causal factors and are by no means random or independent events. For example, the principal input variables associated with the modal split model are the costs and times perceived by the user. From the user's point of view, a high speed trip with short travel times is highly desirable and it is principally the price that prevents everyone from travelling by the fastest mode. However, the relationship between fare, time and distance for each mode is governed by technological factors. Observations of travel time and fare actually form a series of equilibrium points at which demand equals supply. In a statistical sense, the two variables are linearly dependent and each is a surrogate for the other. That is, they both explain the same thing:—distance.

However, this is not very helpful from the point of view of a behavioural model. It is accepted that travel time and cost are causally linked, but that does not explain the trade-off for the user. Assuming that the time and cost preferences for all modes are the same, then a combined set of observations can be generated in which time and cost represent a set of equilibrium points for all modes.

**Adequacy**—A related aspect of mathematical models has to do with the specification and testing of the adequacy of the model. The most important test involves the reasonableness of the predictions and the response of the model to different conditions. The structure of the equations should reflect accepted theories of consumer behaviour. For example, an increase in the price on one mode should at least not be accompanied by an increase in the traffic on that mode or a decrease in the traffic on the competing modes.

A test of the extent to which the model can replicate the existing situation is a second but still important criterion. These tests are the familiar statistical ones such as correlation coefficients and confidence limits. A good fit is a necessary but not sufficient test of the validity of a model. In many cases, the statistical measures of accuracy have to be sacrificed somewhat in the interests of the acceptability of the results.

**Sources of Data**—Data concerning the origins and destinations of passengers on the common carriers (air, rail and bus) was obtained from ticket counts and from the origin-destination survey of passengers conducted by the Canadian Transport Commission in the summer of 1969. Some historical information was available from the ticket counts; however, none of this information contained the detail obtained from the survey.

The quality of the information on inter-city automobile traffic was not comparable to that for common carriers. Highway data had been gathered on different occasions for the purposes of planning local and urban highways. As inter-city travel was of peripheral interest for those purposes, only a limited amount of information had been recorded.

Socio-economic data was available from the 1961 and 1966 census and from surveys of personal income conducted by D.B.S. in 1957 and 1965. Considerable updating to 1969 was required.

## 5.2 The Mathematical Model

**Urban Interaction**—The mathematical equations presented here explain the volume of passenger flows between a particular city pair in terms of the characteristics of the two cities and the attributes of the transportation system serving them. A fundamental assumption is that for the purpose of estimating the demand for transportation, the physical separation of urban centres can be measured solely in terms of the level of service of the transportation system. The rationale states that a decrease in the difficulty of travelling between A and B is equivalent to moving A and B closer together. This assumption applies only in the long term when the social relationships between cities have had sufficient time to adjust to changes in the transportation network. The rationale implies that society perceives distance in terms of the performance of technology in overcoming distance.

The prediction of total common carrier traffic is based on relationships between the cities and the transportation system. Radically new technologies will, over time, have an impact on the pattern or structure of urban development. It is only necessary to look at the effect of the building of the railroads or the widespread use of automobiles to conclude that this is so. However, these effects are not included in the analysis. The mechanisms of urban growth are not well understood and the development of such a model was too large a task for this initial study. Also, when considering that no radically new technology will be introduced until 1980, the time span involved in any re-adjustment of the urban structure would be such that it would not be effective until the end of the study period (1990).

**Dynamic Aspects**—The model is cross-sectional and static in that no use of time series information has been used. The effect of differences in income and population are estimated by observing differences between existing cities in 1969. The relationships determined are then applied to expected differences in these attributes over time. No changing social preferences or attitudes are allowed in the model and it is assumed that the same choices will prevail in 1990 as in 1969.

These last assumptions deserve some discussion. Over the last twenty years the greatest changes in travel behaviour have occured in the large growth in the use of automobiles, aircraft, and to some extent buses.

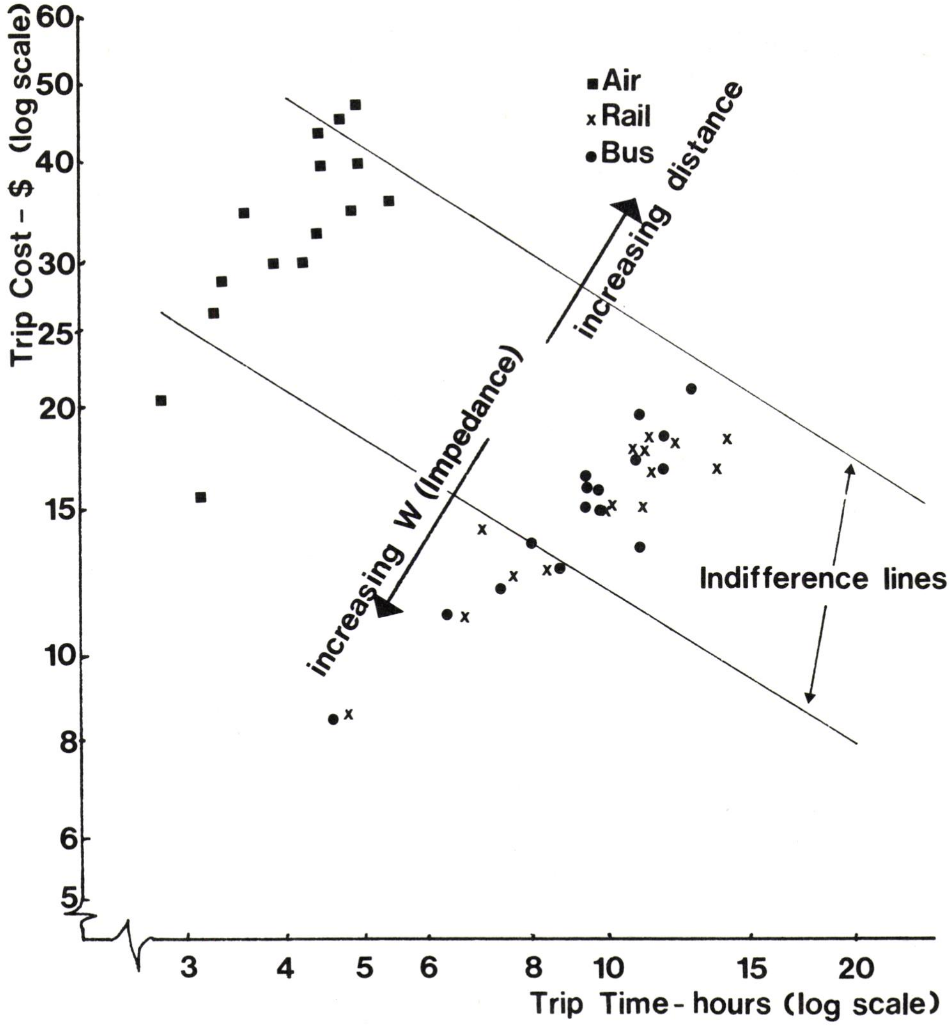



**Figure 5.1** **Trip costs versus trip times for common carrier travel in the Corridor.**

The growth of the airline traffic has been due both to rising incomes (having an effect on both the ability to pay and the value of time) and improvements in the technology. The technological improvements are related to the speed and comfort of the aircraft, with other improvements due to the steady increase in the frequency of service and the number of direct flights. Another effect is that people have to learn about flying and this innovation takes time to diffuse throughout the population.

In this Study, a static model for modal split has been developed in which only the effect of changing technology can be determined. This is not to say other factors are not important; however, within the scope of the study it was not possible to develop the techniques further.

Similar statements can be made concerning the growth of the bus industry. Improved travel times, service frequency, terminals and comfort have been principally responsible for the improved market performance over the shorter distances.

**Automobile**—In inter-city travel the automobile is used for a large portion of non-business, recreational purposes, especially in family situations and business travel where distances are short (say under 100 miles). The large growth in the past has been derived principally from the increasing availability of automobiles, as reflected by vehicle ownership statistics, and improvements in the highway networks. As was seen in Figure 3.24, the growth in households that own an automobile has been very dramatic in the past but has levelled off and seems to be reaching a saturation point. While there are still some segments of the community without access to an automobile (the poor and elderly), the availability of automobiles is not expected to be radically altered over the next twenty years.[1] The inter-city network of limited access expressways is virtually complete and major develop-

[1] It is expected that increasing use will be made of rented as opposed to operator-owned cars for inter-city travel in the coming decade. However, this factor does not alter the basic hypothesis of a stable level for automobile availability.

ments in highway performance is not anticipated. The type of service provided by the automobile is distinctly different from that of any of its competitors: air, rail, or bus. Generally, the vehicle is owned by the user and his perceived cost is lower than his actual cost. The automobile user has instant accessibility to his car and enjoys a great deal of freedom of movement at the beginning and end of his trip. The user of the common carrier is subject to a fixed schedule and has to make his own way around a city.

From this point of view it seems logical to analyze the automobile mode in a different manner from that used for air, rail and bus modes. There is also a significant lack of data on intercity volumes by car while the information regarding the common carriers is more reliable. The approach used was to regard the common carriers and the automobile as two distinct but competitive systems. The model is formulated in such a way that the automobile volumes need not be known in order to determine the parameters of the common carrier model. This approach is acceptable to the general requirements of the study as all of the new technologies under investigation are of the common carrier type. The model predicts the shift of traffic between automobiles and common carrier.

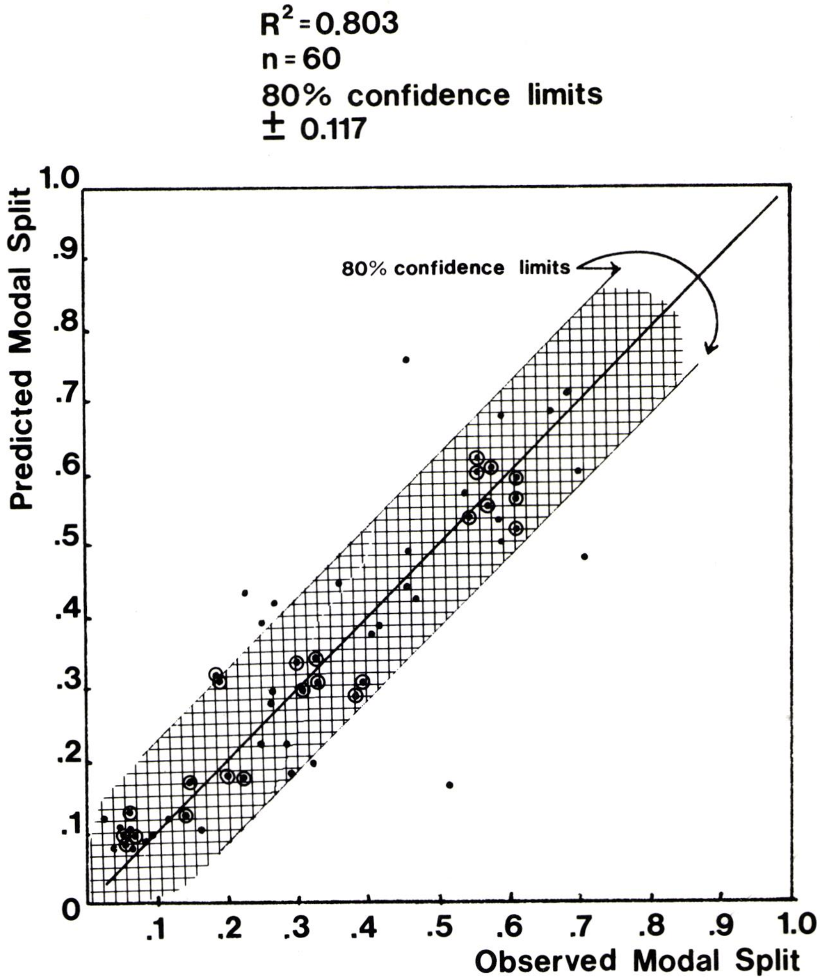



**Figure 5.2** **Comparison of predicted and observed modal split.**

**Common Carrier Modal Split**—The fraction of common carrier traffic that is attracted to each mode between two points is estimated by the following equations:

$$MS_i = \frac{w_i}{W} \tag{1}$$

$$w_i = K_i\,(T_i)^{-3.05}\,(C_i)^{-4.85}\,e^{-3.9/Fi} \tag{2}$$

where $W = \sum_i w_i$ = common carrier level of service (System Impedance)

$MS_i$ = fraction of traffic to mode i (Modal split);

$w_i$ = level of service of mode i;

$T_i$ = total user trip time (including access, egress, terminal waiting, and block time, units—tens of hours);

$C_i$ = total user cost (includes access, egress and fare, units—tens of dollars);

$F_i$ = perceived daily departure frequency;

$K_i$ = Modal constant or acceptability factor (Bus=1.65, Rail=10.0, Air=31.8)

The coefficients and acceptability factors were derived from a least squares procedure, based on 34 observations of modal split between the three common carriers. Access and egress times and costs and terminal waiting times were obtained from the CTC survey. They represent the averages over all trip purposes for particular cities and terminals respectively. Schedule times, fares and departure frequencies were obtained from published carrier schedules.

The modal split model is abstract in the sense that the parameters are the same for all three modes. The $K_i$ coefficients or acceptability factors are specific to particular modes. They reflect first the public acceptance of the mode with regard to such factors as safety, comfort and reliability and second, the fact that the market is segmented. That is, a fairly large part of the market, principally the business traveller, prefers to travel by the fastest mode, with little regard to cost. The effect of these modal specific constants is limited by the parameters on time, cost and frequency but is significant when two modes have approximately the same performance.

Figure 5.1 shows observations of total time and cost for the three modes. Also shown are the indifference lines implied by the modal split model between total trip time and total trip cost. The strong statistical relationship between these two variables within each mode can be seen clearly in Table 5.1. It also indicates that when the data is grouped and treated as a single set of data this linear dependence relationship is suppressed.

**Table 5.1 Correlation Coefficients**

| Variable | Bus | Rail | Air | Grouped Data |
|---|---|---|---|---|
| Time—Cost | .96 | .96 | .84 | −.12 |
| Time—Frequency | .64 | .46 | .32 | −.12 |
| Cost—Frequency | .63 | .38 | .29 | .05 |

The reliability of the model is indicated in Figure 5.2 where a plot of predicted versus observed modal splits is presented. The circled points indicate those observations that represent the flows between cities with direct services such as Montreal—Ottawa. The remainder represent city pairs without direct service such as Montreal—London, where passengers must transfer between connecting services. As expected the results indicate the model is more reliable for direct services.

**Total Common Carrier Demand**—The model used to generate predictions of total common carrier traffic uses population, language, and income to characterize the cities from which the traffic is generated. The common carrier transportation system is represented by W, the level of service variable generated in the modal split model. The competition from the automobile mode is measured by the driving time and perceived cost of operating the vehicle. These variables are related in the following equation:

$$V_{AB} = K_T \bullet P_A \bullet P_B^{1.08} \bullet L_{AB}^{1.30} \bullet e^{-.17/r_A} \bullet e^{0.23(D-T)} \bullet (C-P)^{-0.41} \bullet W^{0.205}$$

where

| | | |
|---|---|---|
| $V_{AB}$ | = | total annual trips generated by city A to city B by common carrier; |
| $K_T$ | = | a constant; |
| $P_A, P_B$ | = | populations of city A and city B (units of thousand); |
| $L_{AB}$ | = | index of linguistic pairing between cities A and B (defined over the range zero to one); |
| $r_A$ | = | fraction of families with annual incomes greater than $12,000; |
| D | = | highway driving time (centre to centre) (hours); |
| T | = | average total trip time by common carrier, weighted according to the modal split (hours); |
| C | = | average total trip cost by common carrier, weighted according to the modal split (dollars); |
| P | = | perceived cost of automobile (3¢/veh-mile and 2.15 pers/veh); |
| W | = | level of service of the common carriers as defined in the modal split model. |

The constants and coefficients have been estimated by a step-wise regression on 34 observations of traffic flow. Census metropolitan areas are used to define the cities. These areas include the central city, the suburbs surrounding it, and adjoining communities (such as Ottawa/Hull and Quebec City/Lévis).

The generator of traffic in the model is the population term. The populations refer to the metropolitan areas and are not restricted to zonal boundaries. The prediction equation generates directed flows; however, since the coefficients on $P_A$ and $P_B$ are very close (1.0, 1.08) the flows from each city of a pair are almost symmetrical.

The income and language variables enter the model as constraints. The language variable is a powerful factor in determining the pattern of interaction between cities, and the presence of this variable in the model has a large effect on the sensitivity of the prediction to changes in the transportation system. The effect of language is quantified by an index, termed the linguistic pairing index, calculated from the 1961 Census. The index is defined over the range zero to one. It is equal to one if the two cities are perfectly paired with respect to language (i.e. if the cities are both English, both French speaking or at least one is completely bilingual). It is equal to zero if the language patterns do not intersect. (See Section 4.3)

Income is represented by the percentage of families with an annual income in excess of $12,000.[1] This cut-off point was chosen arbitrarily in order to introduce the effect of the distribution of income. In effect the percentage of families with incomes in excess of $12,000 is a non-linear function of the mean income.

The form of the income constraint can be seen in Figure 5.3. A forecast of rising incomes results in a decreasing constraint on the generation of traffic. Of principal interest is the saturation effect with mean family incomes of greater than twelve to fifteen thousand dollars per year.

The two terms in equation 3 involving highway driving times and the perceived cost of automobile ($e^{0.23(D-T)}$ and $(C-P)^{-0.41}$) describe the competition for traffic from the automobile mode. It is these terms which generate the estimates of the shift in volume between automobile and common carrier. This shift is much more sensitive to the time differential between highway driving time and common carrier trip time (first term) than it is to the differential in cost (second term).

The level of service of the common carrier system, W, is defined by the modal split model in terms of trip times, trip costs, and departure frequency. It is closely, correlated with distance ($r^2=0.95$) but inversely related. That is, the shortest links in terms of distance have the highest level of service. It is the term ($W^{0.205}$) that is used to estimate the newly generated traffic.

The model does not include variables which measure the attractiveness of cities, nor the intrinsic pairing of cities. Although several such measures were tried, none proved to be significant in the regression analysis. However, an analysis of the resi-

[1] The percentage is calculated from a generalized income distribution for Ontario and Quebec Metropolitan areas derived from 1957, 1961 and 1965 household surveys. The 1969 mean family income was estimated from provincial per capita income published in the National Accounts while the spatial pattern was determined from the 1961 Census data.

duals shows several consistent biases in the predictions. For example, Ottawa is found to be attracting more traffic than the model predicts, while Hamilton both attracts and generates less than is predicted. By the use of dummy variables, the so called "intrinsic characteristics of the cities" can be determined which further reduce the standard error and narrow the confidence limits of the prediction.

In the analysis of residuals, two variables were defined for each city: $A_i$ (=attractiveness of city i) and $B_i$ (=generation of city i). As there are 11 cities in the network there are 22 unknowns. Both variables describe the accuracy of the model in estimating the flows. Values of 1.0 for $A_i$ or $B_i$ would indicate the estimate is perfect while a value of 1.05 would indicate that the model gives a 5% underestimate of traffic. Due to the incomplete nature of the data, it was only possible to estimate 6 of the 22 unknown variables. Table 5.2 shows these results.

**Table 5.2 Intrinsic City Characteristics Calibration**

| City i | $A_i$= Attractiveness | $B_i$= Generation |
|---|---|---|
| Hamilton | 0.58 | 0.55 |
| Quebec | 1.39 | 1.65 |
| Ottawa | 1.25 | — |
| Windsor | 1.22 | — |

**Calibration**—As discussed, the model was estimated by the use of stepwise multiple regression. The fit of the model to the data is shown in Figure 5.4. These results were obtained after the intrinsic characteristics of the cities were included. The extent to which the explanatory variables are uncorrelated is shown in Table 5.3. In this case, the dependent variable is $V_{AB}/P_A$ i.e. the traffic generated per unit of population. The only variable which does not seem to be unrelated to others is the cost differential variable (C−P).

The demand model is one of several formulations that were tried. Table 5.4 shows the results of six formulations including the final one previously presented (column A). The figures entered in the table are the values of the parameters. The values in brackets are the F value of the variable just prior to entering the equation. The effect of the introduction of language constraints and income can be seen by comparing the figures in columns A and B with column C. When the time differential between automobile and common carrier is related to income, better results are obtained (column E). However, where a projection of income is made, the model generates a greater shift between automobile and common carrier than seems reasonable. The effect of introducing the automobile cost competition term $(C-P)^{-.41}$ can be seen by comparing the models in columns

**Table 5.3 Correlation of Explanatory Variables in Demand Model ($R^2$)**

| | | Variables | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | $V_{AB}/P_A$ | dependent variable | — | | | | | | |
| 2 | $P_B$ | destination pop. | .57 | — | | | | | |
| 3 | $L_{AB}$ | linguistic pairing | .28 | 0 | — | | | | |
| 4 | $e^{1/r_A}$ | income in A | 0 | .15 | .05 | — | | | |
| 5 | $e^{(D\text{-}T)}$ | driving time diff. | .03 | 0 | .02 | 0 | — | | |
| 6 | (C-P) | cost differential | .12 | 0 | .05 | .02 | .48 | — | |
| 7 | W | level of service | .44 | .06 | .25 | .06 | .07 | .70 | — |

**Table 5.4 Demand Model Formulations**

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| Equation | (1) | (1) | (1) | (2) | (3) | (4) |
| Parameters: | | | | | | |
| Log (K) | 2.733 | 1.467 | 1.164 | 1.298 | 1.65 | 10.93 |
| $\alpha_1$ | 1.000 | 1.004<br>(5.37) | 0.897<br>(5.37) | — | 1.000<br>* | — |
| $\alpha_2$ | 1.078<br>(42.4) | 1.069<br>(40.7) | 0.944<br>(40.7) | 1.040<br>(61.1) | 1.033<br>(42.4) | 1.086<br>(61.1) |
| $\beta_1$ | 1.302<br>(45.0) | 1.242<br>(17.4) | 0.0<br>* | 1.251<br>(51.9) | 1.252<br>(45.0) | 1.213<br>(51.9) |
| $\beta_2$ | 0.168<br>(2.38) | 0.163<br>(1.93) | 0.0<br>* | 0.124<br>(1.75) | 0.167<br>(2.10) | 0.152<br>(3.63) |
| $\gamma$ | 0.238<br>(10.6) | 0.182<br>(11.4) | 0.299<br>(11.4) | 0.187<br>(9.0) | 0.746<br>(15.7) | 0.812<br>(17.5) |
| $\delta$ | −0.418<br>(0.23) | 0.0<br>* | 0.0<br>* | — | — | — |
| $\theta$ | 0.205<br>(21.2) | 0.265<br>(42.6) | 0.418<br>(42.6) | 0.269<br>(12.9) | 0.275<br>(21.2) | −1.672<br>(15.7) |
| Logarithm form: | | | | | | |
| $R^2$ | 0.931 | 0.968 | 0.943 | 0.967 | 0.969 | 0.976 |
| Standard Error | 0.499 | 0.503 | 0.640 | 0.497 | 0.459 | 0.423 |

Equations

(1) $V_{AB}=K \cdot P_A^{\alpha_1} \cdot P_B^{\alpha_2} \cdot L_{AB}^{\beta_1} \cdot e^{-\beta_2/r_A} \cdot e^{\gamma(D-T)} \cdot (C-P)^{\delta} \cdot W^{\theta}$

(2) $V_{AB}=K \cdot (P_A P_B)^{\alpha_2} \cdot L_{AB}^{\beta_1} \cdot e^{-\beta_2/r_A} \cdot e^{\gamma(D-T)} \cdot W^{\theta}$

(3) $V_{AB}=K \cdot P_A^{\alpha_1} P_B^{\alpha_2} \cdot L_{AB}^{\beta_1} \cdot e^{-\beta_2/r_A} \cdot e^{\gamma \cdot r_{A(D-T)}} \cdot W^{\theta}$

(4) $V_{AB}=K \cdot (P_A P_B)^{\alpha_2} \cdot L_{AB}^{\beta_1} \cdot e^{-\beta_2/r_A} \cdot e^{\gamma \cdot r_{A(D-T)}} \cdot S^{\theta}$

Where S=highway distance

*The parameter value was assumed.

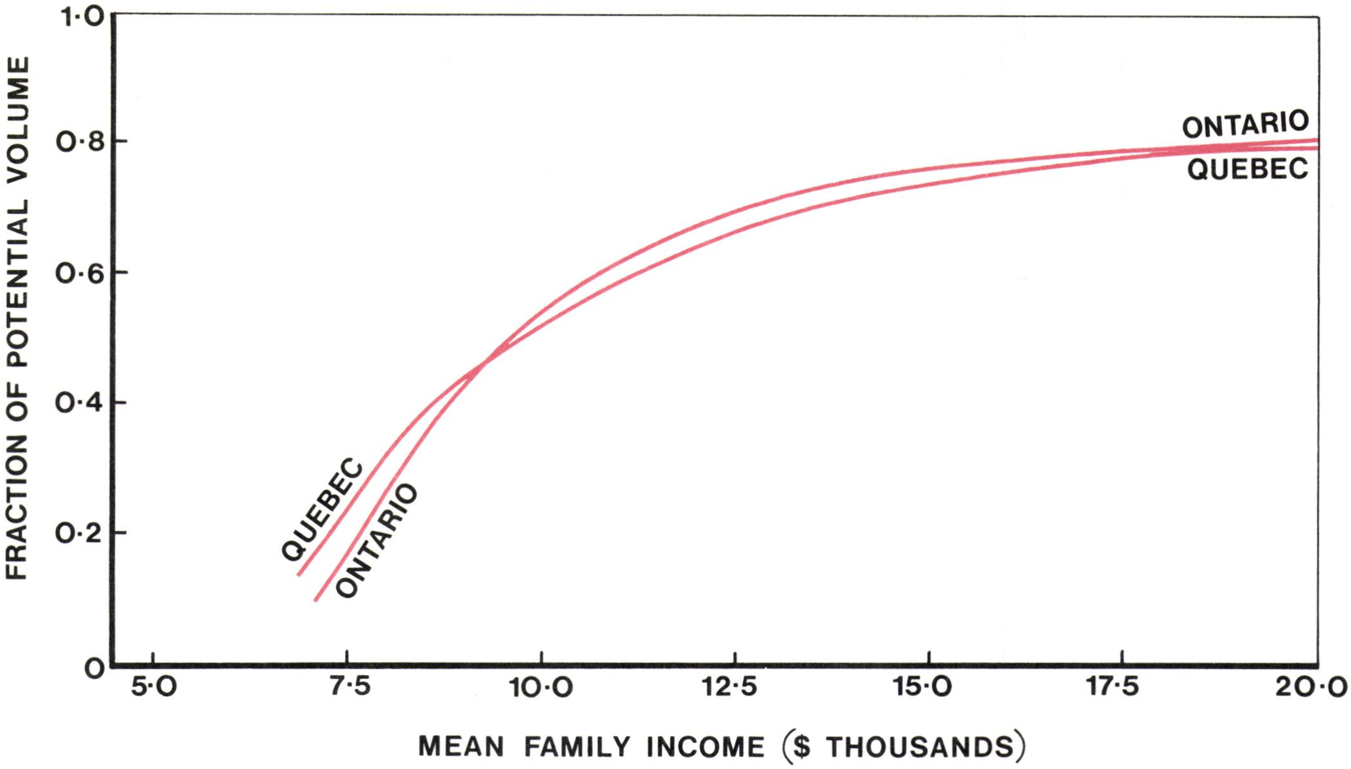



**Figure 5.3 Constraint on travel volumes with respect to mean family income.**

A and B. In statistical terms, the variable is not significant and adds nothing to the accuracy of the prediction. However, the other parameters are relatively stable and the model gives more satisfying results when considering new transportation systems. The formulation in column F tests the effect of substituting a distance variable (highway mileage) for the impedance variable.

**Urban Structure**—The cities or nodes are represented in the model by the following attributes: population, income, language and terminal access times and costs. The access variables were derived separately and are associated with the transportation system. No attempt was made to integrate them with the other city attributes. The language variable is used to describe the potential for the populations of two cities to communicate with each other. Of the two remaining descriptors of cities, population and income, population has the most fundamental role in the demand model.

Two indexes were developed to describe the role a city plays in the system of cities described in Section 4. The first, called system accessibility, was derived from the hierarchical structure, identified by the matrix of telephone calls (refer to Section 4.3). It measures the centrality of each point with respect to all other points. The second, called commercial activity,

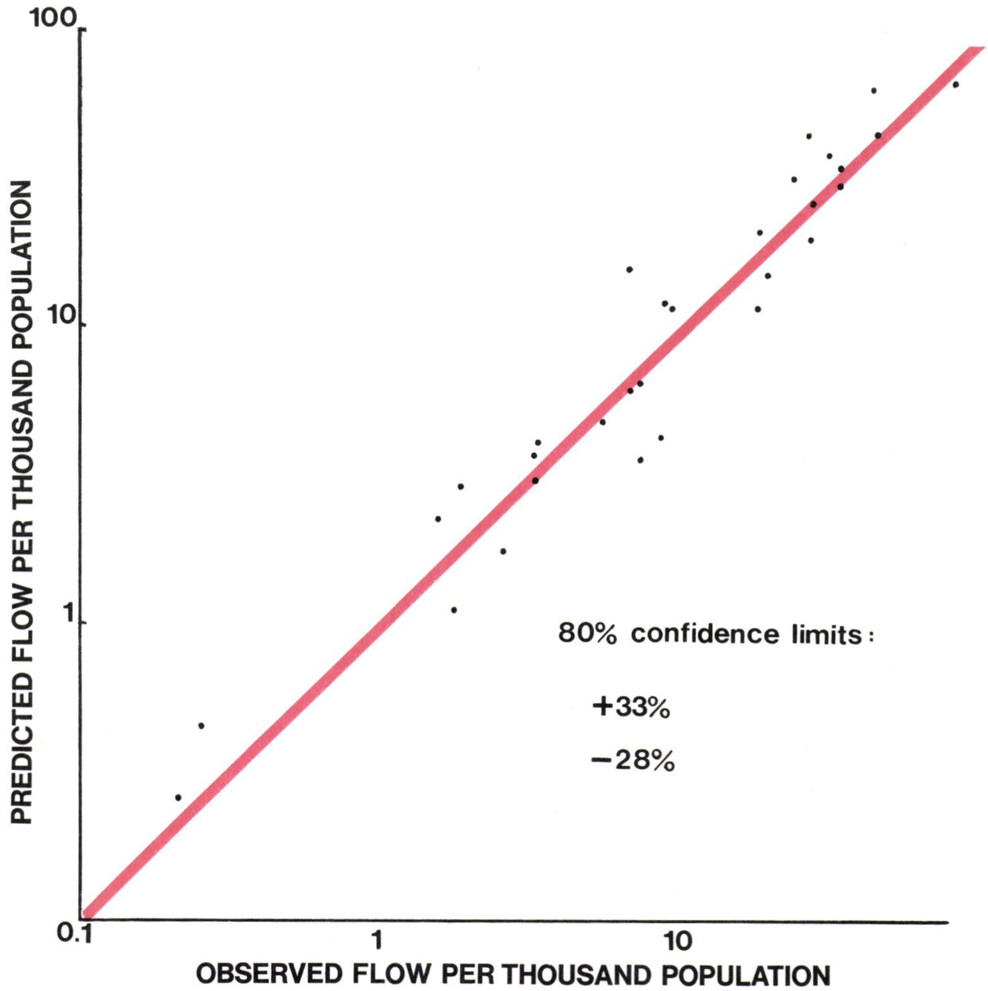



**Figure 5.4 Demand model results with analysis of residuals to determine the intrinsic characteristics of cities.**

is an index of the proportion of the employment which is related to such activities as finance, real estate, and services to business management. Table 5.5 shows how closely these are related to the relative size of the centres.

The coefficients developed for the population term in the demand model are somewhat larger than the experience has been in certain other studies. Probably the most important reason is that all of the cities involved are part of the same city system. The flows within a city system tend to be larger than the flows between cities in different systems. In addition, the language variable has a large constraining effect on the flows which may tend to increase the role of the population term.

**Value of Time**—The modal split model has implications concerning the value of time of the users on particular links and modes. These are shown in Table 5.6. The values on the Toronto-Montreal and Toronto-Ottawa links are as expected from the income distribution of the travellers on the two routes. The slightly higher values on the Ottawa-Toronto link are a result of the poorer rail service and relatively high air fare on the route. The Ottawa-Montreal link is subject to more competition from the automobile mode with subsequent lower fares for rail and air. The improved position of bus travel is evident due to the high frequency of service on Montreal-Ottawa.

**Table 5.6 Implied Value of Travel Time**

| | Air | Rail | Bus |
|---|---|---|---|
| Toronto/Montreal | $5.27 | $1.30 | $1.09 |
| Toronto/Ottawa | 5.75 | 1.43 | 1.09 |
| Ottawa/Montreal | 3.39 | 1.08 | 1.28 |

**Elasticities**—The derived point elasticities[1] of demand for the three principal routes are shown in Table 5.7. The model is consistent with respect to each mode, in that the demand for each mode responds in the proper manner to changes in the level of service of its own mode or competing modes. In cases where the elasticity of total common carrier traffic is significant, the model is consistent (e.g. for changes in schedule time or fare for air between Montreal-Toronto). In some cases, where the elasticities of total demand are very small, some inconsistencies occur (e.g. Montreal-Toronto rail service). This inconsistency is due to the sensitive response of the automobile competition term.

The values of these elasticities is somewhat larger than that usually expressed in the literature. This could be expected for two reasons. The first is that the model was calibrated over a range of travel (less than 500 miles) in which there is a great deal of competition between modes. The second is that no distinction was made in the model between business and non-business travel which in some cases may tend to reduce the cross-elasticities between modes in the market place.

[1] The elasticity is defined as the ratio of the relative change of volume with respect to the relative change of a determining factor. An elasticity with respect to travel time of −1.0 implies that demand would decrease by 1.0% if travel time were increased by 1.0% ($n_t = \Delta V/V \div \Delta T/T$ where $n_t$ = elasticity, V = volume, T = travel time).

**Table 5.5 Correlation of City Characteristics ($R^2$)**

| Variables | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Population | — | | | |
| 2. System Accessibility | 0.85 | — | | |
| 3. Commercial Activity | 0.72 | 0.72 | — | |
| 4. Income | 0.28 | 0.38 | 0.39 | — |

**Table 5.7 Demand Model Point Elasticities**

1. Montreal-Toronto

| effect on volume of: | Schedule Time: Air | Rail | Bus | Fare: Air | Rail | Bus |
|---|---|---|---|---|---|---|
| Air | −0.62 | 0.84 | 0.22 | −2.75 | 1.61 | 0.40 |
| Rail | 0.29 | −1.35 | 0.22 | 1.27 | −2.59 | 0.40 |
| Bus | 0.29 | 0.84 | −2.15 | 1.27 | 1.61 | −3.87 |
| Total | − .21 | 0.01 | 0.00 | −0.90 | 0.01 | 0.07 |

2. Ottawa-Montreal

| effect on volume of: | Schedule Time: Air | Rail | Bus | Fare: Air | Rail | Bus |
|---|---|---|---|---|---|---|
| Air | −0.46 | 0.72 | 0.36 | −2.97 | 1.45 | 0.73 |
| Rail | 0.07 | −0.82 | 0.36 | 0.43 | −1.66 | 0.73 |
| Bus | 0.07 | 0.72 | −1.44 | 0.43 | 1.44 | −2.91 |
| Total | 0.01 | −0.21 | −0.16 | 0.06 | −0.42 | −0.32 |

3. Toronto-Ottawa

| effect on volume of: | Schedule Time: Air | Rail | Bus | Fare: Air | Rail | Bus |
|---|---|---|---|---|---|---|
| Air | −0.58 | 0.70 | 0.36 | −2.71 | 1.22 | 0.66 |
| Rail | 0.27 | −1.52 | 0.36 | 1.26 | −2.64 | 0.66 |
| Bus | 0.27 | 0.71 | −1.88 | 1.26 | 1.22 | −3.48 |
| Total | −0.19 | 0.04 | −0.01 | −0.87 | 0.07 | −0.03 |

## 5.3 Travel Forecasts

**Modal Split**—Predictions of modal split are required to evaluate and optimize different mixes of transportation services. In Figure 5.5 the sensitivity of the prediction to the fare level is shown for a hypothetical Tracked Air Cushion Vehicle service between Montreal and Toronto. Figure 5.6 depicts the effect of varying the daily frequency of a train service giving a four-hour service between Montreal and Toronto.[2] These cases will be discussed more fully in a later section

[2] Note that these graphs show the percentage of common carrier volumes attracted to each mode. It should be pointed out that total volume will also change with respect to changes in fare, time and frequency.

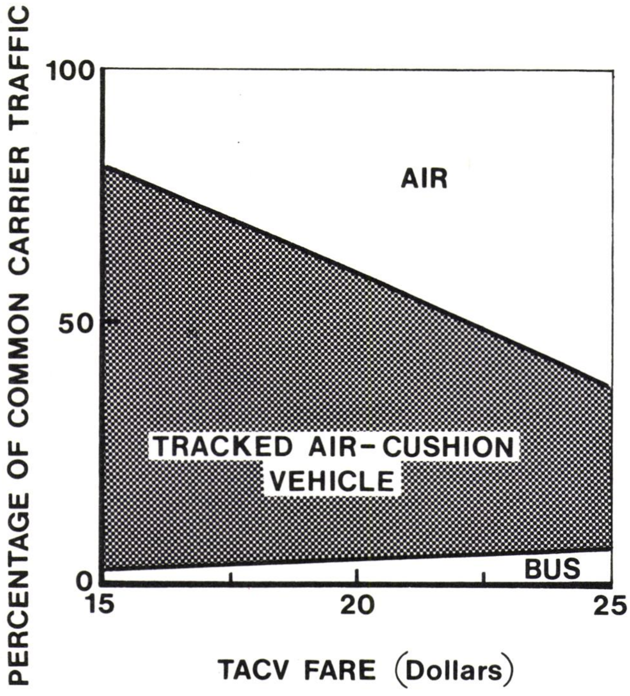



**Figure 5.5** **Change in modal split with increasing fare on a TACV service between Montreal and Toronto.**

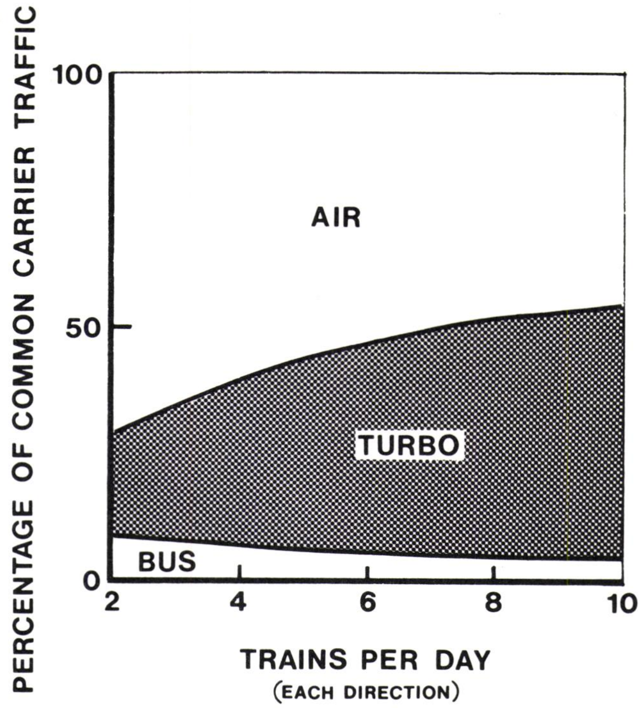



**Figure 5.6** **Change in modal split with increasing frequency on a Turbotrain system between Montreal and Toronto.**

and are presented here to demonstrate some of the relationships inherent in the model.

The information required for prediction consists of the components of trip time, cost and frequency for each mode. For an existing mode there is no difficulty as all that is required are the new schedules.

For new facilities terminal waiting times, consisting largely of time allowance taken by the user, were estimated on the basis of departure frequency, terminal location and design. Access time and costs were estimated from the characteristics of existing terminals and survey information.

The public acceptance factor for a new mode is an important unknown, especially for the TACV. Because the level of service between Montreal and Toronto would be similar to that of the air mode, there is some question as to which factor to use (air or rail).[1] Predictions for two extreme assumptions were made. The first one was to consider the TACV simply as an improved rail mode using the rail public acceptance factor. The second assumed that air an TACV were equal as far as service is concerned. The results are shown in Table 5.8.

The analysis of the potential market for Short Take Off and Landing (STOL) service involves the prediction of the fraction of the air market that would be attracted by it. While in aggregate terms (average trip characteristics) the STOL and conventional air (CTOL) modes give almost exactly the same service there is a considerable difference between access times for different air travellers. The approach taken was to divide Montreal and Toronto into a number of areas and apply the modal split model to each pair of areas in turn on the basis of the alternatives presented to the air users. The fractions obtained for STOL and CTOL were then summed to determine the share of the total air market. The performance

**Table 5.8** **Modal Split Under Two Assumptions of Montreal-Toronto TACV Public Acceptance Factor**

| Modes | Train, TACV equal $K_{TACV}=K_{RAIL}$ | Air, TACV equal $K_{TACV}=K_{AIR}$ |
|---|---|---|
| AIR | .40 | .18 |
| TACV | .54 | .77 |
| BUS | .06 | .05 |
| Total | 1.0 | 1.0 |

**Table 5.9** **Recent Growth**

| | Annual exponential growth rates | | | | | |
|---|---|---|---|---|---|---|
| | Montreal-Toronto | | | Montreal-Ottawa | | |
| | 1965-68 | 1963-68 | 1960-68 | 1965-68 | 1963-68 | 1960-68 |
| Air | 0.0715 | .0720 | .0720 | 0.124 | 0.059 | 0.020 |
| Rail[2] | 0.0720 | na | na | 0 | na | na |
| Bus | 0.151 | 0.242 | na | 0.292 | 0.175 | na |
| Total | 0.075 | — | — | 0.086 | — | — |

na — not available
[2]Rail growths are calculated over 1966-69.

[1] On the short routes such as Toronto to Ottawa the performance of the TACV is dominant and the prediction of modal split is quite insensitive to the value used.

of the air mode as a whole was assessed and a prediction made of the total air and common carrier volumes. These predictions are described in full in Chapter Six.

**Common Carrier Demand**—The sensitivity of the growth predicted by the model for 1971 to 1991 with respect to various assumptions concerning population and income growth is shown in Figure 5.7.

Of interest is the effect of the saturation curve for income. Over the full 20-year period to 1991 high income growth rates do not result in proportionate increases in the long term growth rate in traffic volumes. A high income growth rate implies that the saturation point is reached earlier rather than later. Population and income growths of 0.020 and 0.025 respectively give an equivalent annual growth rate for intercity travel volume to 1991 of 0.057. However, given those assumptions, a faster growth is expected in the 1970's (0.062) than in the 1980's (0.051).

These growth rates are slightly lower than the experience of the last few years but seem reasonable considering the high rate of growth for urban population and income over that period. Table 5.9 shows some of the recent experience with respect to growth in traffic on two routes: Montreal-Toronto and Montreal-Ottawa. Of note is the rapid growth of the bus industry on both routes. Air has maintained a steady growth rate of .072 on the Montreal-Toronto route but has made rather erratic progress on Montreal-Ottawa. There was an actual decline in the early 1960's. Rail has enjoyed a growth rate equal to that of air on Montreal-Toronto but has apparently lost traffic to buses and private automobiles between Montreal and Ottawa.[1]

[1] In part, this may result from the relocation of the Ottawa rail terminal in 1966.

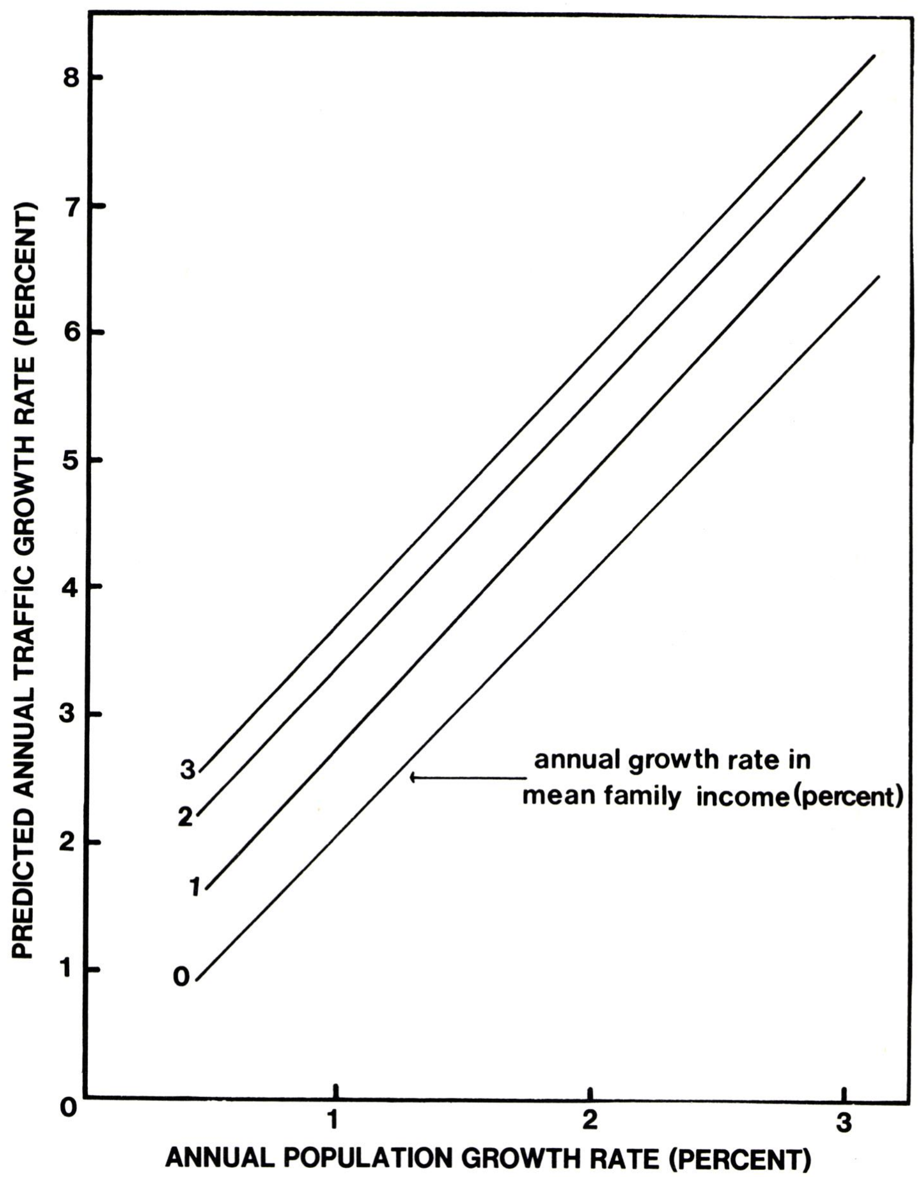



**Figure 5.7** **Growth of annual traffic with income and population growth.**

# 6 EVALUATION

## 6.1 Development Strategies

The application of new technology in the Corridor transportation network is evaluated within the framework of six development strategies extending over the period from 1970 to 1990. These six alternatives are designed to give an indication of the potential contribution of new technologies to the transportation system as a whole. The six strategies are listed in Figure 6.1. Analysis of the full Corridor network was beyond the resources of this study and hence the strategies are confined to the links joining Montreal, Toronto and Ottawa. However, the results of this limited analysis serve to indicate which additional links might benefit from the various new technologies.

In each alternative, passenger demand is predicted for the common carrier modes over the 20-year period of the study and on this basis the anticipated revenue and cost of operation are determined. The strategies are then evaluated in terms of the "present value" of these revenues and costs. That is, all cash flows are inflated to the year in which they occur and then discounted to the base year (1969) using assumed discount and inflation rates.[1] This reduces the flow of revenues and costs to an equivalent amount of money at the base year and allows direct comparison of the economic performance of the various development strategies.

The revenue predictions are sensitive to changes in the level of performance (time, frequency and fare) and are used to measure the benefits of each alternative. In this way benefits arising from time savings or improvements in service frequency are included in the evaluation. The revenues can be considered a measure of the "willingness to pay" by the travelling public for a particular system of transportation services.

As the study is concerned only with the relative merit of alternatives, no attempt has been made to estimate the full cost of system operation; only those revenue and cost elements which change in shifting from one strategy to another are considered. The strategies involving new technology are compared with a base strategy or "null hypothesis" in which the existing transportation system is retained through the full study period. This "present technology" strategy assumes that the system and its technology are evolving but with minimal effect on system performance. The difference in the present value of a strategy involving a new technology and the "present technology" represents the net benefit from introduction of the new technology.

As has been mentioned previously, the evaluation does not include several factors such as safety, noise, air pollution, comfort and reliability that are directly related to the transportation system. Also the effects of new transport technology on regional and urban development are not explicitly included in the evaluation. These points are discussed in more detail in Chapter 7.

The strategies introduce new technology in a time scale considered appropriate to the present stage of development of each innovation and the magnitude of the construction program required to establish an operating system.

In estimating the operating costs involved in this strategy, load factors for air operation approximate present load factors on each route and are left unchanged throughout the study period. On the Montreal-Ottawa and Ottawa-Toronto links, services are costed assuming full DC-9 operation. For Montreal-Toronto, it is assumed that there are equal numbers of DC-9 and DC-8 flights. (The curves of Figure 2.12 indicate the effect which the B-747 and L-1011 might have on costs if they were to take a significant share of air traffic providing that load factors are unaffected.) In all cases, aircraft utilization is taken as 3000 hours per year.

Rail load factors at the beginning of the study period are based on present loading on each route. Train size and frequency of service are held constant through time until the load factor approaches 65 percent which is regarded as a maximum workable load factor. Consist and/or frequency are then adjusted to accommodate traffic at a lower load factor. Buses are assumed to operate with average load factors of 60 percent on all routes.

Short-take-off-and-landing (STOL) aircraft are evaluated in a strategy which assumes that a DHC-7 STOL service is initiated in 1974 between downtown STOLports in Toronto and Montreal.[2] In 1980 this service is replaced by an augmentor-wing aircraft representative of proposed second-generation STOL technology. In both cases, CTOL load factor is used (70 percent) and aircraft utilization is set at 3000 hours per year. Based on the

[1] For purposes of this report, the strategies are compared using discount and inflation rates of 10 and 3 percent respectively. Fixed facilities are depreciated over a 25-year period assuming equal annual payments of depreciation plus interest. The sensitivity of the strategy comparison to the values of these parameters is examined throughout the analysis.

[2] Estimated demand was too low to support STOL services to Malton and Dorval Airports.

| | |
|---|---|
| **PT** | **Present Technology** |
| **STOL** | **Short Takeoff and Landing Aircraft** |
| **HSR1** | **High Speed Rail—Existing Track** |
| **HSR2** | **High Speed Rail—3½ hrs M-T** |
| **HSR3** | **High Speed Rail—3 hrs M-T** |
| **TACV** | **Tracked Air Cushion Vehicle** |

**Figure 6.1 Development strategies.**

difference in total operating costs of STOL and CTOL aircraft, the fare for a STOL flight from Montreal to Toronto is set $3.00 above the CTOL fare.

It is assumed that STOL and CTOL services operate in competition with each other. This being the case, CTOL operators would undoubtedly react to the introduction of an attractive second-generation STOL service by improving their own services wherever possible. Accordingly, with the improved STOL service of 1980, CTOL terminal times for Montreal-Toronto business travellers have been reduced from 80 to 50 minutes through assumed improvements in passenger processing.

In the STOL strategy, operations on the two Ottawa links remain unchanged from the present technology case. The present-technology system is also applied to the Montreal-Toronto link in the years prior to introduction of STOL services in 1974. Beyond 1974 the rail, bus and highway services of the present technology strategy (with appropriate adjustment for changes in demand) operate in competition with the improved air system.[1]

As discussed in Section 2.6, the total cost of centrally-located STOLports in Montreal and Toronto is estimated as 30 million dollars including navigation aids. For costing purposes, STOLport construction is assumed to begin in 1972 for completion in 1974.

In the first of three rail strategies, train equipment capable of higher speeds on existing track is introduced on the three links in 1971 and retained through the remainder of the study period. Costing is based on seven-car integral units (as adopted for the CNR Turbotrain), coupled to give 7, 14 and 21-car trains as required by passenger volumes. Scheduled trip times are taken as:

| | | |
|---|---|---|
| Montreal-Toronto | 4 | hours |
| Toronto-Ottawa | 4 | hours |
| Montreal-Ottawa | 1:40 | hours |

In the other two rail strategies, 3½ and 3-hour rail service is initiated between Montreal and Toronto in 1976. These service improvements involve investment in track improvements estimated at 200 and 500 million dollars respectively. Improvements for the 3½-hour service are assumed to be completed over the 2 years prior to operation while construction costs for 3-hour service are distributed over three years. In estimating the avoidable operating costs charged against these two systems it is assumed that the existing track is upgraded and freight and passenger trains continue to operate on common trackage.[2] Then the basic cost of maintaining and operating the track system is not treated as an avoidable cost. Where trains are operated at speeds greater than the present speed limit, the resulting increase in track maintenance cost is estimated and included as an avoidable cost.

The train consist and frequency for the three rail strategies are shown below for the Montreal-Toronto service.

No attempt has been made to account for increased costs resulting from interference between high speed rail services and freight and track maintenance operations. The effect of frequency on these costs is dependent on the spacing of passing or cross-over track and the type of train control system in operation. Where full two-way central traffic control is in operation (as due for completion on the Montreal-Toronto CNR mainline in early 1971) the effect of high-frequency passenger service on costs of wayfreight and track maintenance operations is negligible. The cost effect of more frequent overtakes of principal freight trains by passenger trains has not been estimated.

For each of the three rail strategies, an "optimum" fare was estimated for the Montreal-Toronto service by performing the analysis for three rail fares while holding bus and air fares unchanged. This "best" fare was taken as the rail fare which would result in the greatest excess of revenues over operating costs for the total common carrier system.[3] In each of the three cases, this fare was found to be approximately 15 percent above current rail fares. This exercise is illustrated in Figure 6.2 for a 3½-hour Montreal-Toronto rail schedule.

On the Toronto-Ottawa and Montreal-Ottawa links, the relative profitability of the air and rail modes is such that a "best" fare would be lower than present rail fare. Air services on these routes operate at a lower level of profitability (considering avoidable costs only) than rail service and hence, over a certain range of rail fare reduction, the shift of travellers from air to rail results in a more "profitable" system. However for this analysis, rail fare on these links has been set 15 percent above present fares.

The tracked-air-cushion-vehicle concept is tested in a strategy which would bring a TACV system into operation on a Montreal-Ottawa-Toronto alignment in 1980. It is assumed that with the introduction of TACV service, rail would no longer serve intercity traffic between

**Train Consist and Frequency for the Montreal-Toronto Service**

| | Trains/day (each way) | | | Cars/Train | | |
|---|---|---|---|---|---|---|
| | 4-hour | 3½-hour | 3-hour | 4-hour | 3½-hour | 3-hour |
| 1972 | 4 | | | 14 | | |
| 1974 | 5 | | | 14 | | |
| 1976 | 5 | 3/2 | 3/3 | 14 | 14/21 | 14/21 |
| 1978 | 3/2[4] | 3/3 | 3/3 | 14/21[4] | 14/21 | 14/21 |
| 1980 | 3/2 | 3/3 | 6 | 14/21 | 14/21 | 21 |
| 1982 | 3/3 | 6 | 6 | 14/21 | 21 | 21 |
| 1984 | 3/3 | 6 | 8 | 14/21 | 21 | 21 |
| 1986 | 6 | 7 | 8 | 21 | 21 | 21 |
| 1988 | 6 | 7 | 10 | 21 | 21 | 21 |
| 1990 | 8 | 8 | 10 | 21 | 21 | 21 |

[4]The split figures denote trains of different length i.e. 3 trains of 14 cars plus 2 trains of 21 cars.

[1] As for the STOL strategy, the present technology case is applied to links and modes where they are unaffected by new technology in each of the remaining four strategies.

[2] As discussed in Section 2.4, construction costs for new trackage are estimated to be approximately the same as the cost of improving existing track to the same standard. In the case of new track devoted to passenger traffic only, the full cost of operation and maintenance would be charged against the passenger services as an avoidable operating cost.

[3] As this study is concerned with the contribution which new technology could make to the overall transport system, choice of this "maximum-system-profit" criterion was a logical one. It is recognized that resulting fare levels may not be "best" fares from the point of view of individual carriers but as shown in Figure 6.1 the total system is insensitive to fare change.

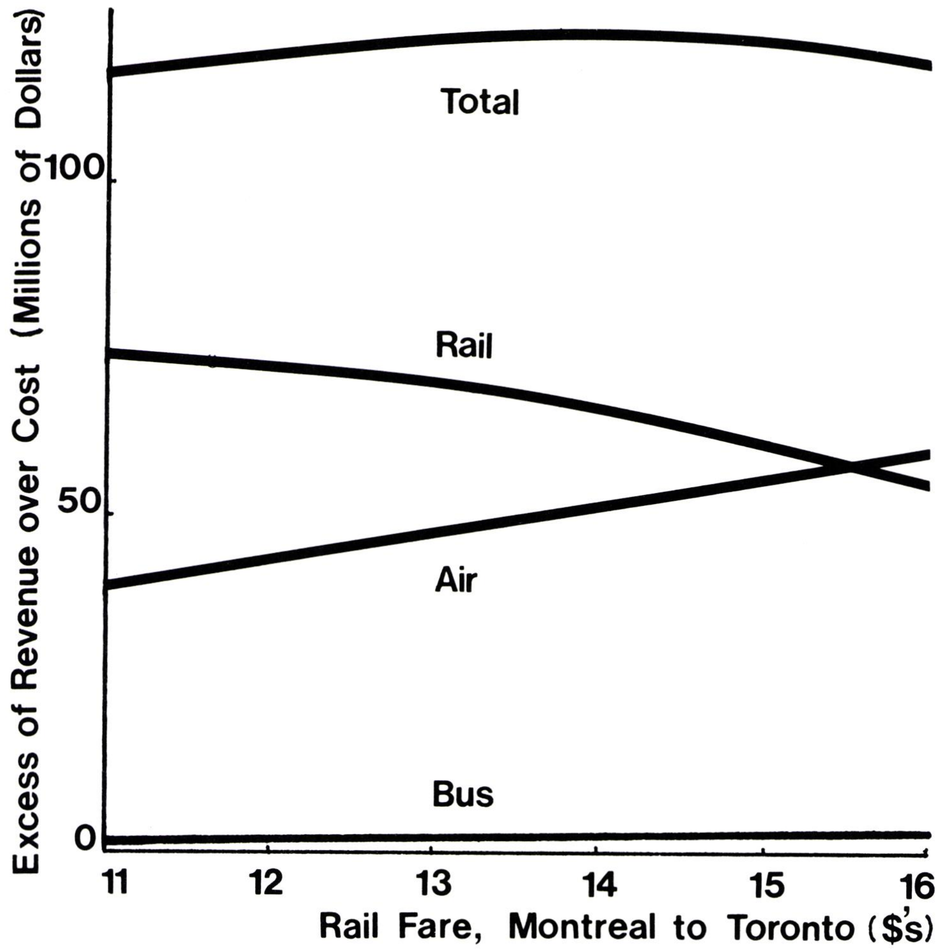



**Figure 6.2 Effect of rail fare on system revenues for HSR2 strategy.**

these centres. TACV operating costs are based on the first-generation Aerotrain I-80 system assuming an average load factor of 75 percent. Block times by TACV are taken as:

| | |
|---|---|
| Montreal-Toronto | 2:30 hours |
| Toronto-Ottawa | 1:25 hours |
| Montreal-Ottawa | 1:05 hours |

As for the rail strategies, the TACV proposal was analyzed for three fares on each link and a fare of approximately 6 cents per passenger-mile was found to produce the most profitable system.

The TACV strategy involves an estimated 520 million dollar investment in fixed facilities such as track structure, terminals, and utility relocation. For costing purposes this construction is assumed to be carried out over a three-year period peaking in 1978 with completion for operation in 1980.

For the sake of brevity in following discussion and illustrations, the various strategies are frequently referred to by the mnemonics listed in Figure 6.1. It should be emphasized that these short forms represent an entire system in operation under a particular strategy. For example, in many cases "TACV" refers to the strategy in which TACV operates rather than to the mode itself.

In summary, a series of development strategies incorporating new technology has been analyzed for the three links joining Montreal, Toronto and Ottawa over a 20-year study period beginning in 1970. The system changes involved in alternative strategies are summarized in Figure 6.3. A strategy which involves no marked change in the transport system was chosen as the base for comparison of development alternatives. The viability of STOL aircraft operation in the Corridor was tested in a strategy in which DHC-7 service between downtown STOLports in Montreal and Toronto would begin in 1974. In 1980, the DHC-7 is replaced with a second-generation STOL aircraft concurrent with improvement in conventional air services. Improvements to rail service include higher-speed trains in operation on existing track in 1971 on each of the three routes. The benefit of further improvement in rail service is tested in two strategies which require major improvement of Montreal-Toronto trackage. For this analysis, these track improvements are timed for completion in 1976. The TACV concept is assessed in the framework of a strategy which brings a TACV system serving Montreal, Toronto and Ottawa into service in 1980.

## 6.2 Strategy Volumes

Origin-destination traffic by each of the common carrier modes was estimated for the six development strategies using the demand and modal split models described in Section 5. Where a link is unaffected by a particular strategy, the present technology case was applied over the appropriate period. For example, in the TACV strategy, the transportation system and demand of the present technology strategy are retained on all links in the years prior to introduction of TACV's.

In estimating passenger volumes, the various modes are described by the elements of time and cost summarized in Table 6.1. The basis for the choice of fares for new technologies has been discussed in the outline of strategies of the last section, but generally an attempt has been made to set fares on new modes at the level which would produce the greatest operating profit for the entire system. For these new technologies, block or schedule times are chosen to be consistent with projected performance of the technology and the conditions under which it might operate.

The time and cost involved in reaching terminals are based on averages derived from the origin-destination survey. These survey values have been applied to new systems on consideration of the type of traveller likely to be attracted to the mode, and the probable general location and design of terminals. Access time and cost, as perceived by surveyed rail passengers, are used for both the TACV and high-speed-rail options. As discussed in following paragraphs, demand for STOL services is estimated in a zone-to-zone analysis of Montreal-Toronto travel. Access time and cost shown in Table 6.1 for STOL services are averages resulting from this zone-by-zone analysis in which access is measured by reported values for rail and bus terminals.

For the improved rail system, terminal times (passenger processing and waiting times) are assumed to be unchanged from current values for rail travellers. The high service frequency of the TACV system, together with no-reservation operation and a minimum of passenger processing, suggest that terminal times for TACV users would be relatively low. The variation of processing times (as perceived by the traveller) is another factor influencing terminal times and in the TACV system this "risk" time is expected to be lower than for the other modes. On this basis, TACV terminal time is set at 40 minutes, or about 20 minutes less than reported terminal times for bus travellers.

The Montreal-Toronto STOL operation would undoubtedly cater largely to business travellers. As an experienced traveller with little luggage, the average business traveller tends to move through terminal and departure areas more rapidly than the average air traveller. This is illustrated by average terminal times for Montreal-Toronto air travellers of 80 minutes for business travellers and 130 for all other trip purposes. As with TACV, the risk time or the passenger's allowance for variation in processing time would undoubtedly be lower for STOL than for CTOL operations. Another factor affecting terminal time is the physical size of the terminal facilities—the distance one would travel in passing through a STOL terminal would be small in comparison with the case at a major airport. Considering these factors, STOL terminal time is set at 40 minutes. To illustrate the effect of changing this value, a 10-minute increase would lower the (second-generation) STOL share of the air market from 39 percent to 35 percent.

The STOL strategy assumes that STOL and CTOL services on the Montreal-Toronto link operate in competition with one another. Faced with the prospect of competition from a highly attractive STOL service as proposed in this strategy from 1980, the major operators of CTOL services on this link would probably attempt to hold their market share at a high level by improving their services wherever feasible. One reaction which might be anticipated is the operation of a high-frequency no-reservation shuttle service resulting in significantly lower passenger processing and terminal waiting times. The effect of such an improvement has been estimated by reducing terminal times for business travellers by ½ hour to give an average terminal time of 70 minutes for all CTOL travellers.

**Table 6.1 Trip Time and Cost by Link and Mode**

| | Trip Time (Minutes) | | | Trip Cost (Dollars) | |
|---|---|---|---|---|---|
| | Access Time | Terminal Time | Block Time | Access Cost | Fare |
| **Montreal-Toronto** | | | | | |
| Air (Conventional) | 60 | 93[1] | 65 | 5.16 | 25.00 |
| DHC-7 | 47[2] | 40 | 90 | 3.52 | 28.00 |
| Augmentor Wing | 47[2] | 40 | 55 | 3.52 | 28.00 |
| Rail (Conventional) | 43 | 75 | 299 | 1.91 | 12.40 |
| Rail (HSR1) | 43 | 75 | 240 | 1.91 | 13.90 |
| Rail (HSR2) | 43 | 75 | 210 | 1.91 | 13.90 |
| Rail (HSR3) | 43 | 75 | 180 | 1.91 | 13.90 |
| Bus | 46 | 61 | 370 | 1.64 | 12.15 |
| TACV | 43 | 40 | 150 | 1.91 | 20.00 |
| **Montreal-Ottawa** | | | | | |
| Air | 56 | 89 | 30 | 4.66 | 11.00 |
| Rail (Conventional) | 50 | 65 | 119 | 2.42 | 4.30 |
| Rail (HSR1) | 50 | 65 | 100 | 2.42 | 4.82 |
| Bus | 40 | 53 | 134 | 1.49 | 4.50 |
| TACV | 50 | 40 | 65 | 2.42 | 6.00 |
| **Toronto-Ottawa** | | | | | |
| Air | 56 | 88 | 55 | 4.66 | 21.00 |
| Rail (Conventional) | 49 | 62 | 299 | 2.41 | 9.40 |
| Rail (HSR1) | 49 | 62 | 240 | 2.41 | 10.52 |
| Bus | 46 | 58 | 285 | 1.64 | 9.60 |
| TACV | 49 | 40 | 85 | 2.41 | 15.00 |

[1] For business travel on this link, terminal time is reduced from 80 to 50 minutes after 1980 in the STOL strategy.

[2] These are averages for those air trips which are assigned to STOL.

Annual two-way passenger volumes are shown in Figures 6.4 to 6.6 for the 20-year study period. Figures 6.26 to 6.32 at the end of this section break this traffic into volume by mode. The average trip time and cost for the common carrier modes are summarized in Table 6.2. These values are the weighted average of the modal characteristics summarized in Table 6.1 and apply only to the period after system changes have been initiated. The estimated fraction of total common carrier traffic carried by each mode is also noted in Table 6.2. This modal split is assumed to be constant and is based on a balance of supply of transport services with demand for transportation at the beginning of the study period or on introduction of service. In a more complete analysis, the equilibrium between supply and demand would be determined for each year of service and the modal split would shift somewhat from year to year.

Travel volumes are based on an assumed increase in real income of 2.5 percent per year. Population is increased at approximately 2.0 percent per year as the mean of "high" and "low" population forecasts. (Detailed discussion of the demographic input to the volume projections is included in Section 4.)

Forecast of patronage on "new technology" modes involves selection of a value for a mode-dependent coefficient in the demand model.[3] In the case of STOL, this coefficient was set so that DHC-7 and second-generation STOL would attract 33 percent and 50 percent of the air market respectively if their frequency, time and cost performance

[3] This parameter accounts for factors other than travel time, cost and service frequency (e.g. passenger comfort and passenger service) not otherwise accounted for in the modal split model. This coefficient is discussed in detail in Section 5 for all technologies considered.

**Table 6.2 Modal Split, Trip Time and Trip Cost**

| Strategy | Average Access Time (Hours) | Average Terminal Waiting Time (Hours) | Average Block Time (Hours) | Average Total Time (Hours) | Average Access Cost (Dollars) | Average Fare ($) | Average Total Cost ($) | Modal Split Air | Rail (TACV) | Bus |
|---|---|---|---|---|---|---|---|---|---|---|
| Montreal-Toronto | | | | | | | | | | |
| Present Technology | .89 | 1.42 | 2.74 | 5.05 | 3.81 | 19.81 | 23.62 | .59 | .36 | .05 |
| STOL (1974-1979) | .84 | 1.33 | 2.78 | 4.95 | 3.60 | 20.35 | 23.95 | .60 | .34 | .06 |
| (1980-1990) | .85 | 1.15 | 2.31 | 4.31 | 3.64 | 21.83 | 25.47 | .69 | .26 | .05 |
| HSR1 (1971-1990) | .88 | 1.40 | 2.46 | 4.74 | 3.68 | 19.89 | 23.57 | .55 | .39 | .06 |
| HSR2 (1976-1990) | .86 | 1.39 | 2.40 | 4.65 | 3.59 | 19.26 | 22.85 | .49 | .46 | .05 |
| HSR3 (1976-1990) | .84 | 1.36 | 2.31 | 4.51 | 3.26 | 18.48 | 21.74 | .42 | .53 | .05 |
| TACV (1980-1990) | .77 | .84 | 2.43 | 4.04 | 2.48 | 20.51 | 22.99 | .18 | .77 | .05 |
| Montreal-Ottawa | | | | | | | | | | |
| Present Technology | .79 | 1.05 | 1.92 | 3.76 | 2.34 | 5.03 | 7.37 | .10 | .57 | .33 |
| HSR1 (1971-1990) | .79 | 1.06 | 1.72 | 3.57 | 2.36 | 5.34 | 7.70 | .10 | .59 | .31 |
| TACV (1980-1990) | .81 | .71 | 1.22 | 2.74 | 2.34 | 5.90 | 8.24 | .02 | .85 | .13 |
| Toronto-Ottawa | | | | | | | | | | |
| Present Technology | .88 | 1.27 | 2.59 | 4.74 | 3.61 | 16.41 | 20.02 | .60 | .19 | .21 |
| HSR1 (1971-1990) | .87 | 1.23 | 2.42 | 4.52 | 3.43 | 15.63 | 19.06 | .50 | .36 | .14 |
| TACV (1980-1990) | .82 | .73 | 1.52 | 3.07 | 2.52 | 15.14 | 17.66 | .06 | .90 | .04 |

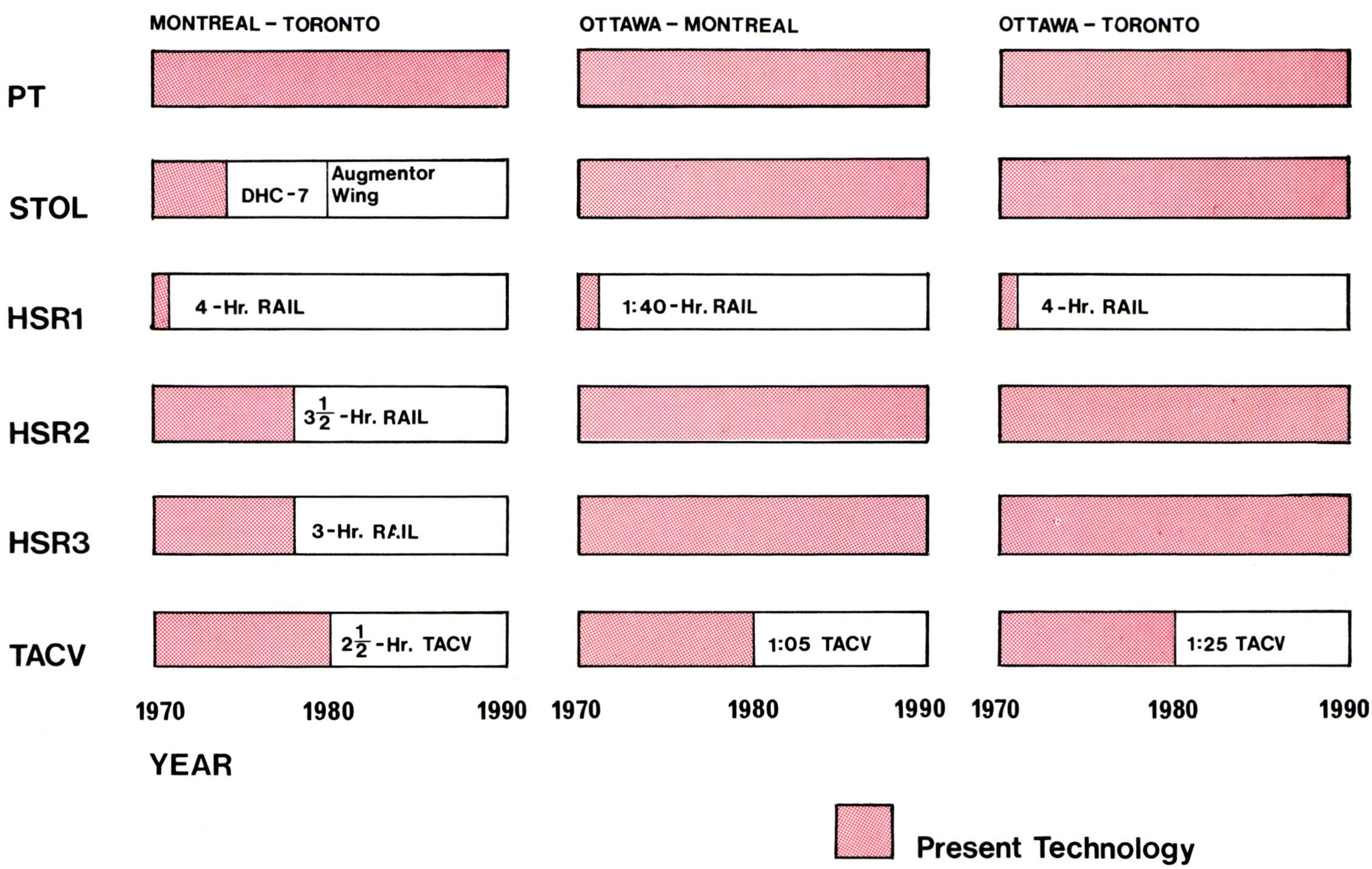



**Figure 6.3 Summary of strategies.**

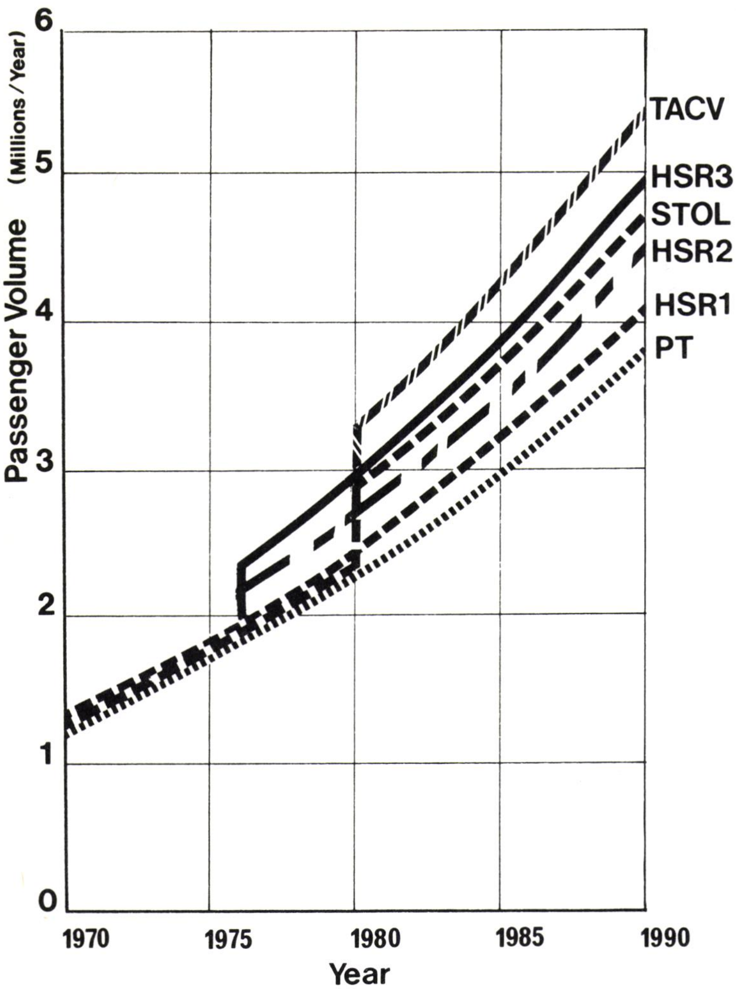



Figure 6.4 Annual two-way origin-destination passengers by common carrier between Montreal and Toronto.

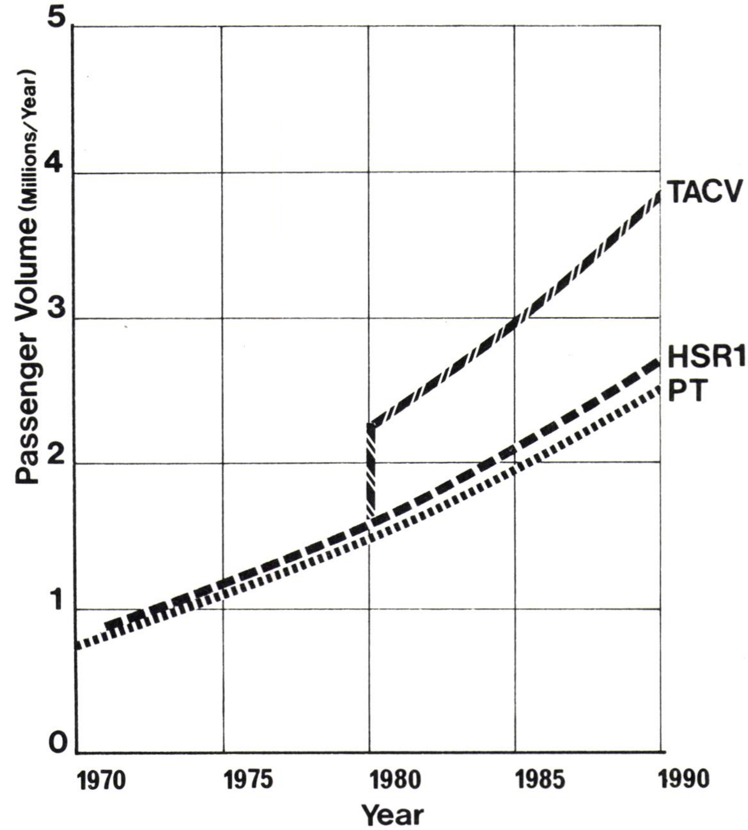



Figure 6.5 Annual two-way origin-destination passengers by common carrier between Montreal and Ottawa.

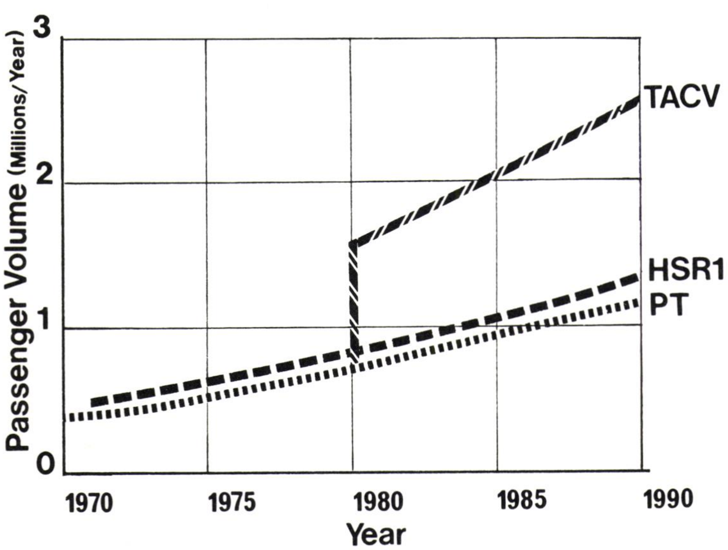



Figure 6.6 Annual two-way origin-destination passengers by common carrier between Toronto and Ottawa.

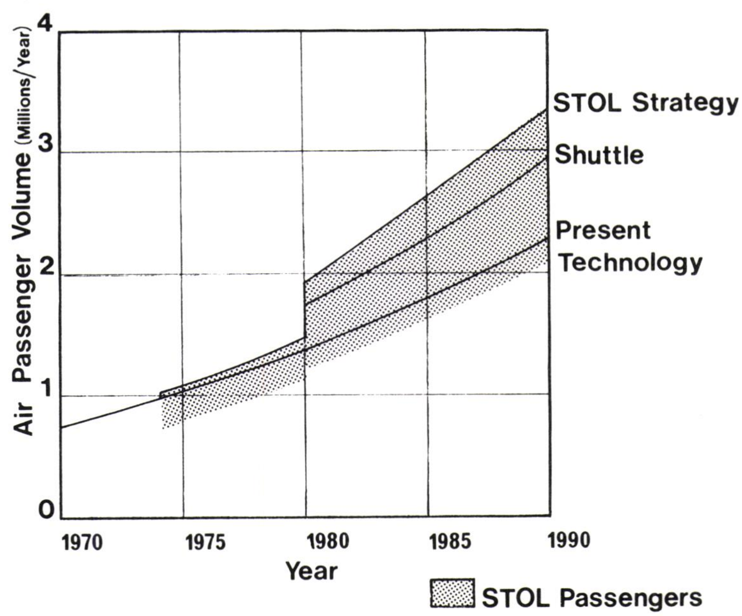



Figure 6.7 STOL strategy: Two-way origin-destination passengers by air between Montreal and Toronto.

were the same as the CTOL service.[1] For TACV the modal coefficient was chosen such that TACV and CTOL are equivalent in respects other than time, cost and frequency. For high-speed rail services this parameter is left unchanged from conventional rail service.

With the exception of the STOL case, volumes for the various strategies are estimated by applying the city-wide averages of Table 6.1 in the demand and modal split models. The diversion of air travellers from CTOL to STOL services is sensitive to the location of trip ends within the cities of origin and destination and cannot be reliably estimated by using average access time and cost based on survey values for any existing mode. For this reason, volumes for the STOL strategy were estimated by first applying the modal split model to representative zones within Montreal and Toronto to estimate the share of the air market captured by the proposed STOL services. Using the split of the air market obtained in this way, the weighted average performance of STOL and CTOL was estimated for input to the system demand model. For this analysis, it is assumed that the STOL market is limited to persons travelling for business purposes, or some 75 percent of the total Toronto-Montreal air market.

The estimate of air volumes resulting from this analysis is shown in Figure 6.7 in relation to volumes for the present technology case. Also shown are air volumes expected if the CTOL service improvements of the STOL strategy are made without introducing STOL services. The DHC-7 service attracts some 23 percent of the air market or sufficient to operate 9 flights per day in each direction in 1974 (assuming an average load factor of 70 percent). Similarly, the augmentor-wing STOL service would attract 39 percent of the air market or sufficient for 15 flights per day in 1980.

As illustrated in Figures 6.4 to 6.6, each change to the system results in total common carrier volumes greater than "present technology" volume. This increase is made up of two components: 1) new trips generated by the reduced

[1] The choice of these values is a matter of judgement, implying that in terms of flight comfort and in-flight service, the first-generation STOL service envisaged in this study would be half as attractive as the competing CTOL service. Similarly, in these respects, the more advanced STOL technology is assumed to be as attractive as CTOL service. Limited variation of these values would not have any substantial effect on system performance.

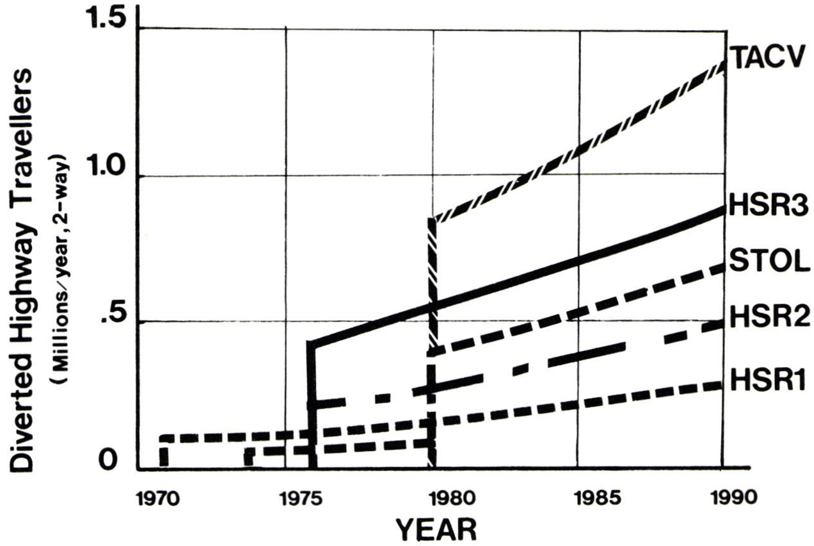



**Figure 6.8** Highway travellers diverted to common carrier (annual two-way origin-destination volume between Montreal and Toronto).

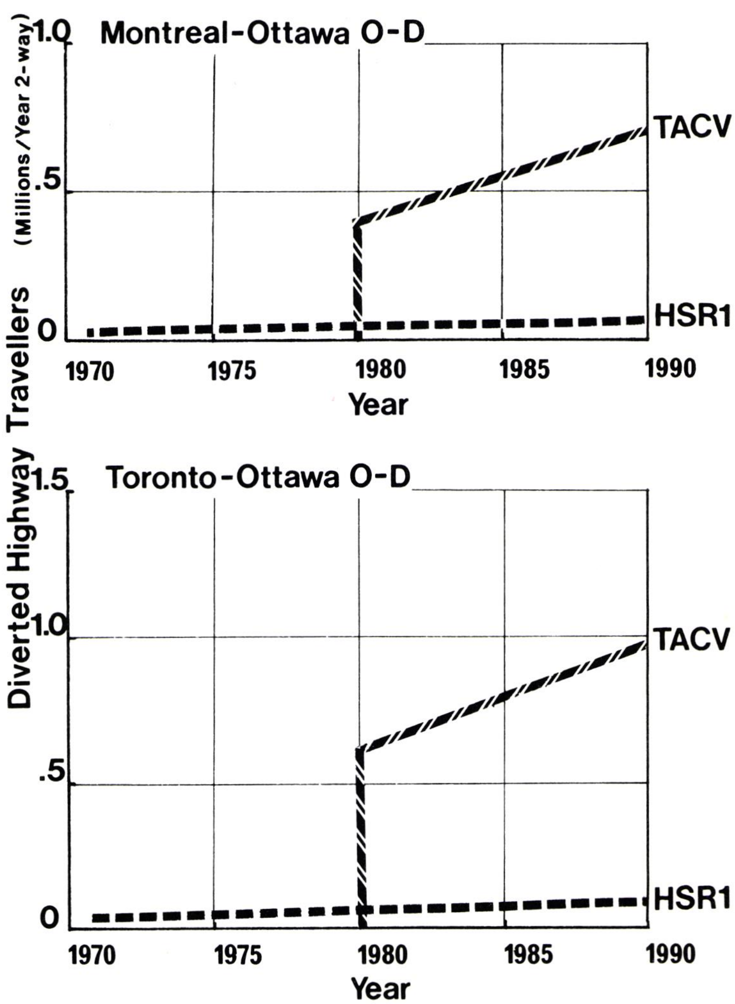



**Figure 6.9** Highway travellers diverted to common carrier (annual two-way origin-destination volume).

travel impedance which is inherent in the strategies, and

2) diversion of trips from automobile to common carrier as a result of improvements in the common carrier modes.

The estimated diversion of passengers from highway travel is summarized in Figures 6.8 and 6.9 for the three links of concern. Relative to the other strategies, the TACV system has a pronounced effect on highway travel. However, as discussed in Section 6.3 this shift is sufficiently small that highway operation would be unaffected.

## 6.3 Strategy Evaluation

This section compares the operation of the six development strategies over the twenty-year period of this Study. In outlining the strategy comparison, only one set of interest and inflation rates is used (10 percent and 3 percent respectively) and capital investment other than for vehicles is amortized on an equal-annual-payments basis over a 25-year period. The effect of departures from these values has been investigated and is summarized in this discussion. Costs and revenues are expressed in terms of their present worth using 1969 as a base year. Vehicles are amortized on a replacement basis over the following time periods:

| | |
|---|---|
| conventional trains | 20 years |
| high-speed trains | 15 years |
| conventional aircraft | 12 years |
| STOL aircraft | 12 years |
| TACV's | 15 years |

Bus operating costs are based on reported costs from a number of sources and therefore are not based on a single amortization assumption.

Revenues and "avoidable" operating costs for each mode, link and strategy are summarized in Tables 6.3 and 6.4 for the 1970-1990 study period. In these figures amortization of capital investment in vehicles is included as an element of operating costs but investment in structures such as track and stations is not accounted for. In the case of air transport serving Ottawa, revenue consistently fails to meet estimated avoidable operating costs.

With the additional exception of rail travel between Ottawa and Toronto under the TACV strategy, revenue exceeds operating cost for all links and modes. The present common carrier modes are affected to varying degrees by the system changes of the development strategies. Figure 6.10 indicates the effect of the strategies on the excess of revenue over avoidable operating costs for rail, bus and CTOL services on the three combined routes. The impact of progressive improvement of the ground modes (as represented by the various strategies) on return to the CTOL system is clearly illustrated here. In the case of rail, the HSR2 option has a smaller return than HSR1 since it benefits only the Montreal-Toronto link. Rail return for the TACV strategy is relatively low since it represents operation from 1970 to 1979 only.

The difference between revenue and operating cost for the three-link system is shown in Figure 6.11. In this comparison the present technology case proves to be the least 'profitable' with less than one-half the excess of the TACV strategy. Using the present technology case as a basis for comparison, Figure 6.12 shows the difference between the operating 'profit' of each strategy and that of the base strategy.

To this point, capital costs other than investment in vehicles has been omitted from operating costs. The cost of facilities such as trackage and terminals involved in the various strategies is summarized in Table 6.5 for a number of depreciation assumptions. These values represent the present worth of all interest and amortization "payments" up to and

**Table 6.3 Revenues and Avoidable Operating Costs—Montreal to Toronto**

| | (Present Worth, Millions of Dollars) | | |
|---|---|---|---|
| | Cost | Revenue | Difference |
| Present Technology | | | |
| Air | 292.8 | 349.2 | 56.4 |
| Rail | 57.6 | 101.7 | 44.1 |
| Bus | 12.3 | 13.8 | 1.5 |
| | | | 102.0 |
| STOL Strategy | | | |
| Air | 380.8 | 448.2 | 67.4 |
| Rail | 54.1 | 95.3 | 41.2 |
| Bus | 14.5 | 16.3 | 1.8 |
| | | | 110.4 |
| HSR1 Strategy | | | |
| Air | 294.9 | 351.7 | 56.8 |
| Rail | 71.3 | 131.6 | 60.3 |
| Bus | 15.8 | 17.7 | 1.9 |
| | | | 119.0 |
| HSR2 Strategy | | | |
| Air | 288.1 | 340.1 | 52.0 |
| Rail | 79.7 | 147.4 | 67.7 |
| Bus | 13.6 | 15.3 | 1.7 |
| | | | 121.4 |
| HSR3 Strategy | | | |
| Air | 281.0 | 331.0 | 50.0 |
| Rail | 102.3 | 181.4 | 79.1 |
| Bus | 14.2 | 15.9 | 1.7 |
| | | | 130.8 |
| TACV Strategy | | | |
| Air | 217.5 | 253.6 | 36.1 |
| Rail to 1979 | 30.4 | 51.5 | 21.1 |
| Bus | 14.1 | 15.8 | 1.7 |
| TACV | 137.4 | 249.7 | 112.3 |
| | | | 171.2 |

Rate of interest = 10%  Rate of inflation = 3%

including 1990. Figure 6.13 shows amortization costs on an equal-annual-payments basis assuming a 25-year amortization period for all fixed-facility capital investment. As the rail services of the HSR1 alternative operate on existing trackage, no capital investment is involved in that strategy. At this stage, it is assumed that any investment in fixed facilities which might be required for the present technology strategy applies equally to all strategies. In other words, volume changes produced by a shift from the present technology strategy to any other strategy are assumed to be insufficient to affect timing or size of investment in facilities such as conventional airports required to support the present technology system. The validity of this assumption is reviewed later in this section. If the amortization and interest charges of Figure 6.13 are applied to the strategy comparison of Figure 6.12, the comparison shifts as illustrated in Figure 6.14. As shown in the figure, high speed rail without benefit of track improvements shows a clear advantage over all other strategies while the other four new technology strategies appear less attractive than the present technology case.

This comparison must be adjusted to allow for differences in total common carrier volume for each of the strategies. To this point, comparison of costs and revenues for the common carrier modes takes full account of trips assigned to these modes in both the present technology strategy and the "new" strategies. It also includes the effect of new travel generated by system improvements as these trips are non-existent in the base or present-technology case and are fully accounted for in the other strategies. However, while costing of each of the "new" strategies includes the effect of trips diverted from highways, this travel has not yet been accounted for in the present-technology strategy. The values of Figure 6.14 must be adjusted for the following three factors:

1) savings in automobile operating costs resulting from diversion from highway travel to other modes,

2) the fact that for diverted auto travellers the value of a trip has not changed from zero to the carrier fare but from the perceived cost of travel by auto to the carrier fare. Auto travellers are, in effect, paying a fare equal to what they perceive to be the cost of making the journey by automobile, and

3) possible reduction (or delay) of investment in highway facilities through reduced highway volumes resulting from diversion of auto travellers.

**Table 6.4 Revenues and Avoidable Operating Costs**

| | (Present Worth, Millions of Dollars) | | |
|---|---|---|---|
| Montreal-Ottawa | Cost | Revenue | Difference |
| Present Technology | | | |
| Air | 31.1 | 16.2 | −14.9 |
| Rail | 35.4 | 36.2 | 0.8 |
| Bus | 18.3 | 22.9 | 4.6 |
| | | | −9.5 |
| HSR1 Strategy | | | |
| Air | 32.3 | 17.9 | −14.4 |
| Rail | 35.1 | 43.3 | 8.2 |
| Bus | 18.0 | 21.4 | 3.4 |
| | | | −2.8 |
| TACV Strategy | | | |
| Air | 20.8 | 11.2 | −9.6 |
| Rail to 1979 | 17.9 | 18.1 | 0.2 |
| Bus | 14.4 | 17.2 | 2.8 |
| TACV | 32.0 | 56.5 | 24.5 |
| | | | 17.9 |
| Toronto-Ottawa | | | |
| Present Technology | | | |
| Air | 98.7 | 96.3 | −2.4 |
| Rail | 12.8 | 12.9 | 0.1 |
| Bus | 11.9 | 14.6 | 2.7 |
| | | | 0.4 |
| HSR1 Strategy | | | |
| Air | 92.8 | 90.1 | −2.7 |
| Rail | 22.6 | 29.7 | 7.1 |
| Bus | 9.1 | 11.1 | 2.0 |
| | | | 6.4 |
| TACV Strategy | | | |
| Air | 64.3 | 60.3 | −4.0 |
| Rail to 1979 | 7.7 | 6.7 | −1.0 |
| Bus | 8.5 | 10.4 | 1.9 |
| TACV | 52.3 | 102.2 | 49.9 |
| | | | 46.8 |

Rate of interest = 10% Rate of inflation = 3%

The first two of these factors are accounted for by crediting to each "new" strategy the difference between actual and perceived costs of auto operation for all trips diverted from highways. The "actual" operating cost of concern here is the avoidable cost of driving and therefore should not include fixed costs such as garaging, insurance, and time-dependent depreciation. In making a travel decision, a driver considers only a portion of auto operating costs. This perceived cost is generally acknowledged to be close to the out-of-pocket operating expenses involved, and for this analysis is taken as the sum of fuel, oil and tire costs. Actual (avoidable) cost and perceived cost are set at 5 and 3 cents per vehicle-mile respectively. This is reduced to a passenger-mile cost by a factor of 2.15 passengers per vehicle and results in an adjustment for trip diversion as shown in Figure 6.15 for each of the strategies. In Figure 6.16. these adjustments have been applied to the comparative costs, increasing the relative profitability of all strategies.

As shown in Figures 6.8 and 6.9, volume of highway traffic is most affected by the

**Table 6.5 Investment Costs for Fixed Facilities**

| | Present Worth of Payments to 1990 (millions of dollars) | | | |
|---|---|---|---|---|
| | STOL | HSR2 | HSR3 | TACV |
| Current Value | 30 | 200 | 500 | 520 |
| Year in Service | 1974 | 1976 | 1976 | 1980 |
| By equal-annual-payments | | | | |
| 15-year amortization | | 139 | 360 | 246 |
| 17 | 23 | | | |
| 25 | 21 | 117 | 302 | 206 |
| 40 | 19 | 108 | 280 | 191 |
| By straight-line depreciation | | | | |
| 15-year amortization | | 139 | 360 | 261 |
| 17 | 23 | | | |
| 25 | 22 | 126 | 326 | 231 |
| 40 | 21 | 118 | 306 | 215 |

Rate of interest = 10% Rate of inflation = 3%

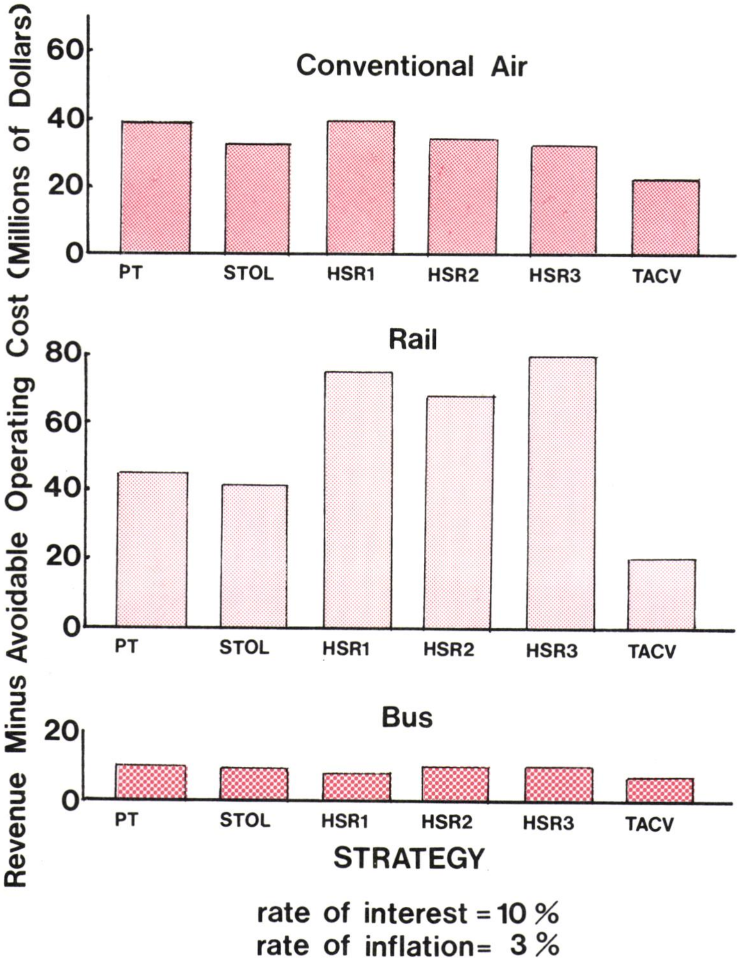



**Figure 6.10 Total system revenue minus avoidable operating cost by mode for each strategy period (present worth 1970-1990).**

TACV system. Under this strategy an estimated 850,000 two-way person trips between Montreal and Toronto would be diverted from highways to the common carriers in 1980. This reduces to 200,000 one-way auto trips per year or a peak-hour change of approximately 65 vehicles per hour.[1] Comparing this with freeway capacities in excess of 1200 vph per lane, it is evident that diversion of traffic from highway travel will have a negligible effect on highway investment. Similarly, for the Montreal-Ottawa and Toronto-Ottawa links, the TACV strategy would reduce highway volumes by 30 and 45 vehicles per peak hour in 1980.

In cases where service improvements to competing modes result in reduced CTOL volumes, they may lead to savings through rescheduling of airport improvements. As shown in Figures 6.26 and 6.27, the TACV strategy has a greater effect on air volumes than any other strategy. Construction of a second Montreal airport at Ste. Scholastique is scheduled for completion prior to 1980 and is therefore unaffected by reduced air volumes by diversion to a TACV system which would be introduced in 1980. However, the need for expanded capacity at St. Scholastique at some future date

[1] This assumes that:
peak month ADT = 1.30 x annual ADT
peak week ADT = peak month ADT
peak day volume = 0.15 x peak week ADT
peak hour volume = 0.08 x peak day volume
where ADT = Average Daily Traffic.

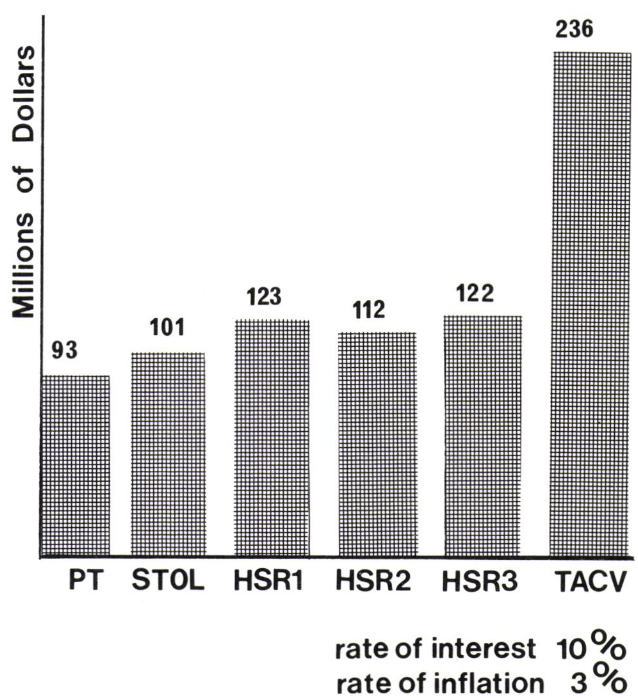



**Figure 6.11 Excess of system revenue over avoidable cost (present worth—1970-1990).**

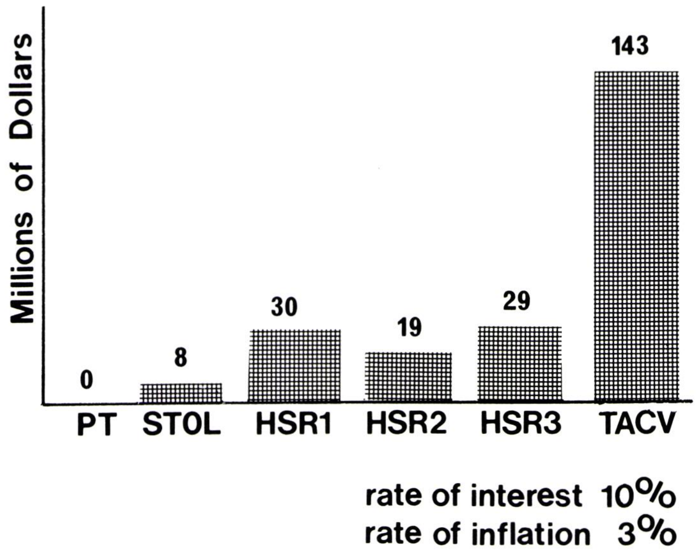



Figure 6.12 Operating 'Profit' compared with present technology 'Profit' (present worth—1970-1990).

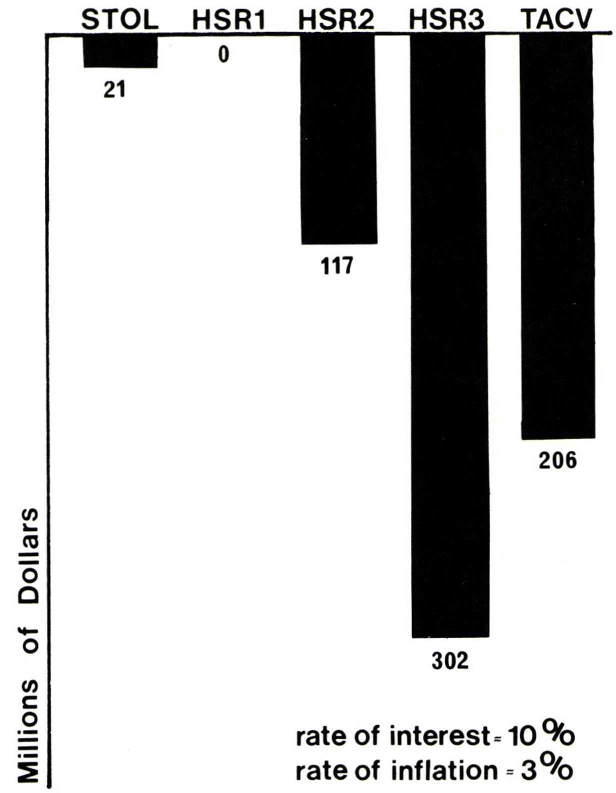



Figure 6.13 Present worth of capital costs (25 year amortization).

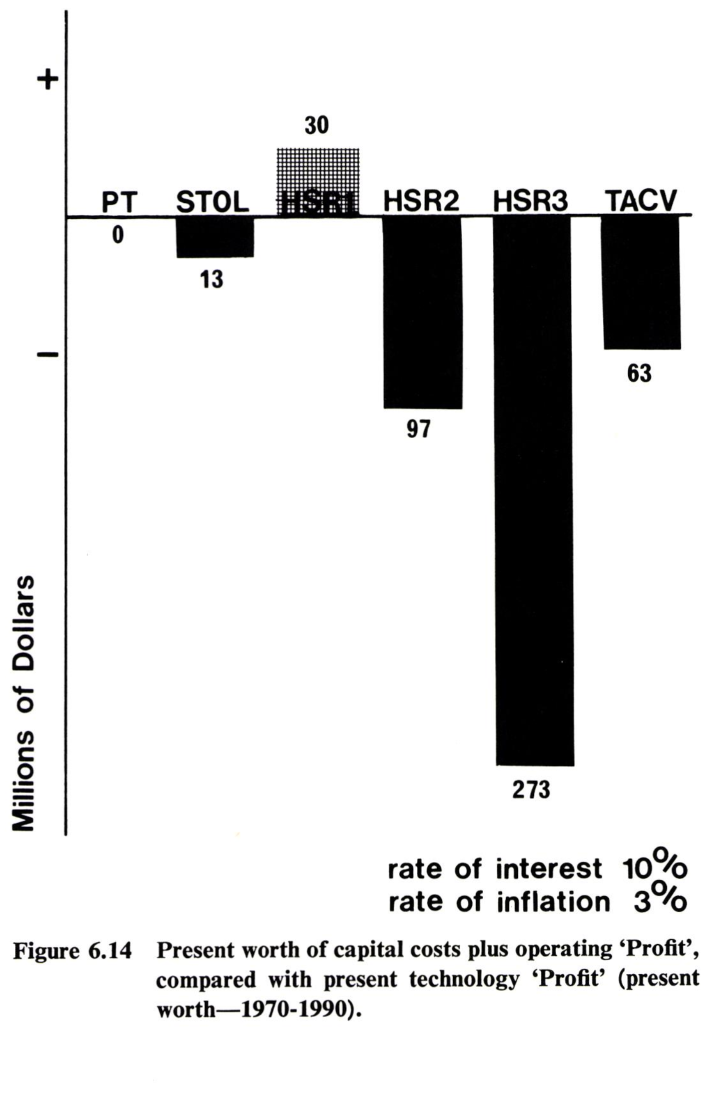



Figure 6.14 Present worth of capital costs plus operating 'Profit', compared with present technology 'Profit' (present worth—1970-1990).

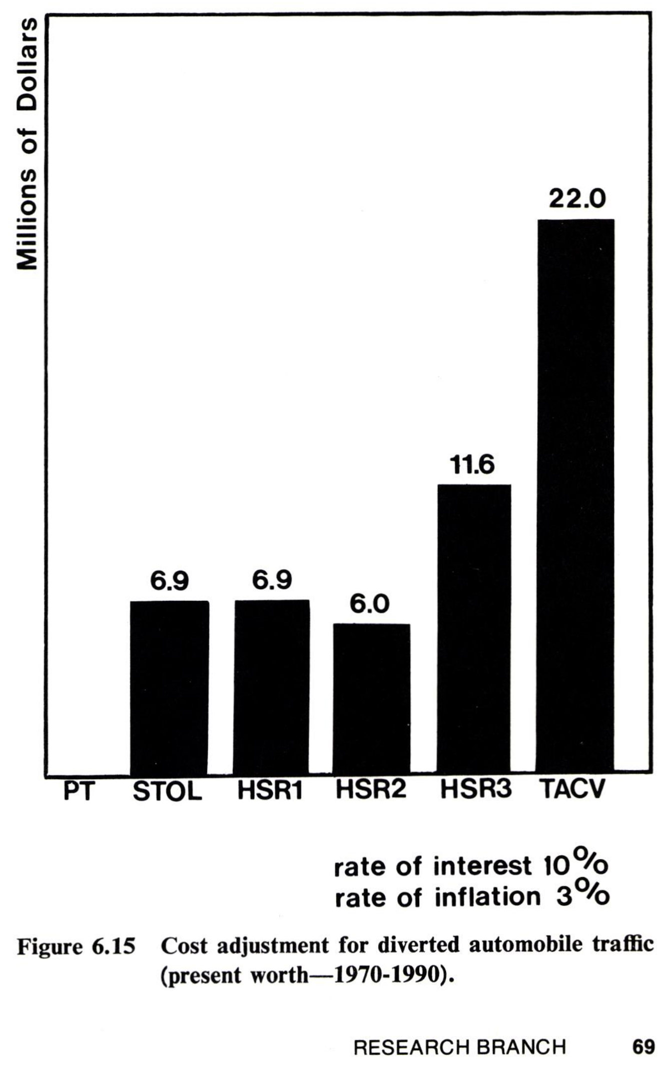



Figure 6.15 Cost adjustment for diverted automobile traffic (present worth—1970-1990).

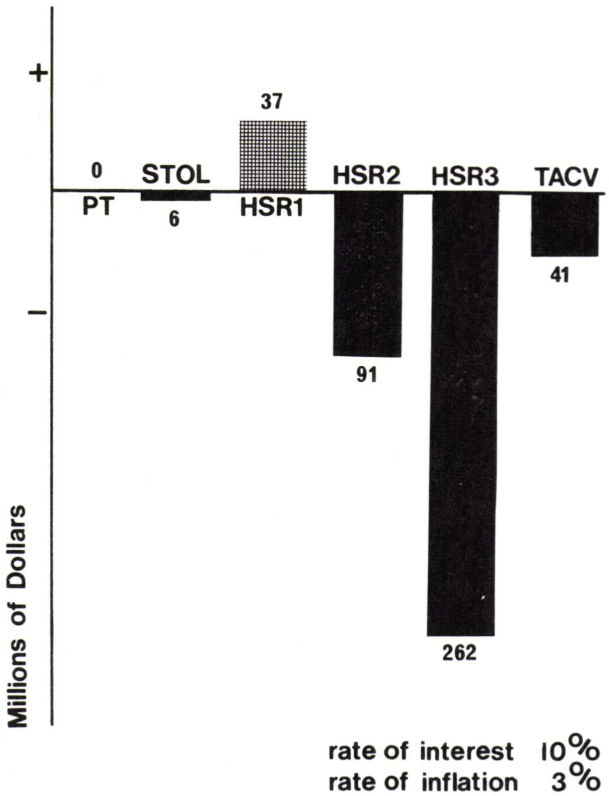



Figure 6.16 Strategy 'Profit' compared with present technology 'Profit' (present worth—1970-1990).

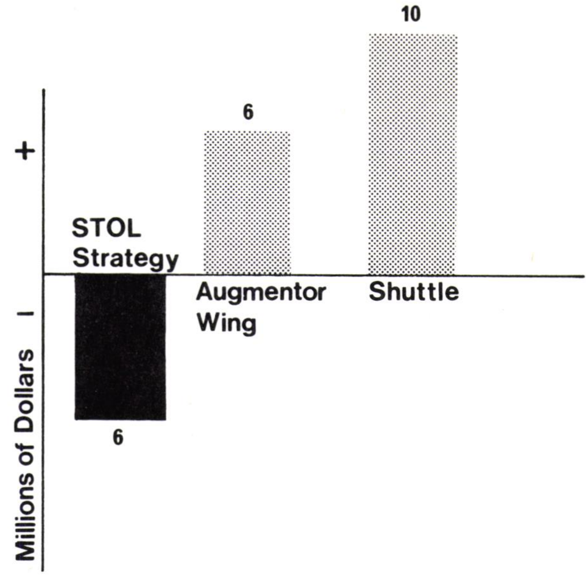



Figure 6.17 Strategy 'Profit' for alternates to STOL strategy (see text for explanation).

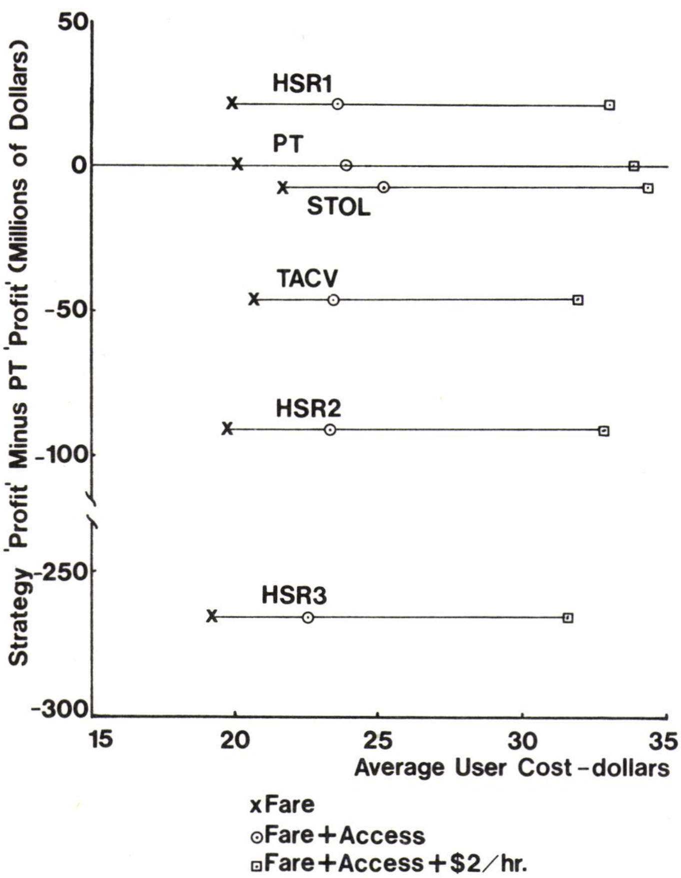



Figure 6.18 Comparison of relative 'Profit' with user cost between Montreal and Toronto.

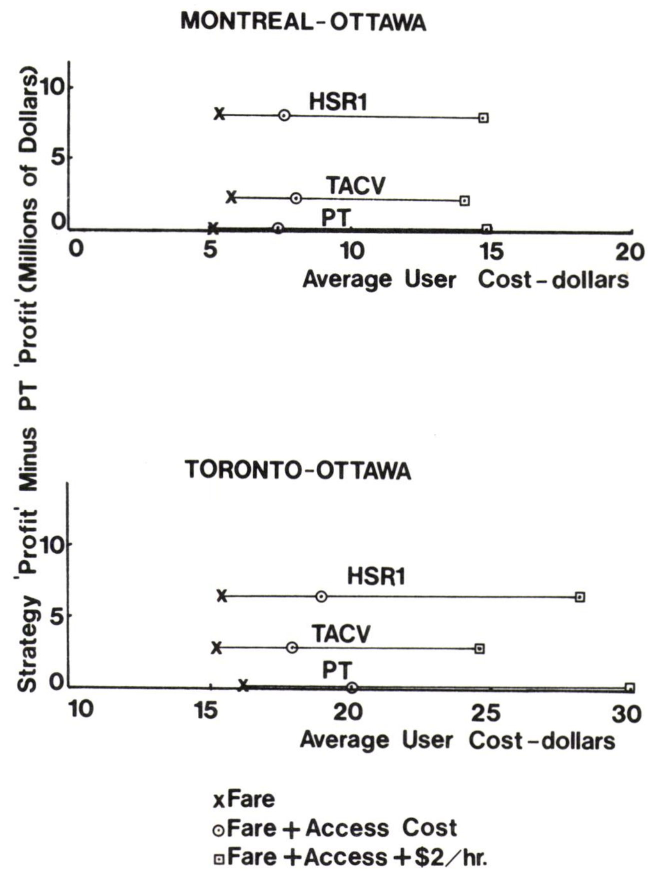



Figure 6.19 Comparison of relative 'Profit' with user cost for specified link.

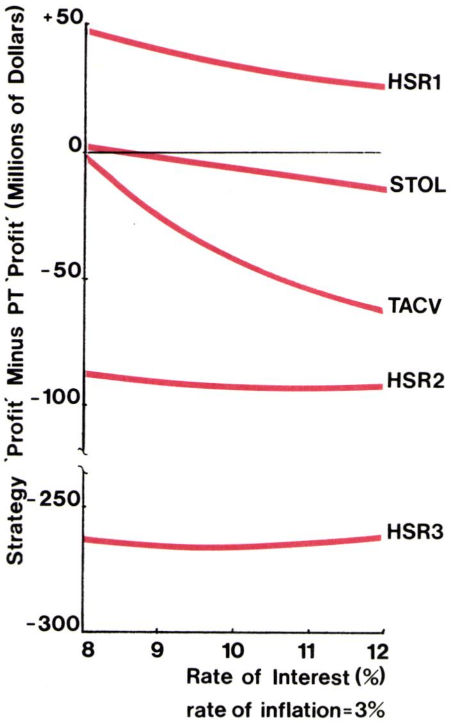



**Figure 6.20** **Sensitivity of strategy comparison to interest rate.**

might be delayed as a result of TACV operation. In the case of Toronto, timing of construction of the Toronto II airport is not yet determined and it is conceivable that an intercity TACV system would permit a later completion date than would otherwise be acceptable. The reduction of air volumes resulting from introduction of TACV would be 8 to 9 percent of predicted total Toronto area enplaned/deplaned passengers for 1980 (ref. 12 and 13). No attempt has been made to estimate the delay in airport construction which this reduction might allow, but it is an important potential benefit of the TACV system and warrants further study. As an indication of the potential savings involved, delay of a 500 million dollar investment from 1980 to 1981 results in an effective saving of 11 million dollars assuming a 10-percent rate of interest and three-percent rate of inflation.

Relief of congestion at conventional airports is one of the important benefits of the STOL concept. However, in the STOL strategy considered here, CTOL volumes are maintained at a high level as a result of the assumed improvements in CTOL services which are incorporated in the strategy.

In all strategies except STOL, only a single change in technology is introduced and consequently the strategy comparison is indicative of the contribution made by that change. However, in the STOL strategy three system changes have been made—introduction of a DHC-7 aircraft, introduction of a second-generation STOL aircraft, and improvement of conventional air service. The effect of each component of the strategy is illustrated in Figure 6.17. Here, the relative profitability of the full STOL strategy is shown in comparison with:

1) the relative profitability of the strategy if the DHC-7 segment is removed and completion of STOLports is rescheduled for 1980 ("Augmentor-Wing"), and

2) system profitability if STOL services and STOLports are removed entirely, retaining only an improved CTOL service from 1980 ("Shuttle").

Figures 6.18 and 6.19 indicate the benefit which the average common carrier traveller gains from the various strategies and compare this benefit with the corresponding system cost. These user costs are the weighted average trip cost over the 20-year study period (for each strategy the

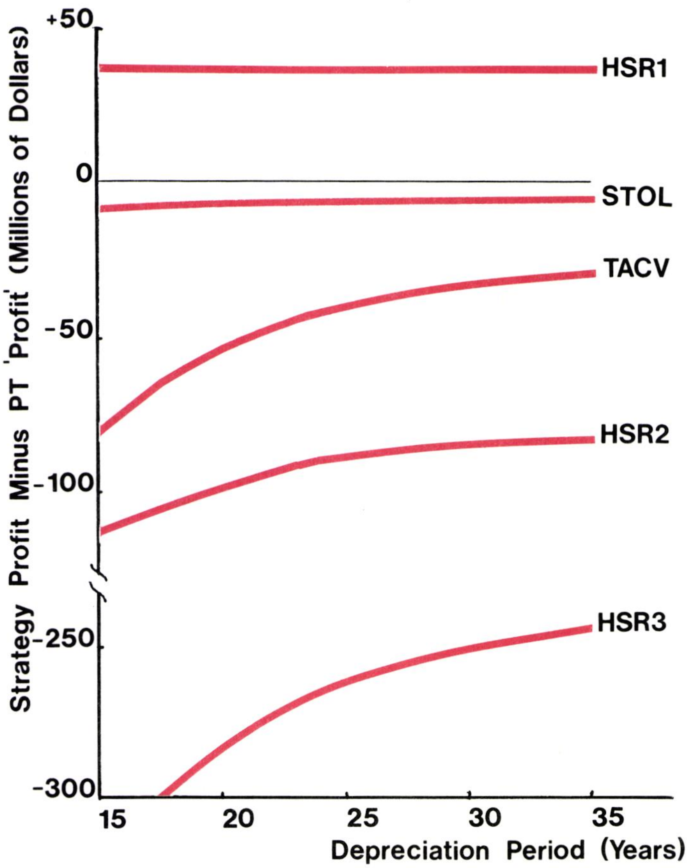



**Figure 6.21** **Sensitivity of strategy comparison to depreciation period.**

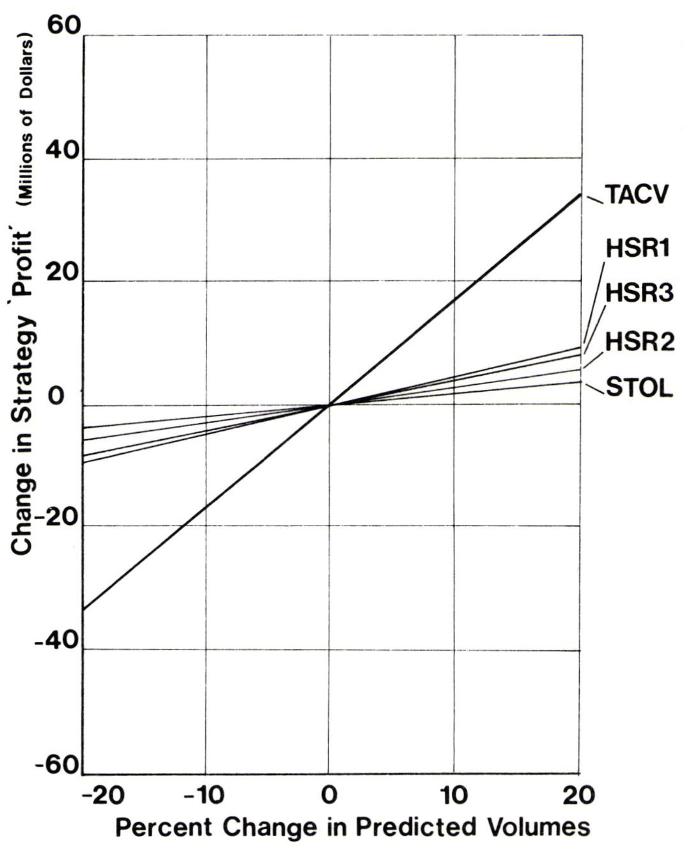



**Figure 6.22** **Sensitivity of strategy comparison to change in passenger volumes.**

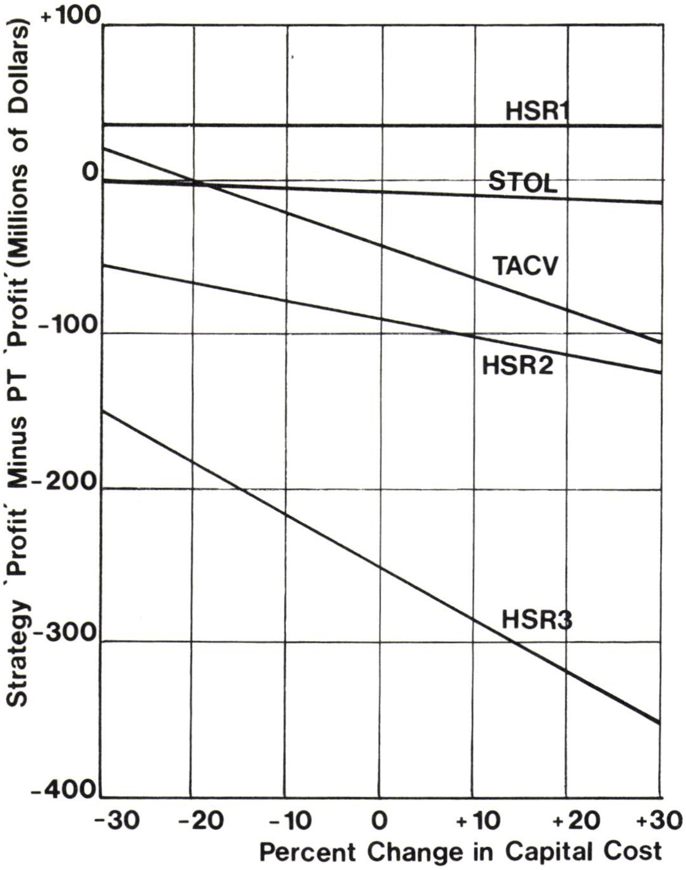



**Figure 6.23 Sensitivity of strategy comparison to change in cost of fixed facilities.**

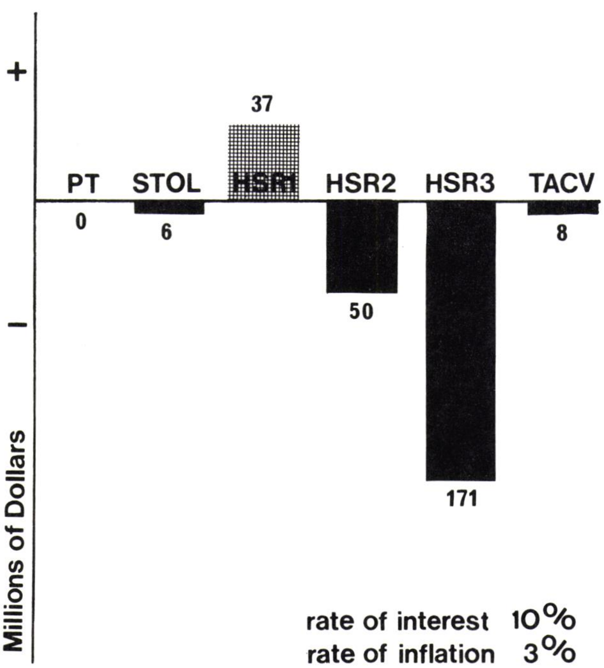



**Figure 6.24 Strategy 'Profit' with capital costs allocated to non-corridor users (present worth—1970-1990).**

"present technology" trip costs apply until system changes are introduced). The figure shows trip cost in terms of fare, access cost and a cost of total travel time. For purposes of this comparison, value of travel time has been taken as $2/hour for all travellers on all links. More correctly, value of time should be varied by mode, trip purpose and trip segment (i.e. access time, terminal waiting time, and 'en route' time). Because of lack of data and the difficulties produced by shifts of travel between modes, a detailed value-of-time analysis was not carried out.[1]

On the Montreal-Toronto link, the HSR1 strategy results in small savings in fare, access cost and time to give a slight decrease in total cost. The STOL system produces a shift of the same magnitude but in the upward direction. The saving in access cost and travel time of this strategy are not sufficient to offset a large increase in average fare. The TACV strategy involves a fare increase but time and access savings result in a substantially lower total trip cost. HSR2 and HSR3 produce similar total-cost savings but this change is based on a fare reduction rather than reduced time and access cost. In terms of total cost to the average user, the Montreal-Ottawa link is little affected by the HSR1 TACV strategies. Both of these strategies result in a lower fare for Toronto-Ottawa travel with the TACV option reducing total trip cost on that link by more than 15 percent.

Costs presented to this point are based on an interest rate of 10 percent and rate of inflation of 3 percent. In most respects, the costing procedure is not dependent on these rates alone but on the difference between the two. Figure 6.20 shows the effect of a change in interest rate with the difference between interest and inflation varying over a range of 5 to 9 percent. The most striking aspect of this comparison is the high sensitivity of the TACV strategy. This effect is the result of the relatively large volumes of the TACV strategy and the fact that this sensitivity is based on *differences* between strategy "profits". With increasing (effective) rate of interest, the HSR1, STOL and TACV strategies become less attractive while the HSR2 and HSR3 alternatives are virtually unaffected. With a five-percent difference between interest and inflation rates, the STOL and TACV strategies are both comparable to the present technology case in terms of estimated system "profit".

[1] See Section 5 for discussion of the value of time which is implicit in the Corridor demand model.

In the comparison of strategies all investment in fixed facilities has been recovered over a 25-year period on an assumption of equal annual payments. The effect of different amortization periods on the return from the various strategies is shown in Figure 6.21. The HSR3 and TACV strategies require by far the largest capital investment and consequently show the greatest sensitivity to depreciation period. This sensitivity is of greatest interest for the TACV strategy in view of its much more favourable position in relation to the present technology base. As an example of the effect of changing depreciation from the 25-year assumption, the strategy comparison is shown below with STOL facilities depreciated over 15 years, TACV over 20 years and rail over 35 years: In each case the figures refer to the strategy profit relative to the present technology base over the 20-year study period.

| Strategy | 25-year Amortization | Variable Depreciation Period |
|---|---|---|
| | ($ million) | ($ million) |
| STOL | −6 | −8 (15 years) |
| HSR1 | 37 | 37 |
| HSR2 | −91 | −85 (35 years) |
| HSR3 | −262 | −245 (35 years) |
| TACV | −41 | −55 (20 years) |

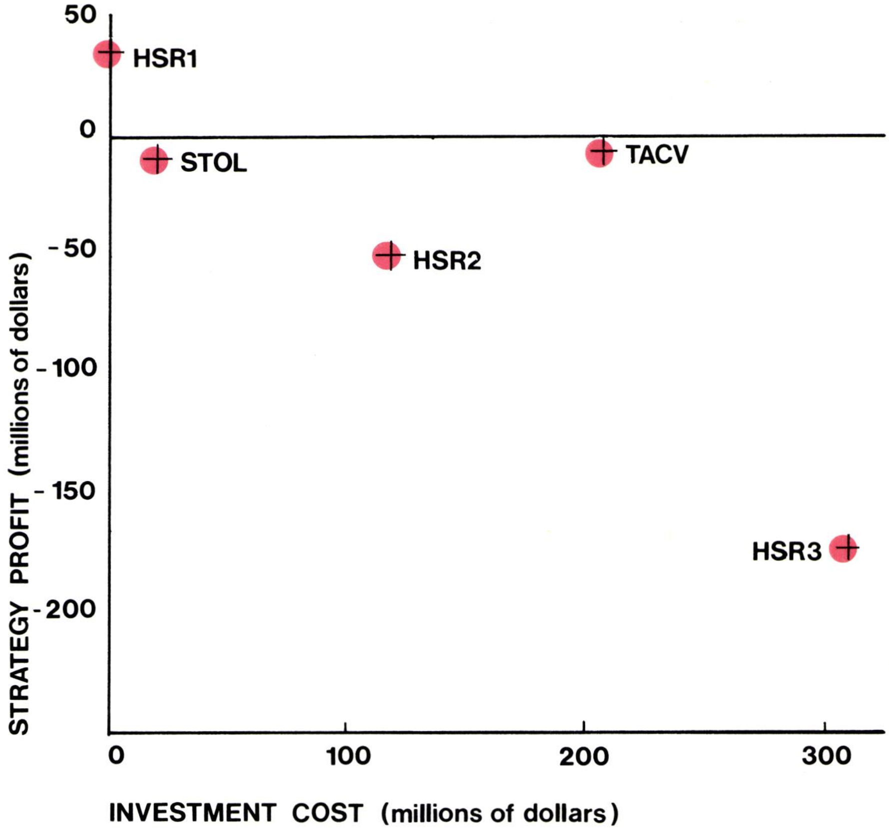



**Figure 6.25 Strategy 'Profit' relative to investment cost (present worth—1970-1990).**

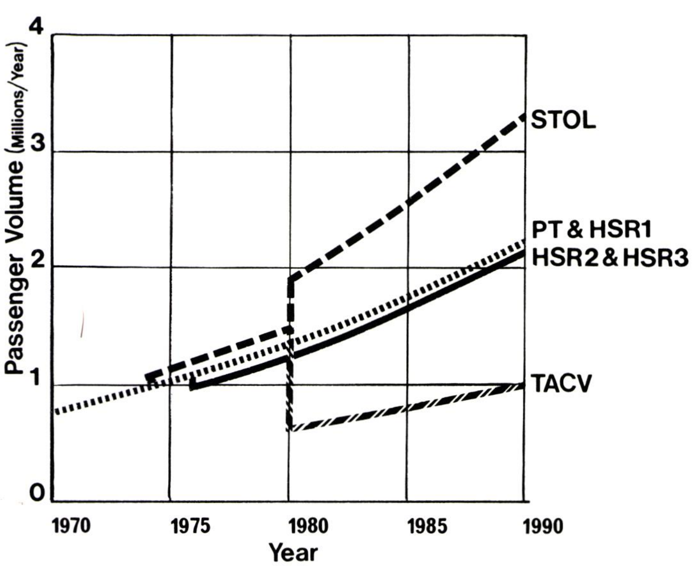



**Figure 6.26 Montreal-Toronto annual two-way origin-destination passenger volume by air.**

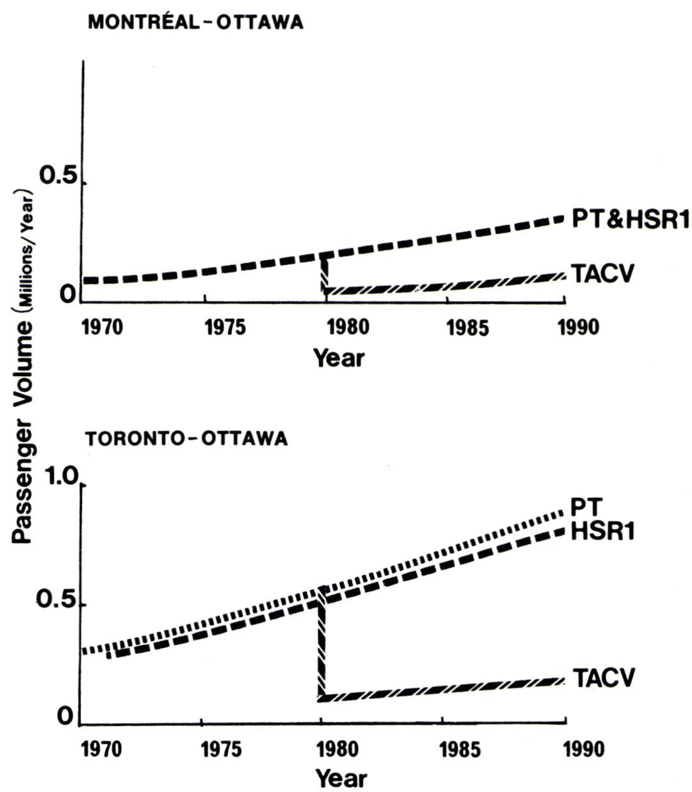



**Figure 6.27 Annual two-way origin-destination passenger volume by air.**

Referring back to Table 6.5 and assuming a 25-year depreciation period for all alternatives, investment costs based on straight-line depreciation rather than equal annual payments would increase costs by 1, 9, 24 and 25 million dollars for the STOL, HSR2, HSR3 and TACV strategies respectively. Relative to the present technology strategy the alternatives would then profit as follows:

| Strategy | Strategy Profit Minus PT Profit |
| --- | --- |
| | ($ million) |
| STOL | −7 |
| HSR1 | 37 |
| HSR2 | −100 |
| HSR3 | −286 |
| TACV | −66 |

Again, because of relatively high volumes and a comparison of differences rather than absolute values, the TACV strategy is by far the most sensitive to changes in demand forecast or unit operating costs. Sensitivity to percent change in prediction of total travel volume is shown in Figure 6.22. A 10 percent difference in the travel forecast would change the TACV/PT comparison by 17 million dollars while the position of all other strategies would shift by less than 5 million dollars. A similar effect would result from changes in estimated operating costs for the various modes. A 10 percent change in air operating costs changes the TACV comparison by $8 million; the same change in operating cost[1] for the TACV system itself would produce a $14 million change in the comparison.

Figure 6.23 illustrates the sensitivity of the strategy comparison to changes in the magnitude or allocation of fixed-facility costs. If the TACV investment costs were reduced by about 20 percent by improving track design or by reallocation of costs, that strategy would produce the same excess of revenue over cost as the present technology strategy. (However, rate of return on investment would be far different for the two strategies). Similarly, if the Montreal and Toronto STOLports were to serve routes other than Montreal-Toronto, reallocation of STOLport costs would place the STOL strategy in a more attractive position.

To this point, the entire capital cost involved in the various strategies has been charged against traffic with origin and destination at the three link ends under consideration (specific O-D traffic). In fact, a significant volume of traffic which would use the TACV or high speed rail systems would have origin or destination beyond these three links. In the present technology case, traffic without origin and destination at the link ends makes up the following fraction of rail traffic on the three links considered:

| | Non-O-D Volume as Percent of Total |
| --- | --- |
| Montreal-Toronto | 45% |
| Toronto-Ottawa | 40% |
| Montreal-Ottawa | 25% |

Assuming that these values remain unchanged through the study period, and that all of the traffic they represent would transfer to TACV or high speed rail on removal of conventional rail services, total volume on these modes would be split as shown below.

[1] Excluding the capital cost of fixed facilities.

| | Specific O-D Passengers (millions) | Other Passengers (millions) | Other Passengers as Percent of Total Traffic |
| --- | --- | --- | --- |
| HSR2 | 414 | 229 | 35% |
| HSR3 | 535 | 229 | 30% |
| TACV | 1460 | 281 | 16% |

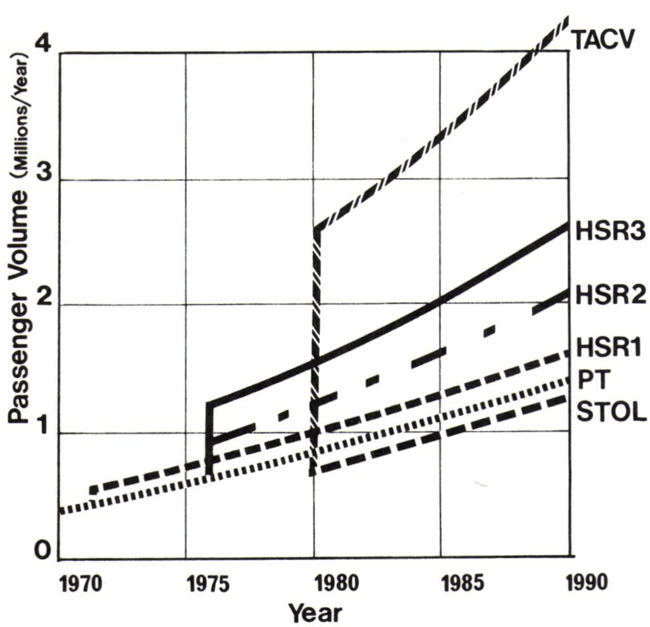



**Figure 6.28 Montreal-Toronto annual two-way origin-destination passenger volume by rail and TACV.**

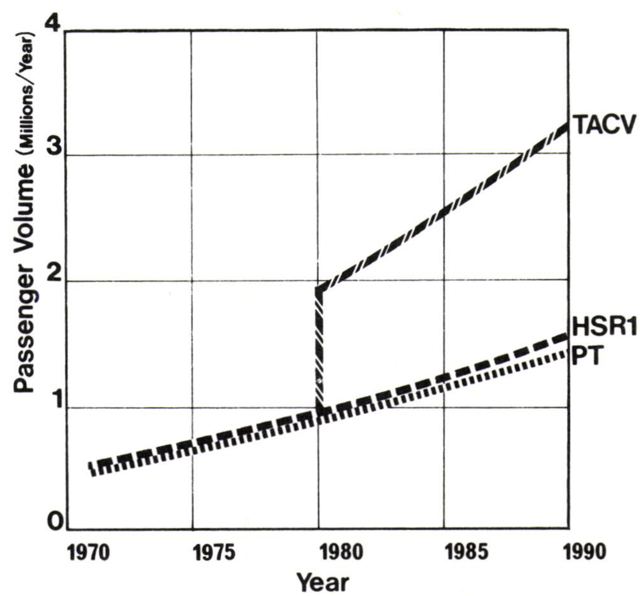



**Figure 6.29 Montreal-Ottawa annual two-way origin-destination passenger volume by rail and TACV.**

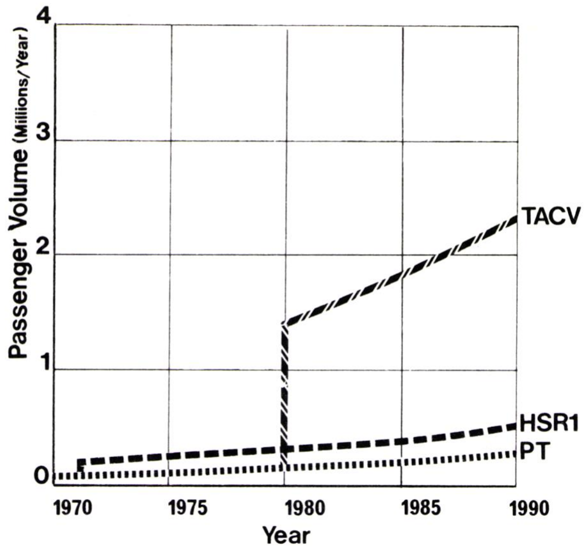



**Figure 6.30** **Ottawa-Toronto annual two-way origin-destination passenger volume by rail and TACV.**

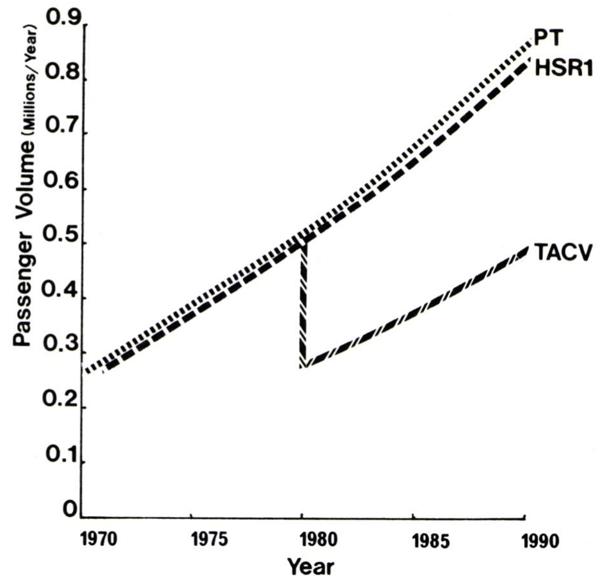



**Figure 6.31** **Montreal-Ottawa annual two-way origin-destination passenger volume by bus.**

Using Figure 6.23 to allocate capital costs to specific O-D traffic in proportion to this traffic breakdown, the strategy comparison is significantly altered as shown in Figure 6.24. This allocation is not strictly correct since:

1) benefits to traffic other than specific O-D traffic have not been included in the comparison, and

2) no account has been taken of the effect of system changes on the volume of traffic with origin and destination beyond the three links considered.

In spite of these shortcomings, this shift does serve to indicate the sensitivity of the strategy comparison to allocation of the substantial capital investment associated with some of the strategies.

In Figure 6.24 the STOL and TACV alternatives appear equally attractive. However, "profit" is a meaningless measure except as related to the investment or other risk required to achieve that return. Figure 6.25 shows the strategy comparison in relation to the investment cost[1] (depreciation plus interest) required to support each system. Any given development strategy is viable only if economic and other return is sufficient to warrant the investment involved. From this chart it is clear that the (economic) return on investment is lower for the TACV than for the STOL strategy. A STOL system, of course, would serve a much smaller segment of the total transportation demand than a ground system.

[1] These values are the present worth of investment costs within the study period. Cost of vehicles is not included.

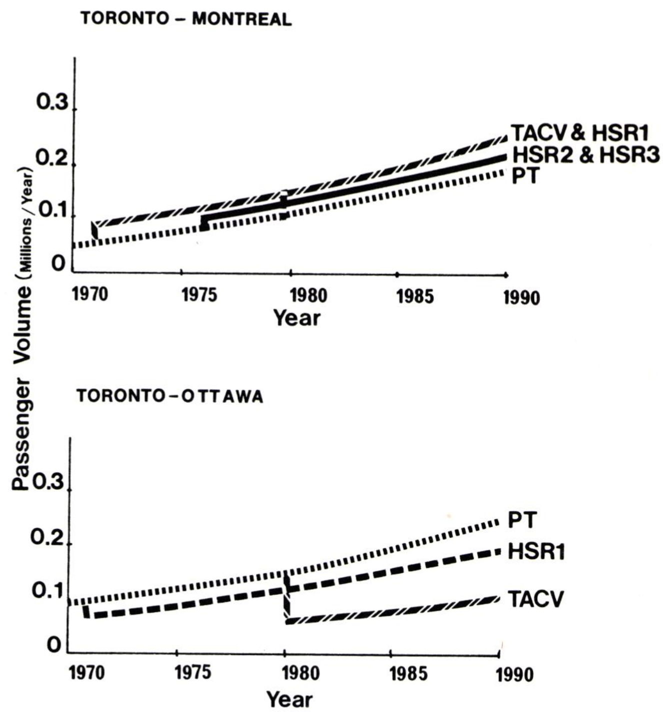



**Figure 6.32** **Annual two-way origin-destination passenger volume by bus.**

As this section has illustrated, a complete comparison of transport development alternatives is a complex matter even when the strategies are simple and comparison is limited to their direct economic consequencies. Although an attempt has been made to demonstrate the impact of the strategies on individual operators, the comparison of Figure 6.25 and preceding illustrations represent only the aggregate strategy cost to the system operators.

This study has included a preliminary assessment of the effect of transport system changes on intercity travellers themselves but it has not been possible to consider the impact on specific groups of users. Chapter 7 notes some possible effects of the strategies on non-users and on the shape and pace of urban and regional development but full consideration of these effects was not considered in this study. Such indirect system costs would be an important aspect of more detailed study of alternatives for development of Corridor passenger transportation.

# 7 CONCLUSIONS

## 7.1 Conclusions

This study has dealt with an assessment of the potential application of new technology to intercity passenger travel under Canadian conditions. Because certain population densities and intercity distances will be more conducive to the development of such technologies, the focus of this assessment has been contained within the most densely populated portion of Canada, namely the Corridor between Quebec City and Windsor, Ontario.

A variety of technological choices ranging from minor improvements of conventional technology, to newer and more sophisticated technologies has been investigated. Each of these technological innovations has been subjected to a three-tiered process of analysis. First, the supply characteristics of each technology have been examined to produce estimates of the cost and performance capability over future time periods and at different volume levels. Second, the demand or market side of travel in the Corridor has been analyzed, and a model has been developed which permits estimating the level of demand for a particular transport technology on the basis of certain demographic estimates and transport system performance characteristics. Finally, the supply and market analyses have been combined to evaluate six alternative strategies for improving the intercity passenger transportation system between Toronto, Ottawa and Montreal.

On the basis of this strategy analysis, three main conclusions emerge:

1. Massive investment required to improve a basically conventional railway system do not seem justified given the distances to be overcome and the population densities to be served. In other words, reductions in running times achieved by major track improvement between say, Montreal and Toronto, do not pay for themselves in terms of either additional revenue or passengers diverted from competing modes.

2. For the evaluation criterion used, the strategy which produces the highest return involves modest improvements to the existing railway system through the introduction of new equipment of the Turbo or Advanced Passenger Train variety. It appears that more leverage can be obtained from the existing railway system through equipment improvements than through improvements to the track structure and right-of-way.

3. Given the uncertainties in long range estimates, differences in profitability among strategies suggest the need for more detailed investigation of both STOL and TACV technologies.

These conclusions are based on the particular evaluation criterion used in the strategy analysis; namely, the net revenue produced by each strategy after all operating costs have been deducted and appropriate allowances made for amortization of capital facilities. Were other criteria to be used, such as the minimization of total travel time or total travel cost, the conclusions might be different. However, in most cases, this net revenue or profitability criterion is the most stringent. In almost every passenger transportation study, other criteria are introduced only after the profitability criterion fails.

It is important to stress that this analysis has not dealt with two aspects of alternative technological development which ultimately might have overriding influence on investment decisions that might be taken within the study area. The first of these concerns the relative flexibility and risk associated with each technology. STOL systems, for example, are undoubtedly more flexible and involve less high risk investment than TACV systems. The STOL aircraft itself has greater flexibility with respect to other uses and the level of capital investment required in STOL-ports is relatively small. By contrast, a TACV system requires substantial capital investment that could not be recaptured in the remote event of the service proving unsuccessful.

A second factor that has not been considered concerns the relative impact of each strategy on regional development patterns. TACV or other forms of ground transport, for example, are likely to prove more useful as tools for achieving certain regional development goals than STOL or conventional air systems. Thus whereas the profitability criterion may indicate that TACV investment is not justified, regional development objectives and/or airport access may become overriding considerations. These same objectives are less likely to be relevant in the case of STOL. In addition, the interaction of intercity transport with local or regional transportation facilities has not been taken into account in these evaluations and this could be a particularly important factor in the case of local problems, such as airport access.

These conclusions, of course, relate to the six specific strategies which have been defined. Although other development strategies could be analyzed, it is unlikely that modifications and refinements to the six basic strategies would significantly alter the study conclusions.

## 7.2 Additional Comments

Additional conclusions can be derived from the analysis and these are grouped in two sections—General—and by Strategies.

### General

— in terms of total system performance, introduction of STOL and TACV cannot be justified in the coming decade although a STOL service would return a system benefit once 'second-generation' technology becomes available, while at the end of the decade a second-generation TACV system could be available and could possibly be an advantageous strategy.

— in the 1970's the greatest benefit would be derived from improvements in the existing modes, such as on-time reliability (and consequent reduction in waiting times), passenger processing procedures, and rail improvements using existing trackage.

— access to terminals and processing/waiting times in terminals make up a large segment of total trip time and consequently improvements in this area will have significant payoffs.

— in the 'strategies' considered here, the transfer of travel from highways to the common carrier modes is a small part of total highway volume. As a consequence, benefits such as reduced air pollution or delayed highway investment will be negligible.

— it is uncertain whether STOL and TACV could operate at acceptable noise levels, although in the case of TACV, noise problems would be almost eliminated by the use of linear motor propulsion in a second-generation system.

## Strategies

**STOL**—Although the DHC-7 operating between downtown STOLports in Montreal and Toronto would return a profit to the STOL operator, it cannot be justified in terms of system profitability. This situation results from the relatively low speed of the DHC-7.

— a second-generation STOL aircraft could be available within about six years of the DHC-7 and would generate a relatively attractive system return.

— the STOL strategy could look more attractive if other STOL services into Montreal and Toronto were shown to be viable and, as a consequence, STOLport costs spread over a larger user base.

— almost all benefits of a STOL operation would go to the business traveller (13% of Montreal-Toronto travel for the DHC-7, 26% for second-generation STOL). On the other hand, indirect costs such as the noise and risk associated with aircraft operations could affect large numbers of non-users depending on the location of STOLports and the performance of the technology. To a certain extent STOL would result in a diversion of terminal-area congestion from conventional airports to STOLport locations. If STOLports were centrally located, their surrounding area would probably be more sensitive to congestion than CTOL terminals.

— the viability of STOL is highly dependent on institutional factors such as whether STOL and CTOL services are operated by the same carrier or by competitors.

**TACV**—With TACV track costs allocated on a passenger-mile basis for a first-generation system, Montreal-Toronto traffic is carried at a loss whereas traffic on the shorter links returns a net 'profit'.

— the higher block speeds provided by the second-generation system could significantly change the TACV profit position of the strategy. In addition, the higher capacity capability of the second-generation system could generate additional revenue from airport and regional services.

— with a TACV service as proposed in this strategy, benefits are spread over a large segment of common carrier travellers (77% of Montreal-Toronto travel).

## 7.3 Suggestions for Additional Study

The study analysis suggests several areas for further research and follow-up work. There is an immediate need for detailed study directed toward improving existing modes of travel. Here, timing is important as the need for these improvements could be obviated by technical developments in the late 1970's. The two areas which hold the greatest promise are application of turbotrain technology to rail operations on existing track and improvements in conventional air services. In the case of the turbotrain, a short-term program of study should assess the market for a network of improved rail services. In addition, operational aspects of higher speed rail services warrant close study. Integration of higher speed passenger services with freight operations and the risk involved in high-speed operation through highway grade crossings are examples of the type of problem which requires close and immediate study. For conventional air services, it is evident that reduction in time spent in terminal areas (for example, improvements in passenger handling and processing procedures and improved on-time reliability of access modes), would benefit both the traveller and the 'profitability' of the transport system.

Areas in which there is a need for long term research and development are tabulated below:

**TACV**—study of the technical feasibility of a second-generation system with continual monitoring of current development work on linear motor propulsion.

— study of the economic payoff due to improved performance provided by a second-generation TACV system.

— a program to study possible reductions in guideway construction costs.

— closer study of right-of-way requirements in the urban areas of Montreal, Ottawa and Toronto in order to verify the preliminary costs.

— a study of the operational problems involved in making joint use of the guideway for airport access and 'regional' transportation as well as intercity travel.

- study of the capacity of the system in peak hours and how this might expand in second-generation versions.
- study of the cost of extending the system to Quebec City or Southern Ontario and possible benefits of doing so.

**STOL**—consideration of the benefits of early introduction of turbo-jet STOL.

- optimization of STOLport landing strip length by study of the trade-off between aircraft economics and take-off requirements.
- optimization of aircraft size by balancing the economies of larger aircraft with the loss of market due to less frequent service.[1]
- study of the structure of indirect operating costs for small operators over short stage lengths.
- a broader look at the market for the DHC-7 aircraft.[1]

Throughout this study it has been assumed that all modes operate without serious congestion through the full study period. The validity of this assumption and the possible impact of congestion on system operation should be subjected to close scrutiny. The particular areas of concern are the urban highway network and the air services system.

The inter-city transportation system, as outlined in this report, is an integral part of the urban, regional and national systems. Decisions made by operators of inter-city services on terminal location could impose quite severe problems on the urban network and create access problems. Similarly, decisions made by urban planners could preempt solutions to inter-city problems. Hence it is important to integrate and co-ordinate the planning of all transport facilities.

The problem of correctly predicting the demand for new modes needs further examination. The most advantageous extension of the work presented in this paper would be to develop disaggregated demand models. That is, separation of the total demand by trip type (e.g. business or non-business), and by type of person (e.g. car owner and non-car owner), with individual analysis of these components. There is also a need to take account of subjective characteristics such as convenience, safety, and reliability by developing the capability to quantify the public's perception of these characteristics.

Another related field requiring further study is the influence of cultural and linguistic factors on travel in Eastern Canada. Very little work has been carried out in identifying and predicting these important relationships.

Finally, the automobile is and will continue to be the dominant mode in urban, regional, and inter-city transport and it is against this background that new transport technology must be measured. Changes in patterns of automobile ownership and availability must be assessed as they will affect both the attitude of policy-makers towards, and the demand for common carrier transportation.

[1] Studies in these areas are currently in progress.

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## 8.2 List of U.S. Northeast Corridor Studies

The extensive work on the US Northeast Corridor performed by contractors for the US Office of High Speed Ground Transportation, provided useful information for the Canadian study. The 17 final reports are listed below. These reports, in turn, reference much additional work.

| | |
|---|---|
| NEC Transportation: *Problems and Prospects* | NECTP 210, PB 190 930 |
| Status of the Transportation System and Plans for Improving Intercity Transportation in the NEC | NECTP 211, PB 190 931 |
| NEC Transportation Facts and Statistics | NECTP 212, PB 190 932 |
| **Project Methodology** | |
| National Bureau of Standards Modelling for the NECTP | NECTP 213, PB 190 933 |
| HSGT Mode Service Analysis in NEC | NECTP 214, PB 190 934 |
| Air Mode Service Analysis in NEC | NECTP 215, PB 190 935 |
| TRANSOP Model Methodology | NECTP 216, PB 190 936 |
| Access and Demand Data Used in the Development and Calibration of NEC Transportation Models | NECTP 217, PB 190 937 |
| Impact Studies: NECTP | NECTP 218, PB 190 938 |
| Passenger Demand and Modal Split Models | NECTP 230, PB 190 946 |
| **Modal Descriptions** | |
| HSGT Systems Engineering Study, *Tracked Air Cushion Vehicles* | NECTP 219, PB 190 939 |
| V/STOL Mode Descriptions | NECTP 220, PB 190 940 |
| **Costing Projections and Techniques** | |
| Prospective Costs of Capital in the NEC | NECTP 221, PB 190 941 |
| Cost Analyses for NECTP, Volume 1, High Speed Ground Modes | NECTP 222, PB 190 942 |
| Cost Analyses for NECTP, Volume II, Air and Highway Modes | NECTP 223, PB 190 943 |
| External Costs and Benefits Analyses, NECTP | NECTP 224, PB 190 944 |
| Theory and Implementation of Cost and Benefit Analysis of Transportation Systems: The NECTP | NECTP 225, PB 190 945 |

# 9 APPENDIX

## The Origin Destination Survey—Summer 1969

### CONTENTS

## 9.1 Introduction

The survey was carried out as part of the Intercity Passenger-Transportation Study of all intercity travel in the Quebec City-Windsor Corridor. It consists of a sample of approximately 50,000 passengers travelling between Quebec City, Montreal, Ottawa and Toronto on three modes: *air, rail and bus*. The specific routes sampled were Montreal-Ottawa, Montreal-Toronto, Ottawa-Toronto, Quebec-Montreal and Quebec-Ottawa.

The purpose of the survey was to measure the flows of passengers between corridor cities, the performance of the transportation system and to determine the characteristics of the travellers. The individual trip histories contain information relating to specific origins and destinations (coded to census tracts for the major cities), city of residence, terminal access (mode, time and cost), terminal waiting times, and trip purpose. The socio-economic characteristics include income, occupation, language, principal industry of occupation, education, age and sex and the residence of friends and relatives.

Passengers were surveyed with the use of self-administered questionnaires, a copy of which can be seen at the end of the appendix. In the case of the air and bus modes, questionnaires were distributed to passengers as they boarded the vehicles and collected either by the cabin crew during the flight or by the bus operator at the end of the trip. On trains, the questionnaires were distributed and collected by interviewers travelling on the train. A "head count" was obtained from the airlines and bus companies, while on trains the counts were obtained by the interviewers directly.

The sample period was a nine-week period from June 17 to August 17 inclusive. Only one mode was sampled on any given day, but each mode was sampled at least once on each day of the week. Over the nine-week period, air and rail were sampled on 14 days and bus on 15 days.

## 9.2 Analysis of Sample Population

This section outlines the sampling procedure in some detail, indicates which flights, buses and trains were sampled and the method by which estimates of the total population[1] were made.

In order to obtain population estimates and to provide a mechanism for obtaining unbiased cross-tabulations, the sample was partitioned into homogeneous stratifications. The valid questionnaires belonging to each stratification were assigned a weighting factor based on the estimated population of the stratification and the number of valid questionnaires. For this analysis, a valid questionnaire is defined as one which contains valid responses to the questions concerning city of residence, trip origin and trip destination.

### 9.2.1 Bus

(a) **Sampling Procedure** Buses were sampled once on Tuesdays, three times on Sundays and Fridays and twice on the other days of the week.

For the purposes of the survey certain conventions were adopted:

A. No distinction was made between the carriers Voyageur Provincial and Voyageur Colonial.

B. Only express buses travelling between the above mentioned cities were sampled. Local buses that made frequent stops between two corridor cities were omitted as the intent of the vast majority of these passengers was not to travel from one corridor city to another but to an intermediate point.

C. On the Montreal-Quebec bus route, only those buses travelling along the South Shore (via St. Hyacinthe and Drummondville) were sampled. Those buses travelling the northern route, (via Three Rivers) are not express and were omitted.

D. Bus 999 was designated as the one travelling Ottawa-Quebec via North Montreal.

E. The bus shown in the Toronto-Ottawa schedule as Route 5 was designated by 995.

(b) **Stratification**—The total population of bus trips was first stratified according to day of the week, route and time of day.

By stratifying, a small sample can be grouped with larger ones thereby giving more dependable results. Also any distinction that may exist between the characteristics of the travellers over different time periods can be maintained. Otherwise they may be lost through aggregation.

The time strata generally adhered to are:

| | |
|---|---|
| (1) | 6:00 AM—11:00 AM |
| (2) | 11:00 AM— 4:00 PM |
| (3) | 4:00 PM— 8:00 PM |
| (4) | 8:00 PM— 6:00 AM |

(c) **Procedure**—Passenger counts for all buses on every sample day were available from the carrier. Questionnaires were assigned to the appropriate day/time/route stratification and given weighting factors to expand the sample to the volume over a route for the nine-week period as follows:

$$\frac{\#\text{ of passengers in stratification}}{\#\text{ of questionnaires}} \times \frac{\#\text{ of these days in the 9-week period}}{\#\text{of times this day of the week was sampled}}$$

(d) **Bus Summary**—The first column of Table 9.1 lists those buses that were sampled and the second those that were not. The third column lists those sampled buses whose questionnaires will be used as representative of the buses not sampled.

### 9.2.2 Air

(a) **Sampling Procedure**—The three carriers whose flights were sampled were Air Canada, CP Air, and Quebecair. Flights were sampled once on a Wednesday, three times on Tuesdays, and twice on the other days of the week. In looking at the flow between a specific pair of corridor cities, four types of flights can occur:

1. Those that originate and terminate in the two cities being considered.

2. Those that originate in a different city but continue on to one of the corridor cities and terminates in the second.

3. Those that originate at one of the two cities stop at the second but continue on to a further destination.

4. Those that originate at a different city, stop at the corridor cities, and then continue on to a further destination.

(b) **Estimation**—Unlike the buses, estimation was done by flight number rather than day of the week. The airline provided the counts of the total load on the different flights. However, this count included not only the passengers that both boarded and departed in a corridor city, but also those that were in transit, having boarded the flight at an earlier point. To derive the number of boarding passengers, traffic flow statistics prepared by DBS were used. They provided the ratio of in transit passengers to total passengers on the various flight numbers. When multi-

[1] Population here refers to the total passenger volumes of which a proportion was sampled by the O-D questionnaire.

plied by the carrier count this ratio gives an estimate of the people boarding and departing in corridor cities.

(c) **Stratification**—All the flights that occurred during the sample period, whether sampled or not, were grouped under their flight numbers. For each sampled flight both the number of questionnaires and the estimation of the number of passengers travelling from the one corridor city to the other was available. If it was found that a certain flight number had not been sampled adequately, one of two actions was taken:

a) If there was another flight following the same route the available set of questionnaires was applied to the estimations of both flights. For example, in looking at the Ottawa-Montreal route, flight AC 206 had been sampled only once on July 3, and only 7 valid questionnaires were available from this flight. The total estimated traffic was 392. This flight is then grouped with flight AC 954, which was sampled 7 times. Its total estimated traffic was 524 and the total number of questionnaires available was 140. When the two flights are combined, the total estimated traffic is $392 + 524 = 916$;

**Table 9.1 Buses Not Sampled**

| Route | Buses Sampled | Buses Not Sampled | Questionnaires from sampled Buses applicable to Buses not sampled |
|---|---|---|---|
| Montreal-Ottawa | x69 x73 x77 x83<br>x71 x27 x79 x63<br>x43 x67 x81<br>x45 x47 x59<br>x37 x75 x13 | | |
| Ottawa-Montreal | x38 x54 x80 x88<br>x72 x76 x82 x64<br>x74 x52 x84 x46<br>x62 x68 x86<br>x60 x78 x70 | x48—late hour | x64, x88, x70 |
| Ottawa-Toronto | x33 x31<br>x25 x23<br>x29 x17<br>x11 x13<br>995 (RTE 5) | x19—early hour<br>x27—local<br>x21—local | x25, x31, x33<br>no estimate<br>no estimate |
| Toronto-Ottawa | 16 x28<br>x18 x32<br>x26 x36<br>x38 x34<br>x30 | x20—late hour<br>24—local<br>22—local | x32, x34, x36<br>no estimate<br>no estimate |
| Montreal-Quebec | 109 125 141<br>101 107 129<br>115 127 131<br>123 117 143<br>103 121 | all buses via North Shore<br>R-53, 105, 137 } local<br>119, 111—late at night | no estimate<br>no estimate<br>145, 139, 117, 143 |
| Quebec-Montreal | 102 106 152<br>112 146 150<br>114 108 140<br>104 128 156<br>134 110 158<br>116 154 146 | all buses via North Shore<br>R-53, 122, 120, 126, 144, 148 } local<br>132—too late<br>100—too early | no estimate<br>no estimate<br>108, 120<br>102, 154, 112 |
| Toronto-Montreal | x18<br>x20<br>x70<br>x72<br>x82 | 28, 32, 2A) local<br>x40, x84, x38 } too late | no estimate<br>x70, x72 |
| Montreal-Toronto | 21 x25<br>x23 x87<br>x85<br>x79<br>x81 | 27—local<br>x37—too late | no estimate<br>x87, x81, x25 |
| Ottawa-Quebec | 999 | | |

and the total number of questionnaires is 151. These questionnaires will now be applied to the 916 passengers.

b) If there is no other flight on the same route, the traffic flow statistics prepared by DBS are used to derive the average amount of traffic for this flight number during a period of comparable length to the sampling period. This figure was then added to the total estimated flow of a flight of type (1) (Flights that originate and terminate in the city pair) which operated in the same time period. For example, on the Toronto-Montreal route, flight CP 505 travels Mexico-Toronto-Montreal. Neither this flight nor any other flight that travels this route was sampled. The traffic flow statistics indicated that on 12 flights during this period 544 people boarded the flight in Toronto and deplaned in Montreal. The flight operated 9 times in the sample period and therefore, multiplying 544 by 9/12 gives an unbiased estimate of Toronto-Montreal traffic on this flight. These passengers will be represented by questionnaires from a flight which travels the Toronto-Montreal route at approximately the same time. In this case survey data from AC 952 was applied to the unsampled (CP 505) flight.

(d) **Procedure**—Once the flights were combined, the total estimated traffic was divided by the total number of valid questionnaires available. This figure was multiplied by

$$\frac{63}{14} = \frac{\text{(number of days in sample period)}}{\text{(number of days sampled)}}$$

to expand it to cover the full 9-week period.

(e) **Flight Summary**—The first column of Table 9.2 indicates which flights were sufficiently sampled, the second indicates which flights were not sufficiently sampled. Flights whose questionnaires are used as representative of the unsampled flights are given in column three.

## 9.2.3 Rail

(a) **Sampling Procedure**—Rail passengers were sampled on Canadian National and Canadian Pacific Rail services operating between Toronto-Montreal, Toronto-Ottawa, Ottawa-Montreal and Montreal-Quebec.

The following conventions were adopted for the survey:

A. On the Montreal-Toronto route, train CN 51 was joined at Brockville by train CN 41 travelling from Ottawa to Toronto. For the purposes of the survey, both were referred to as train CN 541.

B. On the Toronto-Montreal route train CN 50 split at Brockville and part of it, designated as train CN 40 travelled to Ottawa. For the purposes of this survey both of these trains were referred to as train CN 504.

C. On the Montreal-Quebec route, CN 12 was not sampled as it travels

**Table 9.2 Flights in Sample**

| Route | A Flights Sufficiently Sampled | | B Flights insufficiently Sampled or not Sampled at all | C Flights with which (B) are combined |
|---|---|---|---|---|
| Ottawa-Montreal | AC 400 | | CP 74 | AC 400 |
| | 382 | | AC 206 | 954 |
| | 388 | | AC 264 | 260 |
| | 954 | | AC 248 | 400 |
| | 260 | | AC 458 | 400 |
| | 390 | | AC 360 | 954 |
| | 900 | | | |
| Montreal-Ottawa | AC 365 | | | |
| | 247 | | CP 75 | } |
| | 391 | | AC 457 | }AC 391 |
| | 923 | | AC 515 | } |
| | 209 | | | |
| | 951 | | | |
| | 351 | | | |
| | 203 | | | |
| | 381 | | | |
| Quebec-Montreal | AC 365 | | | |
| | 307 | QB 501 | | |
| | 361 | 283 | AC 381 | AC 311 |
| | 351 | 503 | | |
| | 363 | 513 | | |
| | 957 | 291 | | |
| | 959 | 517 | | |
| | 385 | | | |
| Montreal-Quebec | AC 960 | QB 510 | AC 350 | AC 958 |
| | 360 | 282 | | |
| | 958 | 502 | | |
| | 352 | 512 | | |
| | 380 | | | |
| | 300 | | | |
| | 386 | | | |
| Toronto-Ottawa | AC 440 | | AC 264 | } |
| | 996 | | 400 | } |
| | 920 | | 510 | } |
| | 242 | | 458 | }Together |
| | 968 | | 260 | } |
| | 950 | | CP 74 | } |
| | 452 | | | |
| | 932 | | | |
| | 378 | | | |
| Ottawa-Toronto | AC 443 | CP 75 | AC 379 | AC 931 |
| | 173 | | AC 457 | 459 |
| | 931 | | AC 515 | 459 |
| | 185 | | | |
| | 909 | | | |
| | 997 | | | |
| | 459 | | | |
| | 961 | | | |
| | 953 | | | |

during the early hours in the morning (23:45-03:15) and was destined for the Maritime via Lévis rather than Quebec City with only a nominal number of passengers detraining at Lévis. CP 156, the "Dayliner" train was also omitted as it stopped more often than the regular Montreal-Quebec trains.

D. On the Quebec-Montreal route, CN 17 was omitted as it travelled during the early morning hours (04:55-08:25) with very few passengers between those two cities. CP 151, the Dayliner was also not sampled, as it made more frequent stops than other Quebec-Montreal trains.

E. On the Montreal-Ottawa route, CP 133, CP 137, and CP 131 were local trains via the North Shore Route and so were not sampled.

F. Similarly, on the Ottawa-Montreal route CP 132, CP 138 and CP 134 were not sampled.

(b) **Estimation**—The procedure for estimating the flow of traffic on each train is as follows:

1. For each day of the week in which counts were taken for a specific train, the average of these counts was used as the estimate. For example, for train CN 55, counts are available on three Fridays of 238, 248 and 225. The average of these figures (237) is our estimate of the traffic on this train for Fridays.

2. A particular train may not have been sampled at all on a specific day of the week. In such cases, an estimate of weekly traffic is made using the counts from other days and an estimate of the daily variation of passengers obtained from other data. For example, on CN 55, estimates are available for every day except Tuesday. The sum of these estimates is 1213. The total percentage of people that travel on these 6 days of the week is estimated as 88 percent of the total week. The difference between the estimate of the weekly traffic (1384) and the sum for 6 days (1213) is our estimate of the traffic on Tuesdays. In this example it is 171.

(d) **Stratification**—Where samples were available for each stratification (train, day of the week) the ratio

$$\frac{\text{total estimated traffic}}{\text{total valid questionnaires}}$$

was calculated. In instances where no valid questionnaires were obtained for a specific train, questionnaires from a similar train were used to estimate the characteristics of its passengers.

Certain criteria were used in deciding which trains were to be combined:

a) No transcontinental trains were combined with any others or each other. This applies to CN 1, CN 2, CP 1, CP 2.

b) Trains which were sampled very infrequently were kept isolated. For example CN 8.

c) Trains travelling the same route and making similar stops were combined. For example, the Rapido trains CN 61, CN 65 between Montreal and Toronto are combined.

d) CN and CP trains are always kept separate.

As a final step, passenger volumes were then expanded to the full nine week sampling period.

(d) **Train Summary**—The first column of Table 9.3 lists all the trains that were sampled and shows which trains were combined. The second column indicates which trains were omitted, and gives the reason for their omission.

| Route | A Flights Sufficiently Sampled | | B Flights Insufficiently Sampled or not Sampled at all | C Flights with which (B) are combined |
|---|---|---|---|---|
| Ottawa-Quebec | AC 378 | | | |
| Quebec-Ottawa | AC 379 | | | |
| Toronto-Montreal | AC 992 | CP 70 | CP 254 | AC 454 |
| | 804 | 72 | CP 204 | AC 454 |
| | 994 | 76 | CP 505 | AC 952 |
| | 506 | 80 | AC 500 | AC 804 |
| | 508 | | AC 620 | AC 622 |
| | 952 | | AC 836 | AC 952 |
| | 254 | | AC 876 | AC 454 |
| | 870 | | AC 834 | AC 653 |
| | 840 | | AC 494 | AC 952 |
| | 744 | | AC 912 | AC 840 |
| | 454 | | AC 184 | AC 812 |
| | 874 | | | |
| | 653 | | | |
| | 812 | | | |
| | 960 | | | |
| | 878 | | | |
| | 682 | | | |
| | 622 | | | |
| Montreal-Toronto | AC 803 | CP 73 | CP 502 | AC 955 |
| | 263 | 81 | CP 105 | 955 |
| | 743 | | CP 203 | 955 |
| | 712 | | CP 071 | 995 |
| | 805 | | CP 077 | 995 |
| | 621 | | AC 181 | 871 |
| | 871 | | AC 625 | 621 |
| | 809 | | AC 993 | 509 |
| | 845 | | AC 501 | 821 |
| | 970 | | AC 879 | } |
| | 995 | | AC 877 | } |
| | 511 | | AC 881 | } AC 995 |
| | 821 | | AC 461 | } |
| | 513 | | AC 949 | } |
| | 509 | | | |
| | 955 | | | |
| | 875 | | | |
| | 685 | | | |

**Table 9.3 Trains in Sample**

| Route | Trains Sampled (in their groupings) | | Trains Not Sampled |
|---|---|---|---|
| Toronto-Montreal | CN "504" | | |
| | CN 54<br>CN 58 | | |
| | CN 60<br>CN 64 | | |
| Montreal-Toronto | CN "541" | | |
| | CN 55<br>CN 59 | | |
| | CN 61<br>CN 65 | | |
| Ottawa-Montreal | CN 2 | CP 2 | CP 132—local<br>CP 138—local |
| | CN 30<br>CN 34<br>CN 36 | CP 232<br>CP 234 | CP 134—local |
| | | CP 236 | |
| | CN 38<br>CN 130 | | |
| Montreal-Ottawa | CN 1 | CP 1 | CP 133—local<br>137—local<br>131—local |
| | CN 31<br>CN 35 | CP 233<br>CP 235 | |
| | CN 33<br>CN 133<br>CN 39<br>CN 139 | | |
| Montreal-Quebec | CN 16 | CP 152<br>CP 154 | CN 12—Early-Minimal Traffic |
| | CN 122 | | CP 156—local |
| | CN 20<br>CN 24 | | |
| Quebec-Montreal | CN 11 | CP 153<br>CP 155 | CN 17—Early-Minimal Traffic |
| | CN 123 | | CP 151—local |
| | CN 22<br>CN 25 | | |
| Ottawa-Toronto | CN 45 | | |
| | CN 49 | | |
| Toronto-Ottawa | CN 44 | | |
| | CN 48 | | |

**Table 9.4 Estimated Average Weekly Flows for Sample Period of June 17, 1969—August 17, 1969**

| Mode | Route | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Montreal to Ottawa | Ottawa to Montreal | Montreal to Quebec | Quebec to Montreal | Toronto to Ottawa | Ottawa to Toronto | Montreal to Toronto | Toronto to Montreal |
| Air | 2,709 | 2,149 | 2,317 | 2,075 | 5,026 | 3,682 | 13,790 | 12,600 |
| Rail | 4,333 | 4,396 | 4,277 | 3,452 | 1,897 | 1,246 | 11,886 | 9,793 |
| Bus | 4,550 | 5,257 | 4,102 | 4,984 | 2,324 | 2,338 | 2,160 | 2,625 |

## 9.2.4 Flow Summary

Estimated average weekly flows for each route via the three modes air, rail and bus are given in Table 9.4. They represent the estimated total "population" from which the sample was obtained.

The figures indicated for the air routes are the passengers whose origin is the departure city (but whose final destination may be beyond the second city). The rail passenger flows do not consist entirely of through traffic, as on many trains passengers could detrain at intermediate points.

In the vast majority of cases, express buses were the only buses sampled and the flows can safely be said to consist of through traffic. However on the Montreal-Toronto and Toronto-Montreal routes, all buses stop at Kingston and a portion of these flows will contain traffic into Kingston.

**Confidence Intervals**—Estimates of traffic flows for the different modes, have been developed in this analysis. Development of the data indicates that the estimates for bus trips and air flights are more accurate than the estimates for rail traffic, due to the lack of accurate railroad passenger counts.

In statistics when a specific estimate is made on the basis of statistical data it is desirable to determine two values A and B such that there is a probability of $1-\alpha$ that the true value of the parameter being estimated "$\delta$" falls between A and B. That is Prob $(A < \delta > B) = 1-\alpha$. The values A and B are called $100\,(1-\alpha)\,\%$ confidence limits and the interval between them is called the $100\,(1-\alpha)\,\%$ confidence interval.

As an example a comparison was made between the air, rail and bus trips on the Montreal to Toronto route. For each flight, bus or train on the route, both the mean and variance were calculated and both 90% and 60% confidence intervals for weekly traffic were developed. The standard deviations for the trains were greater on the average than those for the buses or flights by a factor of about 5. See Table 9.5.

## 9.3 Survey Data

The following tables have been prepared from the origin-destination survey questionnaires:

**Table 9.6** Distribution of income by mode and purpose.

**Table 9.7** Distributions by age, sex and city.

**Tables 9.8 and 9.9** Distribution of Linguistic Characteristics.

In referring to these tables, the following qualifications should be noted:

**All Distributions**

**1.** Respondents start and end their trip within the study area—Quebec City to Windsor.

**2.** No weighting factors have been applied. (i.e. Each questionnaire returned had a weighting of unity.)

**3.** Pleasure travel should be termed non-business as it includes all purposes (blanks as well) other than business.

**4.** Respondents in each table are resident in the city indicated in the heading.

**5.** The computer printout produces percentages to two decimal places. The validity of each percentage is relative to the indicated sample size but in general the figures after the decimal point should be rounded up or ignored.

**Income Distribution**

**1.** Only respondents over 15 years of age are included.

**2.** The distribution for Quebec includes all respondents resident in the urban areas of the province: Montreal, Quebec City, Trois Rivières, Sherbrooke, etc.

**3.** The distribution for Ontario includes all respondents resident in the urban areas of the province: Toronto, Ottawa, Hamilton, Windsor, London, Kitchener, Waterloo, etc.

**Linguistic Distribution**

**1.** The language data given for Montreal-Toronto, Montreal-Ottawa, and Montreal-Quebec City traffic refers to respondents who are resident in Montreal.

**Table 9.5 Estimated Confidence Intervals for Weekly Flows on the Montreal-Toronto Route**

| | 90% Confidence Interval | | 60% Confidence Interval | |
|---|---|---|---|---|
| | Maximum | Minimum | Maximum | Minimum |
| Air | 21,476 | 7,119 | 17,738 | 9,814 |
| Rail | 18,602 | 4,125 | 14,925 | 8,501 |
| Bus | 3,797 | 523 | 2,962 | 1,358 |

**Table 9.6 Distribution of Income of Corridor Travellers**

a) **Residents of Montreal**

| Salary Range | Air Percentages Business | Air Pleasure | Air All | Rail Percentages Business | Rail Pleasure | Rail All | Bus Percentages Business | Bus Pleasure | Bus All |
|---|---|---|---|---|---|---|---|---|---|
| < $3000 | 0.32 | 3.71 | 1.30 | 2.08 | 8.93 | 7.80 | 4.95 | 13.06 | 12.61 |
| $3001 — 5000 | 0.76 | 7.11 | 2,60 | 2.84 | 17.07 | 14.73 | 10.89 | 23.26 | 22.57 |
| 5001 — 7000 | 2.40 | 10.20 | 4,66 | 7.20 | 20.30 | 18.15 | 16.83 | 21.50 | 21.24 |
| 7001 — 9000 | 6.44 | 9.74 | 7.40 | 13.07 | 13.57 | 13.49 | 16.83 | 12.95 | 13.16 |
| 9001 — 11000 | 9.28 | 11.59 | 9.95 | 15.91 | 10.78 | 11.63 | 16.83 | 8.96 | 9.40 |
| 11001 — 13000 | 12.12 | 11.44 | 11.92 | 13.07 | 6.95 | 7.96 | 8.91 | 5.80 | 5.97 |
| 13001 — 15000 | 14.14 | 7.26 | 12.15 | 13.83 | 5.76 | 7.09 | 10.89 | 4.80 | 5.14 |
| 15001 — 20000 | 19.38 | 14.84 | 18.06 | 17.81 | 7.44 | 9.11 | 7.92 | 4.39 | 4.59 |
| > 20000 | 35.16 | 24.11 | 31.96 | 14.39 | 9.19 | 10.04 | 5.94 | 5.27 | 5.31 |
| Sample Size | 1534 | 647 | 2231 | 528 | 2689 | 3217 | 101 | 1707 | 1808 |
| Non Respondants | 41 | 102 | 143 | 28 | 639 | 667 | 26 | 541 | 567 |

b) **Residents of Toronto**

| Salary Range | Air Percentages Business | Air Pleasure | Air All | Rail Percentages Business | Rail Pleasure | Rail All | Bus Percentages Business | Bus Pleasure | Bus All |
|---|---|---|---|---|---|---|---|---|---|
| < $3000 | 0.30 | 2.12 | 0.81 | 0.36 | 7.67 | 6.73 | 6.90 | 12.50 | 12.36 |
| $3001 — 5000 | 0.56 | 5.97 | 2.05 | 2.18 | 13.05 | 11.66 | 10.34 | 22.34 | 22.04 |
| 5001 — 7000 | 1.47 | 9.81 | 3.77 | 7.27 | 18.85 | 17.37 | 17.84 | 19.24 | 19.19 |
| 7001 — 9000 | 4.70 | 11.54 | 6.59 | 10.55 | 15.92 | 15.23 | 13.79 | 12.94 | 12.96 |
| 9001 — 11000 | 9.31 | 8.89 | 9.19 | 17.45 | 11.34 | 12.12 | 13.79 | 9.57 | 9.68 |
| 11001 — 13000 | 11.68 | 9.81 | 11.17 | 9.45 | 8.89 | 8.96 | 6.90 | 7.00 | 7.00 |
| 13001 — 15000 | 13.76 | 7.96 | 12.16 | 13.62 | 6.92 | 7.80 | 17.24 | 7.00 | 7.26 |
| 15001 — 20000 | 23.82 | 13.79 | 21.05 | 17.45 | 8.20 | 9.38 | 0.00 | 4.61 | 4.49 |
| > 20000 | 34.40 | 30.11 | 33.21 | 21.45 | 9.16 | 10.73 | 13.79 | 4.79 | 5.01 |
| Sample Size | 1977 | 754 | 2731 | 275 | 1878 | 2153 | 29 | 1128 | 1157 |
| Non Respondants | 65 | 102 | 167 | 20 | 342 | 362 | 5 | 306 | 311 |

*(Continued)*

**Table 9.6 Distribution of Income of Corridor Travellers** *(Concluded)*

**c) Residents of Ottawa**

| Salary Range | Air Percentages | | | Rail Percentages | | | Bus Percentages | | |
|---|---|---|---|---|---|---|---|---|---|
| | Business | Pleasure | All | Business | Pleasure | All | Business | Pleasure | All |
| < $3000 | 1.09 | 1.33 | 1.17 | 0.96 | 6.32 | 5.32 | 2.34 | 8.75 | 8.34 |
| $3001 — 5000 | 0.61 | 4.77 | 1.92 | 3.19 | 13.09 | 11.24 | 5.47 | 16.00 | 15.32 |
| 5001 — 7000 | 2.55 | 10.08 | 4.91 | 4.47 | 15.66 | 13.57 | 12.50 | 18.04 | 17.68 |
| 7001 — 9000 | 6.31 | 9.02 | 7.16 | 11.50 | 13.16 | 12.85 | 15.62 | 14.17 | 14.26 |
| 9001 — 11000 | 13.47 | 15.12 | 13.99 | 20.45 | 12.35 | 13.87 | 16.41 | 11.76 | 12.05 |
| 11001 — 13000 | 11.04 | 9.81 | 10.66 | 13.10 | 8.60 | 9.44 | 15.62 | 8.59 | 9.04 |
| 13001 — 15000 | 13.35 | 11.14 | 12.66 | 13.10 | 10.37 | 10.88 | 7.03 | 6.60 | 6.63 |
| 15001 — 20000 | 27.91 | 16.18 | 24.23 | 19.49 | 8.82 | 10.82 | 17.19 | 9.39 | 9.89 |
| > 20000 | 23.67 | 22.55 | 23.31 | 13.74 | 11.62 | 12.01 | 7.81 | 6.71 | 6.78 |
| Sample Size | 824 | 377 | 1201 | 313 | 1360 | 1673 | 128 | 1863 | 1991 |
| Non Respondants | 13 | 56 | 69 | 13 | 228 | 241 | 14 | 473 | 487 |

**d) Residents of Quebec City**

| Salary Range | Air Percentages | | | Rail Percentages | | | Bus Percentages | | |
|---|---|---|---|---|---|---|---|---|---|
| | Business | Pleasure | All | Business | Pleasure | All | Business | Pleasure | All |
| < $3000 | 0.00 | 0.69 | 0.25 | 3.52 | 11.01 | 10.04 | 3.77 | 12.82 | 12.19 |
| $3001 — 5000 | 0.78 | 13.19 | 5.22 | 8.45 | 20.55 | 18.98 | 9.43 | 24.65 | 23.59 |
| 5001 — 7000 | 2.33 | 12.50 | 5.97 | 6.34 | 20.65 | 18.80 | 18.87 | 21.69 | 21.49 |
| 7001 — 9000 | 6.98 | 13.19 | 9.20 | 15.49 | 13.84 | 14.05 | 22.64 | 15.21 | 15.73 |
| 9001 — 11000 | 11.63 | 9.03 | 10.70 | 14.79 | 10.60 | 11.22 | 13.21 | 8.73 | 9.04 |
| 11001 — 13000 | 16.67 | 12.50 | 15.17 | 9.66 | 5.56 | 6.11 | 15.09 | 5.21 | 5.90 |
| 13001 — 15000 | 10.47 | 6.25 | 8.96 | 11.97 | 4.10 | 5.20 | 5.66 | 3.52 | 3.67 |
| 15001 — 20000 | 20.93 | 13.19 | 18.16 | 15.49 | 6.18 | 7.39 | 7.55 | 3.10 | 3.41 |
| > 20000 | 30.23 | 19.44 | 26.37 | 14.08 | 7.34 | 8.21 | 3.77 | 5.07 | 4.98 |
| Sample Size | 258 | 144 | 402 | 142 | 954 | 1096 | 53 | 710 | 763 |
| Non Respondants | 10 | 27 | 37 | 17 | 275 | 292 | 8 | 207 | 215 |

**e) Residents of the Province of Quebec**

| Salary Range | Air Percentages | | | Rail Percentages | | | Bus Percentages | | |
|---|---|---|---|---|---|---|---|---|---|
| | Business | Pleasure | All | Business | Pleasure | All | Business | Pleasure | All |
| < $3000 | 0.55 | 2.58 | 1.18 | 1.89 | 8.81 | 7.69 | 3.39 | 11.34 | 10.84 |
| $3001 — 5000 | 0.81 | 7.56 | 2.89 | 3.79 | 16.77 | 14.67 | 9.49 | 20.26 | 19.58 |
| 5001 — 7000 | 2.44 | 10.72 | 4.98 | 6.58 | 19.22 | 17.17 | 15.59 | 20.19 | 19.90 |
| 7001 — 9000 | 6.35 | 9.98 | 7.46 | 13.06 | 13.69 | 13.59 | 17.63 | 13.85 | 14.09 |
| 9001 — 11000 | 10.89 | 12.39 | 11.35 | 17.05 | 11.12 | 12.08 | 15.59 | 10.04 | 10.39 |
| 11001 — 13000 | 12.55 | 10.81 | 12.01 | 12.46 | 7.06 | 7.93 | 12.98 | 6.82 | 7.20 |
| 13001 — 15000 | 13.47 | 8.31 | 11.88 | 13.16 | 6.59 | 7.66 | 7.80 | 5.34 | 5.49 |
| 15001 — 20000 | 22.03 | 14.88 | 19.83 | 17.95 | 7.46 | 9.16 | 11.53 | 6.34 | 6.67 |
| < 20000 | 30.92 | 22.78 | 28.42 | 14.06 | 9.27 | 10.05 | 6.10 | 5.82 | 5.84 |
| Sample Size | 2710 | 1203 | 3913 | 1003 | 5187 | 6190 | 295 | 4383 | 4678 |
| Non Respondants | 66 | 187 | 253 | 58 | 1201 | 1259 | 49 | 1253 | 1302 |

**f) Residents of Ontario**

| Salary Range | Air Percentages | | | Rail Percentages | | | Bus Percentages | | |
|---|---|---|---|---|---|---|---|---|---|
| | Business | Pleasure | All | Business | Pleasure | All | Business | Pleasure | All |
| < $3000 | 0.53 | 2.20 | 1.02 | 0.66 | 7.58 | 6.57 | 3.78 | 10.22 | 9.89 |
| $3001 — 5000 | 0.53 | 5.75 | 2.06 | 3.19 | 13.00 | 11.57 | 7.57 | 18.57 | 18.00 |
| 5001 — 7000 | 1.95 | 9.99 | 4.30 | 6.52 | 18.08 | 16.39 | 12.97 | 19.07 | 18.75 |
| 7001 — 9000 | 5.18 | 10.90 | 6.86 | 11.84 | 15.24 | 14.75 | 15.14 | 13.57 | 13.65 |
| 9001 — 11000 | 10.48 | 11.43 | 10.76 | 18.09 | 12.29 | 13.14 | 17.30 | 11.02 | 11.34 |
| 11001 — 13000 | 11.61 | 10.22 | 11.20 | 11.17 | 8.73 | 9.09 | 12.97 | 7.90 | 8.16 |
| 13001 — 15000 | 13.78 | 8.78 | 12.31 | 14.63 | 7.85 | 8.84 | 8.11 | 6.55 | 6.63 |
| 15001 — 20000 | 24.83 | 14.31 | 21.74 | 17.95 | 8.07 | 9.51 | 13.51 | 7.23 | 7.55 |
| > 20000 | 31.10 | 26.42 | 29.73 | 15.96 | 9.16 | 10.15 | 8.65 | 5.88 | 6.02 |
| Sample Size | 3186 | 1321 | 4507 | 752 | 4408 | 5161 | 185 | 3404 | 3589 |
| Non Respondants | 98 | 201 | 299 | 55 | 833 | 888 | 21 | 881 | 902 |

**Table 9.7 Distribution of Age and Sex of Corridor Travellers**

a) **Residents of Montreal**

Air Percentages

| Age Range | Business | | Pleasure | | All | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| 1 — 15 | 8.00 | 0.00 | 1.41 | 0.85 | 0.44 | 0.26 |
| 16 — 20 | 0.26 | 0.06 | 4.51 | 8.31 | 1.58 | 2.64 |
| 21 — 25 | 4.80 | 1.02 | 6.90 | 9.72 | 5.46 | 3.74 |
| 26 — 35 | 27.90 | 1.79 | 14.93 | 8.87 | 23.85 | 4.00 |
| 36 — 45 | 33.40 | 1.34 | 13.52 | 7.61 | 27.19 | 3.30 |
| 46 — 55 | 20.35 | 0.90 | 9.01 | 4.51 | 16.81 | 2.02 |
| 56 — 65 | 7.68 | 0.19 | 3.52 | 2.25 | 6.38 | 0.84 |
| > 65 | 0.32 | 0.00 | 2.25 | 1.83 | 0.92 | 0.57 |
| Sample Size | 1480 | 83 | 398 | 312 | 1878 | 395 |
| Non Respondants | 3 | 0 | 3 | 2 | 6 | 2 |

Rail Percentages

| Age Range | Business | | Pleasure | | All | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| 1 — 15 | 0.00 | 0.00 | 1.42 | 2.97 | 1.22 | 2.55 |
| 16 — 20 | 2.08 | 1.13 | 8.16 | 8.99 | 7.30 | 7.89 |
| 21 — 25 | 7.94 | 1.89 | 8.40 | 10.41 | 8.34 | 9.21 |
| 26 — 35 | 20.23 | 3.59 | 6.70 | 9.82 | 8.60 | 8.95 |
| 36 — 45 | 23.82 | 1.89 | 5.84 | 8.90 | 8.36 | 7.91 |
| 46 — 55 | 24.20 | 1.32 | 4.36 | 7.45 | 7.14 | 6.59 |
| 56 — 65 | 9.07 | 0.95 | 3.92 | 6.24 | 4.65 | 5.50 |
| > 65 | 1.89 | 0.00 | 2.81 | 3.61 | 2.68 | 3.11 |
| Sample Size | 472 | 57 | 1647 | 1890 | 1819 | 1947 |
| Non Respondants | 2 | 0 | 11 | 18 | 13 | 18 |

Bus Percentages

| Age Range | Business | | Pleasure | | All | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| 1 — 15 | 0.00 | 0.00 | 1.10 | 2.11 | 1.04 | 2.00 |
| 16 — 20 | 9.40 | 0.00 | 9.58 | 8.29 | 9.57 | 7.85 |
| 21 — 25 | 17.09 | 4.27 | 14.52 | 13.66 | 14.66 | 13.16 |
| 26 — 35 | 10.26 | 8.55 | 8.72 | 10.21 | 8.80 | 10.12 |
| 36 — 45 | 19.66 | 2.56 | 4.46 | 6.76 | 5.26 | 6.53 |
| 46 — 55 | 11.97 | 5.13 | 3.45 | 5.51 | 3.90 | 5.49 |
| 56 — 65 | 2.56 | 3.42 | 2.16 | 4.55 | 2.18 | 4.49 |
| > 65 | 4.27 | 0.85 | 1.72 | 3.21 | 1.86 | 3.09 |
| Sample Size | 58 | 29 | 954 | 1133 | 1042 | 1162 |
| Non Respondants | 1 | 0 | 4 | 7 | 5 | 7 |

b) **Residents of Toronto**

Air Percentages

| Age Range | Business | | Pleasure | | All | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| 1 — 15 | 0.05 | 0.00 | 0.24 | 1.81 | 0.11 | 0.53 |
| 16 — 20 | 0.20 | 0.05 | 4.23 | 7.37 | 1.39 | 2.21 |
| 21 — 25 | 4.40 | 1.01 | 9.66 | 9.30 | 5.95 | 3.46 |
| 26 — 35 | 25.49 | 1.42 | 13.65 | 8.82 | 22.00 | 3.60 |
| 36 — 45 | 33.74 | 1.57 | 13.89 | 8.09 | 27.88 | 3.49 |
| 46 — 55 | 22.51 | 1.21 | 7.73 | 5.07 | 18.15 | 2.35 |
| 56 — 65 | 7.38 | 0.25 | 3.86 | 3.50 | 6.35 | 1.21 |
| > 65 | 0.61 | 0.10 | 1.81 | 0.97 | 0.96 | 0.36 |
| Sample Size | 1866 | 111 | 456 | 372 | 2322 | 483 |
| Non Respondants | 3 | 1 | 1 | 2 | 4 | 3 |

Rail Percentages

| Age Range | Business | | Pleasure | | All | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| 1 — 15 | 1.06 | 0.00 | 2.05 | 2.51 | 1.94 | 2.22 |
| 16 — 20 | 1.41 | 0.00 | 5.93 | 9.66 | 5.41 | 8.56 |
| 21 — 25 | 6.01 | 4.24 | 9.71 | 12.67 | 9.29 | 11.71 |
| 26 — 35 | 13.07 | 4.24 | 8.34 | 10.44 | 8.88 | 9.73 |
| 36 — 45 | 25.44 | 4.95 | 4.24 | 7.61 | 6.66 | 7.31 |
| 46 — 55 | 21.91 | 4.24 | 4.01 | 7.98 | 6.06 | 7.55 |
| 56 — 65 | 8.83 | 1.41 | 2.92 | 5.56 | 3.59 | 5.09 |
| > 65 | 3.18 | 0.00 | 2.42 | 3.97 | 2.50 | 3.51 |
| Sample Size | 229 | 54 | 869 | 1325 | 1098 | 1379 |
| Non Respondants | 1 | 1 | 3 | 11 | 4 | 12 |

Bus Percentages

| Age Range | Business | | Pleasure | | All | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| 1 — 15 | 0.00 | 0.00 | 1.62 | 2.72 | 1.58 | 2.66 |
| 16 — 20 | 3.12 | 3.12 | 6.54 | 8.30 | 6.46 | 8.18 |
| 21 — 25 | 15.62 | 3.12 | 11.61 | 14.03 | 11.70 | 13.78 |
| 26 — 35 | 25.00 | 6.25 | 11.39 | 9.33 | 11.70 | 9.26 |
| 36 — 45 | 12.50 | 6.25 | 3.01 | 5.58 | 3.23 | 5.60 |
| 46 — 55 | 15.62 | 0.00 | 2.87 | 6.83 | 3.16 | 6.68 |
| 56 — 65 | 6.25 | 0.00 | 2.50 | 6.47 | 2.58 | 6.32 |
| > 65 | 3.12 | 0.00 | 1.98 | 5.22 | 2.01 | 5.10 |
| Sample Size | 26 | 6 | 565 | 796 | 591 | 802 |
| Non Respondants | 0 | 0 | 3 | 12 | 3 | 12 |

*(Continued)*

**Table 9.7 Distribution of Age and Sex of Corridor Travellers** *(Concluded)*

**c) Residents of Ottawa**

Air Percentages

| | Business | | Pleasure | | All | |
|---|---|---|---|---|---|---|
| Age Range | Male | Female | Male | Female | Male | Female |
| 1 — 15 | 0.00 | 0.00 | 0.72 | 2.39 | 0.24 | 0.82 |
| 16 — 20 | 0.25 | 0.37 | 3.11 | 6.70 | 1.22 | 2.53 |
| 21 — 25 | 8.79 | 1.24 | 6.94 | 12.44 | 8.16 | 5.06 |
| 26 — 35 | 21.66 | 1.36 | 12.68 | 8.13 | 18.60 | 3.67 |
| 36 — 45 | 27.35 | 1.11 | 10.77 | 8.13 | 21.70 | 3.51 |
| 46 — 55 | 26.11 | 1.73 | 8.61 | 6.94 | 20.15 | 3.51 |
| 56 — 65 | 8.66 | 0.00 | 3.35 | 3.83 | 6.85 | 1.31 |
| > 65 | 1.24 | 0.12 | 1.20 | 4.07 | 1.22 | 1.47 |
| Sample Size | 760 | 48 | 198 | 220 | 958 | 268 |
| Non Respondants | 1 | 0 | 0 | 2 | 1 | 2 |

Rail Percentages

| | Business | | Pleasure | | All | |
|---|---|---|---|---|---|---|
| Age Range | Male | Female | Male | Female | Male | Female |
| 1 — 15 | 0.00 | 0.00 | 1.83 | 4.04 | 1.53 | 3.37 |
| 16 — 20 | 1.60 | 3.19 | 7.19 | 11.67 | 6.27 | 10.27 |
| 21 — 25 | 10.54 | 1.92 | 9.53 | 12.81 | 9.69 | 11.01 |
| 26 — 35 | 22.68 | 3.51 | 6.81 | 9.09 | 9.43 | 8.17 |
| 36 — 45 | 22.36 | 2.24 | 4.16 | 8.71 | 7.17 | 7.64 |
| 46 — 55 | 22.68 | 1.28 | 4.73 | 7.26 | 7.69 | 6.27 |
| 56 — 65 | 6.07 | 1.60 | 2.40 | 5.24 | 3.00 | 4.64 |
| > 65 | 0.00 | 0.32 | 1.96 | 2.59 | 1.63 | 2.21 |
| Sample Size | 269 | 44 | 612 | 973 | 881 | 1017 |
| Non Respondants | 0 | 1 | 4 | 8 | 4 | 9 |

Bus Percentages

| | Business | | Pleasure | | All | |
|---|---|---|---|---|---|---|
| Age Range | Male | Female | Male | Female | Male | Female |
| 1 — 15 | 0.00 | 0.00 | 2.98 | 2.13 | 2.81 | 2.01 |
| 16 — 20 | 2.99 | 2.24 | 8.58 | 12.04 | 8.26 | 11.49 |
| 21 — 25 | 8.96 | 2.99 | 10.31 | 12.76 | 10.23 | 12.21 |
| 26 — 35 | 21.64 | 2.99 | 7.51 | 8.36 | 8.31 | 8.05 |
| 36 — 45 | 24.63 | 4.48 | 4.36 | 6.76 | 5.49 | 6.63 |
| 46 — 55 | 13.43 | 5.22 | 3.96 | 8.58 | 4.49 | 8.39 |
| 56 — 65 | 6.72 | 2.24 | 1.73 | 5.56 | 2.01 | 5.37 |
| > 65 | 0.00 | 1.49 | 1.24 | 3.16 | 1.17 | 3.06 |
| Sample Size | 105 | 29 | 915 | 1335 | 1020 | 1364 |
| Non Respondants | 0 | 1 | 4 | 13 | 4 | 14 |

**d) Residents of Quebec City**

Air Percentages

| | Business | | Pleasure | | All | |
|---|---|---|---|---|---|---|
| Age Range | Male | Female | Male | Female | Male | Female |
| 1 — 15 | 0.00 | 0.00 | 0.61 | 3.05 | 0.24 | 1.22 |
| 16 — 20 | 0.40 | 0.81 | 6.71 | 13.41 | 2.92 | 5.84 |
| 21 — 25 | 4.45 | 1.62 | 4.27 | 9.76 | 4.38 | 4.87 |
| 26 — 35 | 25.10 | 2.02 | 11.59 | 5.49 | 19.71 | 3.41 |
| 36 — 45 | 32.79 | 1.21 | 11.59 | 7.32 | 24.33 | 3.65 |
| 46 — 55 | 23.48 | 0.81 | 6.10 | 6.71 | 16.55 | 3.16 |
| 56 — 65 | 7.29 | 0.00 | 7.32 | 2.44 | 7.30 | 0.97 |
| > 65 | 0.00 | 0.00 | 1.22 | 2.44 | 0.49 | 0.97 |
| Sample Size | 231 | 16 | 81 | 83 | 312 | 99 |
| Non Respondants | 0 | 0 | 0 | 1 | 0 | 1 |

Rail Percentages

| | Business | | Pleasure | | All | |
|---|---|---|---|---|---|---|
| Age Range | Male | Female | Male | Female | Male | Female |
| 1 — 15 | 0.00 | 0.00 | 2.18 | 1.92 | 1.93 | 1.70 |
| 16 — 20 | 0.00 | 0.00 | 9.49 | 10.89 | 8.43 | 9.67 |
| 21 — 25 | 7.59 | 2.07 | 7.75 | 12.11 | 7.73 | 10.98 |
| 26 — 35 | 27.59 | 6.21 | 5.92 | 7.93 | 8.35 | 7.73 |
| 36 — 45 | 15.17 | 5.52 | 4.36 | 6.62 | 5.57 | 6.50 |
| 46 — 55 | 18.62 | 3.45 | 5.75 | 8.01 | 7.19 | 7.50 |
| 56 — 65 | 9.66 | 2.07 | 4.70 | 6.01 | 5.26 | 5.57 |
| > 65 | 1.38 | 0.69 | 2.70 | 3.66 | 2.55 | 3.33 |
| Sample Size | 116 | 29 | 492 | 656 | 608 | 685 |
| Non Respondants | 0 | 0 | 3 | 4 | 3 | 4 |

Bus Percentages

| | Business | | Pleasure | | All | |
|---|---|---|---|---|---|---|
| Age Range | Male | Female | Male | Female | Male | Female |
| 1 — 15 | 0.00 | 0.00 | 0.62 | 1.24 | 0.58 | 1.16 |
| 16 — 20 | 1.79 | 0.00 | 9.77 | 11.12 | 9.25 | 10.40 |
| 21 — 25 | 12.50 | 7.14 | 13.72 | 16.69 | 13.64 | 16.07 |
| 26 — 35 | 19.64 | 5.36 | 7.54 | 7.79 | 8.32 | 7.63 |
| 36 — 45 | 26.79 | 3.57 | 4.82 | 6.67 | 6.24 | 6.47 |
| 46 — 55 | 14.29 | 1.79 | 3.83 | 6.18 | 4.51 | 5.90 |
| 56 — 65 | 3.57 | 3.57 | 2.35 | 3.96 | 2.43 | 3.93 |
| > 65 | 0.00 | 0.00 | 2.10 | 1.61 | 1.97 | 1.50 |
| Sample Size | 44 | 12 | 362 | 447 | 406 | 459 |
| Non Respondants | 0 | 0 | 0 | 2 | 0 | 2 |

### Table 9.8 Distribution of Linguistic Characteristics for Corridor Travellers*

#### a) Residents of Montreal

| Language | Air Percentages | | | Rail Percentages | | | Bus Percentages | | |
|---|---|---|---|---|---|---|---|---|---|
| | Business | Pleasure | All | Business | Pleasure | All | Business | Pleasure | All |
| English only | 22.43 | 22.95 | 22.59 | 20.63 | 19.82 | 19.96 | 5.60 | 14.14 | 13.69 |
| French only | 1.12 | 2.95 | 1.70 | 1.09 | 7.32 | 6.45 | 8.00 | 10.65 | 10.51 |
| English Principal-Moderate Bil. | 36.31 | 37.45 | 36.67 | 27.72 | 29.05 | 28.86 | 18.40 | 22.51 | 22.29 |
| French Principal-Moderate Bil. | 3.59 | 8.99 | 5.30 | 10.67 | 15.50 | 14.85 | 24.00 | 22.01 | 22.12 |
| English Principal-Fluent Bil. | 12.14 | 9.66 | 11.36 | 11.23 | 8.64 | 9.01 | 11.20 | 8.19 | 8.35 |
| French Principal-Fluent Bil. | 20.94 | 13.42 | 18.57 | 24.64 | 15.58 | 16.85 | 30.40 | 17.05 | 17.75 |
| Other Main Language | 3.47 | 4.56 | 3.82 | 3.62 | 4.09 | 4.02 | 2.40 | 5.46 | 5.30 |
| Sample Size | 1614 | 745 | 2359 | 562 | 3401 | 3953 | 125 | 2235 | 2360 |
| Non Respondants | 12 | 23 | 35 | 4 | 76 | 80 | 2 | 35 | 87 |

#### b) Residents of Toronto

| Language | Air Percentages | | | Rail Percentages | | | Bus Percentages | | |
|---|---|---|---|---|---|---|---|---|---|
| | Business | Pleasure | All | Business | Pleasure | All | Business | Pleasure | All |
| English only | 61.54 | 48.35 | 57.67 | 65.20 | 55.20 | 56.35 | 46.87 | 51.42 | 51.32 |
| French only | 0.25 | 0.35 | 0.28 | 0.34 | 0.48 | 0.47 | 3.12 | 0.35 | 0.41 |
| English Principal-Moderate Bil. | 28.68 | 35.58 | 30.71 | 23.99 | 29.75 | 29.09 | 31.25 | 26.37 | 26.47 |
| French Principal-Moderate Bil. | 0.49 | 1.18 | 0.69 | 0.68 | 1.80 | 1.67 | 3.12 | 2.70 | 2.71 |
| English Principal-Fluent Bil. | 4.42 | 6.86 | 5.14 | 3.38 | 4.70 | 4.54 | 6.25 | 6.23 | 6.23 |
| French Principal-Fluent Bil. | 1.52 | 3.55 | 2.12 | 1.89 | 3.16 | 2.99 | 0.00 | 3.32 | 3.25 |
| Other Main Language | 3.09 | 4.14 | 3.40 | 4.73 | 4.91 | 4.89 | 9.37 | 9.62 | 9.61 |
| Sample Size | 2036 | 846 | 2882 | 296 | 2279 | 2575 | 32 | 1445 | 1477 |
| Non Respondants | 9 | 28 | 37 | 3 | 43 | 46 | 2 | 51 | 53 |

#### c) Residents of Quebec City

| Language | Air Percentages | | | Rail Percentages | | | Bus Percentages | | |
|---|---|---|---|---|---|---|---|---|---|
| | Business | Pleasure | All | Business | Pleasure | All | Business | Pleasure | All |
| English only | 0.37 | 0.00 | 0.23 | 0.63 | 1.19 | 1.13 | 0.00 | 2.10 | 1.97 |
| French only | 1.87 | 10.98 | 5.45 | 7.59 | 25.70 | 23.67 | 15.52 | 21.22 | 20.87 |
| English Principal-Moderate Bil. | 9.74 | 10.40 | 10.00 | 3.16 | 7.00 | 6.57 | 8.62 | 7.51 | 7.58 |
| French Principal-Moderate Bil. | 23.22 | 39.88 | 29.77 | 28.48 | 41.61 | 40.14 | 34.48 | 43.31 | 42.78 |
| English Principal-Fluent Bil. | 10.49 | 6.36 | 8.86 | 12.66 | 5.81 | 6.57 | 8.62 | 5.30 | 5.50 |
| French Principal-Fluent Bil. | 54.31 | 32.37 | 45.68 | 47.47 | 18.62 | 21.84 | 32.76 | 19.12 | 19.94 |
| Other Main Language | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.07 | 0.00 | 1.44 | 1.35 |
| Sample Size | 267 | 173 | 440 | 158 | 1257 | 1415 | 58 | 905 | 963 |
| Non Respondants | 1 | 6 | 7 | 1 | 22 | 23 | 3 | 31 | 34 |

#### d) Residents of Ottawa

| Language | Air Percentages | | | Rail Percentages | | | Bus Percentages | | |
|---|---|---|---|---|---|---|---|---|---|
| | Business | Pleasure | All | Business | Pleasure | All | Business | Pleasure | All |
| English only | 47.12 | 42.07 | 45.38 | 43.34 | 36.23 | 37.39 | 28.17 | 35.06 | 34.67 |
| French only | 0.60 | 0.92 | 0.71 | 0.51 | 1.51 | 1.31 | 4.23 | 2.72 | 2.80 |
| English Principal-Moderate Bil. | 33.41 | 31.49 | 32.75 | 29.10 | 28.50 | 28.60 | 23.24 | 25.16 | 25.05 |
| French Principal-Moderate Bil. | 1.56 | 3.68 | 2.29 | 3.10 | 7.00 | 6.37 | 8.45 | 9.07 | 9.03 |
| English Principal-Fluent Bil. | 6.25 | 8.74 | 7.10 | 9.29 | 7.91 | 8.14 | 7.75 | 6.98 | 7.02 |
| French Principal-Fluent Bil. | 9.37 | 8.97 | 9.23 | 11.46 | 16.61 | 15.77 | 21.83 | 15.75 | 16.09 |
| Other Main Language | 1.68 | 4.14 | 2.53 | 3.41 | 2.23 | 2.43 | 6.34 | 5.27 | 5.33 |
| Sample Size | 832 | 435 | 1267 | 323 | 1656 | 1979 | 142 | 2393 | 2535 |
| Non Respondants | 6 | 11 | 17 | 3 | 29 | 32 | 0 | 67 | 67 |

* See question 17 in the questionnaire for classification.

*(Continued)*

**Table 9.8 Distribution of Linguistic Characteristics for Corridor Travellers*** *(Concluded)*

**e) Residents of Hamilton**

| | Air Percentages | | | Rail Percentages | | | Bus Percentages | | |
|---|---|---|---|---|---|---|---|---|---|
| Language | Business | Pleasure | All | Business | Pleasure | All | Business | Pleasure | All |
| English only | 73.08 | 53.73 | 65.50 | 45.00 | 49.30 | 48.94 | 57.14 | 58.93 | 58.82 |
| French only | 0.00 | 0.00 | 0.00 | 0.00 | 0.47 | 0.43 | 0.00 | 0.00 | 0.00 |
| English Principal-Moderate Bil. | 20.19 | 28.36 | 23.39 | 40.00 | 35.35 | 35.74 | 28.57 | 20.54 | 21.01 |
| French Principal-Moderate Bil. | 0.00 | 2.99 | 1.17 | 5.00 | 1.40 | 1.70 | 0.00 | 1.79 | 1.68 |
| English Principal-Fluent Bil. | 5.77 | 7.46 | 6.43 | 0.00 | 5.58 | 5.11 | 0.00 | 6.25 | 5.88 |
| French Principal-Fluent Bil. | 0.00 | 2.99 | 1.17 | 0.00 | 1.86 | 1.70 | 14.29 | 3.57 | 4.20 |
| Other Main Language | 0.96 | 4.48 | 2.34 | 10.00 | 6.05 | 6.38 | 0.00 | 8.93 | 8.40 |
| Sample Size | 104 | 67 | 171 | 20 | 215 | 235 | 7 | 112 | 119 |
| Non Respondants | 0 | 1 | 1 | 0 | 5 | 5 | 0 | 4 | 4 |

**f) Residents of Sherbrooke**

| | Air Percentages | | | Rail Percentages | | | Bus Percentages | | |
|---|---|---|---|---|---|---|---|---|---|
| Language | Business | Pleasure | All | Business | Pleasure | All | Business | Pleasure | All |
| English only | 58.14 | 33.33 | 46.34 | 69.23 | 59.09 | 59.79 | 25.00 | 38.55 | 37.36 |
| French only | 0.00 | 5.13 | 2.44 | 0 00 | 2.84 | 2.65 | 0.00 | 3.61 | 3.30 |
| English Principal-Moderate Bil. | 20.93 | 38.46 | 29.27 | 15.38 | 22.73 | 22.22 | 50.00 | 24.10 | 26.37 |
| French Principal-Moderate Bil. | 0.00 | 2.56 | 1.22 | 0.00 | 2.84 | 2.65 | 12.50 | 20.48 | 19.78 |
| English Principal-Fluent Bil. | 4.65 | 2.56 | 3.66 | 7.69 | 4.55 | 4.76 | 12.50 | 3.61 | 4.40 |
| French Principal-Fluent Bil. | 13.95 | 15.38 | 14.63 | 0.00 | 5.68 | 5.29 | 0.00 | 8.43 | 7.69 |
| Other Main Language | 2.33 | 2.56 | 2.44 | 7.69 | 2.27 | 2.65 | 0.00 | 1.20 | 1.10 |
| Sample Size | 43 | 39 | 82 | 13 | 176 | 189 | 8 | 83 | 91 |
| Non Respondants | 1 | 1 | 2 | 0 | 5 | 5 | 0 | 0 | 0 |

**g) Residents of Trois-Rivières**

| | Air Percentages | | | Rail Percentages | | | Bus Percentages | | |
|---|---|---|---|---|---|---|---|---|---|
| Language | Business | Pleasure | All | Business | Pleasure | All | Business | Pleasure | All |
| English only | 61.76 | 42.86 | 53.23 | 23.08 | 27.23 | 26.96 | 0.00 | 39.47 | 37.50 |
| French only | 0.00 | 0.00 | 0.00 | 0.00 | 12.57 | 11.76 | 0.00 | 5.26 | 5.00 |
| English Principal-Moderate Bil. | 17.65 | 21.43 | 19.35 | 23.08 | 18.32 | 18.63 | 0.00 | 15.79 | 15.00 |
| French Principal-Moderate Bil. | 2.94 | 10.71 | 6.45 | 15.38 | 20.42 | 20.10 | 0.00 | 18.42 | 17.50 |
| English Principal-Fluent Bil. | 8.82 | 17.86 | 12.90 | 15.38 | 8.38 | 8.82 | 0.00 | 15.79 | 15.00 |
| French Principal-Fluent Bil. | 2.94 | 3.57 | 3.23 | 23.08 | 9.95 | 10.78 | 100.00 | 2.63 | 7.50 |
| Other Main Language | 5.88 | 3.57 | 4.84 | 0.00 | 3.14 | 2.94 | 0.00 | 2.63 | 2.50 |
| Sample Size | 34 | 28 | 62 | 13 | 191 | 204 | 2 | 38 | 40 |
| Non Respondants | 0 | 0 | 0 | 0 | 6 | 6 | 0 | 2 | 2 |

* See question 17 in the questionnaire for classification.

**Table 9.9 Distribution of Linguistic Characteristics for Travellers Resident in Montreal**

a) **Montreal to Toronto**

| Language | Air Percentages | | | Rail Percentages | | | Bus Percentages | | |
|---|---|---|---|---|---|---|---|---|---|
| | Business | Pleasure | All | Business | Pleasure | All | Business | Pleasure | All |
| English only | 25.14 | 29.94 | 26.26 | 22.09 | 26.88 | 26.21 | 33.33 | 22.83 | 23.08 |
| French only | 0.92 | 1.20 | 0.98 | 3.83 | 2.07 | 2.10 | 0.00 | 3.15 | 3.08 |
| English Principal-Moderate Bil. | 40.73 | 40.72 | 40.73 | 33.72 | 42.11 | 40.94 | 0.00 | 35.43 | 34.62 |
| French Principal-Moderate Bil. | 2.75 | 5.39 | 3.37 | 6.98 | 4.51 | 4.85 | 0.00 | 10.24 | 10.00 |
| English Principal-Fluent Bil. | 12.48 | 9.58 | 11.80 | 13.95 | 9.77 | 10.36 | 0.00 | 6.30 | 6.15 |
| French Principal-Fluent Bil. | 15.23 | 10.18 | 14.04 | 16.28 | 8.65 | 9.71 | 66.67 | 11.02 | 12.31 |
| Other Main Language | 2.75 | 2.99 | 2.81 | 4.85 | 6.02 | 5.83 | 0.00 | 11.02 | 10.77 |
| Sample Size | 545 | 167 | 712 | 86 | 532 | 618 | 3 | 127 | 130 |
| Non Respondants | 0 | 2 | 2 | 0 | 10 | 10 | 0 | 1 | 1 |

b) **Montreal to Ottawa**

| Language | Air Percentages | | | Rail Percentages | | | Bus Percentages | | |
|---|---|---|---|---|---|---|---|---|---|
| | Business | Pleasure | All | Business | Pleasure | All | Business | Pleasure | All |
| English only | 26.25 | 6.67 | 20.91 | 21.90 | 22.81 | 22.59 | 14.29 | 17.58 | 17.33 |
| French only | 0.00 | 0.00 | 0.00 | 0.73 | 3.92 | 3.15 | 3.57 | 6.05 | 5.87 |
| English Principal-Moderate Bil. | 31.25 | 40.00 | 33.64 | 32.12 | 31.57 | 31.70 | 10.71 | 25.65 | 24.53 |
| French Principal-Moderate Bil. | 3.75 | 3.33 | 3.64 | 3.65 | 11.52 | 9.63 | 17.86 | 15.27 | 15.47 |
| English Principal-Fluent Bil. | 11.25 | 10.00 | 10.91 | 11.68 | 11.06 | 11.21 | 17.86 | 8.65 | 9.33 |
| French Principal-Fluent Bil. | 22.50 | 30.00 | 24.55 | 24.82 | 15.67 | 17.86 | 28.57 | 18.73 | 19.47 |
| Other Main Language | 5.00 | 10.00 | 6.36 | 5.11 | 3.46 | 3.85 | 7.14 | 8.07 | 8.00 |
| Sample Size | 80 | 30 | 110 | 137 | 434 | 571 | 28 | 347 | 375 |
| Non Respondants | 1 | 0 | 1 | 1 | 5 | 6 | 0 | 3 | 3 |

c) **Montreal to Quebec City**

| Language | Air Percentages | | | Rail Percentages | | | Bus Percentages | | |
|---|---|---|---|---|---|---|---|---|---|
| | Business | Pleasure | All | Business | Pleasure | All | Business | Pleasure | All |
| English only | 9.09 | 2.38 | 6.92 | 9.52 | 3.62 | 4.36 | 3.03 | 5.37 | 5.19 |
| French only | 0.00 | 7.14 | 2.31 | 0.00 | 15.61 | 13.66 | 15.15 | 15.85 | 15.80 |
| English Principal-Moderate Bil. | 29.55 | 4.76 | 21.54 | 19.05 | 11.99 | 12.87 | 9.09 | 10.73 | 10.61 |
| French Principal-Moderate Bil. | 6.82 | 30.95 | 14.62 | 19.05 | 31.22 | 29.70 | 30.30 | 35.37 | 34.99 |
| English Principal-Fluent Bil. | 11.36 | 11.90 | 11.54 | 11.11 | 7.24 | 7.72 | 12.12 | 6.34 | 6.77 |
| French Principal-Fluent Bil. | 43.18 | 38.10 | 41.54 | 39.68 | 29.19 | 30.50 | 30.30 | 23.66 | 24.15 |
| Other Main Language | 0.00 | 4.76 | 1.54 | 1.59 | 1.13 | 1.19 | 0.00 | 2.68 | 2.48 |
| Sample Size | 88 | 42 | 130 | 63 | 442 | 505 | 33 | 410 | 443 |
| Non Respondants | 2 | 1 | 3 | 0 | 10 | 10 | 0 | 6 | 6 |

CANADA

CANADIAN TRANSPORT COMMISSION

(français au verso)

The Canadian Transport Commission is undertaking a survey of passenger travel between major cities in Ontario and Quebec. This will help in planning better facilities for future travel. We would appreciate it if you would help us by completing the questions below. **ALL ANSWERS WILL BE TREATED IN THE STRICTEST CONFIDENCE.**

During the period this survey is undertaken we would like to obtain a separate questionnaire for every journey. Even if you have completed a questionnaire for a previous journey we would appreciate your time and effort in also completing this one.

**PLEASE FILL IN THE INFORMATION OR CHECK ☐√ THE APPROPRIATE BOX.**

**THIS QUESTIONNAIRE WILL BE COLLECTED BEFORE THE END OF THE JOURNEY.**

1. Where do you live? *(Your permanent residence)*

   City or Town ______________________ Prov. ______________________

*(Check one box only ☐√ )*

2. Are you making

| | | |
|---|---|---|
| An outward journey of a round trip? | ☐ | 1 |
| A return journey of a round trip? | ☐ | 2 |
| Part of an outward journey? | ☐ | 3 |
| Part of a return journey? | ☐ | 4 |
| A one-way trip (not returning)? | ☐ | 5 |

3. During your trip, did you (or will you) spend time in more than one city? *(Do not count cities you just pass through)*

| | | |
|---|---|---|
| Yes | ☐ | 1 |
| No | ☐ | 2 |

*If you answered No ☐√ to question 3 do not answer question 4.*

4. What are the cities you stop in or visit? *(Please check appropriate area of city visited as well as giving city name)*

| | | (1) CENTER | (2) SUBURB |
|---|---|---|---|
| City ______________ | Prov. ______________ | ☐ | ☐ |
| City ______________ | Prov. ______________ | ☐ | ☐ |
| City ______________ | Prov. ______________ | ☐ | ☐ |

Office Use Only

| | |
|---|---|
| 14–16 | |
| 17 | |
| 18 | |
| 19–22 | |
| 23–26 | |
| 27–30 | |

Office

| | |
|---|---|
| 1–4 | RUN |
| 5–6 | SECTION # |
| 7–9 | DATE D M |
| 10–12 | QID # |
| 13 | CLASS ½ |
| | S.A. |

Official Use Only

5. At what terminal did you board *this* vehicle? 31 32

Terminal: ______________________________

6. Where did you start from in order to get to the terminal at which you boarded *this* vehicle? 33

City ______________________________

Nearest street intersection __________________ at ______________________ 38

7. How did you get to the terminal?

*(Check only one box, representing the longest part of this connecting trip)*

| | | | |
|---|---|---|---|
| Subway or Metro | | 1 | |
| Bus or Trolley | | 2 | |
| Walk all the way | | 3 | |
| Taxi or limousine | | 4 | |
| Private car driver | | 5 | 39 |
| Private car passenger | | 6 | |
| Rental car | | 7 | |
| Transferred from another vehicle giving intercity service* | | 8 | |
| Other *(specify)* | | 9 | |

**If you did transfer from another vehicle giving major intercity service there is no need to fill out questions 8 and 9.*

8. Approximately how many minutes did it take you to travel to the terminal from your starting point? 40

__________ minutes 42

9. How much did it cost to travel from your starting point to the terminal? *(If you drove or shared a private car, or rent a car, or shared a taxi estimate your cost or share of cost)* $ ______ . ___ 43

46

10. How long were you at the terminal before this vehicle departed? *(If still waiting, how long do you think the wait will be? )* 47

__________ minutes 49

11. What is the main purpose of your journey today? *(Check only one please)*

| | | | |
|---|---|---|---|
| Vacationing/sightseeing | | 1 | |
| Visiting friends and relatives | | 2 | |
| Shopping/attending an entertainment or sporting event | | 3 | |
| Going to or coming from place of work (commuting) | | 4 | 50 |
| Travelling on company business | | 5 | |
| Travelling on personal business | | 6 | |
| Other *(please specify)* | | 7 | |

End of Card 1

Official Use Only

12. At which terminal will you get off *this* vehicle? 14 15

Terminal: ______________________

13. When you get off *this* vehicle at the terminal what is your destination? 16

City ______________________ 21

Nearest street intersection ______________ at ______________ 21

14. How will you get from the terminal to this destination?

*(Check only one box, representing the longest part of this connecting trip)*

| | | |
|---|---|---|
| Subway or metro | | 1 |
| Bus or trolley | | 2 |
| Walk all the way | | 3 |
| Taxi or limousine | | 4 |
| By car parked at terminal | | 5 |
| Will be picked up by car | | 6 |
| Will rent car | | 7 |
| Will transfer to another vehicle giving intercity service* | | 8 |
| Other | | 9 |

22

**If you will be transferring to another vehicle giving major intercity service, there is no need to fill out questions 15 and 16.*

15. How long do you think it will take you to get from the terminal to your final destination? 23 25

______ minutes

16. How much do you think it will cost you to travel from the terminal at which you leave this vehicle to your final destination? *(If using private car please estimate cost)* 26 29

$______.____

*TO HELP US CLASSIFY THE ANSWERS ABOVE WE WOULD LIKE TO OBTAIN SOME PERSONAL INFORMATION. WE DO NOT REQUIRE YOUR NAME OR ADDRESS AND ALL INFORMATION IS TREATED IN THE STRICTEST CONFIDENCE.*

17. Can you tell us about your principal language?

| | | |
|---|---|---|
| I speak English only | | 1 |
| I speak English principally and am moderately bilingual | | 3 |
| I speak French principally and am moderately bilingual | | 4 |
| I speak English principally but am fluently bilingual | | 5 |
| I speak French principally but am fluently bilingual | | 6 |
| My main language is other than French or English | | 7 |

30

18. What was your *family's total income* last year?

| | | | |
|---|---|---|---|
| under | 3000 $ year | | 1 |
| between | 3001 – 5000 | | 2 |
| " | 5001 – 7000 | | 3 |
| " | 7001 – 9000 | | 4 |
| " | 9001 – 11000 | | 5 |
| " | 11001 – 13000 | | 6 |
| " | 13001 – 15000 | | 7 |
| " | 15001 – 20000 | | 8 |
| | over 20000 | | 9 |

31

Official Use Only

19. What sort of business do you work in?

*(If more than one indicate only the principal one)*

| | | |
|---|---|---|
| Manufacturing Industry | | 01 |
| Retail and Wholesale Trade | | 02 |
| Construction | | 03 |
| Transport and Communication | | 04 |
| Finance, Insurance, or Real Estate | | 05 |
| Medical and related services | | 06 |
| Federal and Provincial Government | | 07 |
| Community service | | 08 |
| Housewife, student, or retired | | 09 |
| Unemployed | | 10 |
| Other *(Please specify)* | | 11 |

32 33

20. What sort of work do you do?

*(If more than one indicate only the principal one)*

| | | |
|---|---|---|
| Managerial | | 1 |
| Professional | | 2 |
| Sales | | 3 |
| Clerical | | 4 |
| Skilled worker/technician | | 5 |
| Semi skilled labouring | | 6 |
| Unskilled labour | | 7 |

34

21. Please indicate the highest extent of your education.

| | | |
|---|---|---|
| No schooling | | 1 |
| Elementary School (Grades 1 – 8) | | 2 |
| Secondary School (Grades 9 – 12) | | 3 |
| Grade 13 | | 4 |
| Community College | | 5 |
| University but less than 1st degree | | 6 |
| University: 1st degree | | 7 |
| University: Higher degree | | 8 |
| Other *(specify)* | | 9 |

35

22. Which age group are you in?

| | | |
|---|---|---|
| 15 or Under | | 1 |
| 16 – 20 | | 2 |
| 21 – 25 | | 3 |
| 26 – 35 | | 4 |
| 36 – 45 | | 5 |
| 46 – 55 | | 6 |
| 56 – 65 | | 7 |
| over 65 | | 8 |

36

23. Please check male or female.

| | | |
|---|---|---|
| Male | | 1 |
| Female | | 2 |

37

24. Is there any city or area in which you have a concentration of relatives or friends, whom you may visit from time to time? *List more than one city or area if appropriate.*

City____________________ Prov. ____________________

City____________________ Prov. ____________________

City____________________ Prov. ____________________

City____________________ Prov. ____________________

38

49

**THANK YOU FOR YOUR COOPERATION. This Questionnaire will be collected from you. Should we miss collecting yours we would appreciate your leaving it on the seat.**

**CANADIAN TRANSPORT COMMISSION**
**RESEARCH DIVISION**
**OTTAWA 4.**

CANADA

COMMISSION CANADIENNE DES TRANSPORTS

*(English on the reverse side)*

La Commission canadienne des Transports poursuit actuellement une étude sur les voyages effectués entre les principales villes de l'Ontario et du Québec. Cette étude contribuera à améliorer les conditions des voyages à venir. Nous apprécierions beaucoup si vous vouliez bien nous aider en remplissant le questionnaire ci-dessous. **TOUTES LES RÉPONSES SERONT CONSIDÉRÉES COMME STRICTEMENT CONFIDENTIELLES.**

Pendant la période où cette étude est entreprise nous aimerions obtenir un questionnaire différent pour chaque voyage. Même si vous avez déjà rempli un questionnaire au cours d'un voyage précédent, nous vous serions grandement reconnaissants de vouloir bien consacrer un peu de votre temps à prendre la peine de remplir celui-ci.

**RÉPONDEZ S'IL VOUS PLAIT AUX QUESTIONS POSÉES OU COCHEZ** [√] **LA CASE APPROPRIÉE.**

**CE QUESTIONNAIRE SERA RAMASSÉ AVANT LA FIN DU VOYAGE.**

Réservé à l'Administration

1. Où habitez vous? *(Résidence principale)*

   *Ville* ____________ Province ____________

2. Faites-vous *(Ne cochez qu'une case* [√]*)*

| | | |
|---|---|---|
| Un voyage aller d'un voyage aller et retour? | | 1 |
| Un voyage retour d'un voyage aller et retour? | | 2 |
| Une partie d'un voyage aller? | | 3 |
| Une partie d'un voyage retour? | | 4 |
| Un voyage aller (sans retour)? | | 5 |

3. Pendant votre voyage, vous êtes vous arrêté ou vous arrêterez-vous dans plus d'une ville? *(Ne comptez pas les villes que vous ne faites que traverser)*

| | | |
|---|---|---|
| Oui | | 1 |
| Non | | 2 |

*Si vous avez répondu non* [√] *à la question 3, ne répondez pas à la question 4.*

4. Quelles sont les villes où vous vous êtes arrêté ou que vous avez visitées? *(Indiquez pour chaque ville son nom, la province où elle se trouve et cochez en outre la case correspondant à la partie de la ville visitée)*

| | | (1) CENTRE | (2) FAUBOURGS |
|---|---|---|---|
| Ville ____________ | Province ____________ | | |
| Ville ____________ | Province ____________ | | |
| Ville ____________ | Province ____________ | | |

TRAJET 1 4

SECTION # 5 6

DATE J M 7 9

IDQ # 10 12

CLASSE ½ 13

14 16 17 18 19 22 23 26 27 30

S.A.

Réservé à l'Administration

5. À quelle station avez-vous pris *ce* véhicule? — 31 32

Station: ____________________

6. D'où êtes-vous parti pour aller à la station où vous avez pris *ce* véhicule? — 33 … 38

Ville: ____________________

Croisement de rues le plus proche ____________________

7. Comment vous êtes vous rendu à cette station?

*(Ne cochez qu'une case représentant la partie la plus longue de ce voyage de correspondance)*

| | | | |
|---|---|---|---|
| Métro | | 1 | |
| Bus ou Tramway | | 2 | |
| À pied tout le long du trajet | | 3 | |
| Taxi ou limousine | | 4 | |
| Conducteur d'une voiture privée | | 5 | 39 |
| Passager d'une voiture privée | | 6 | |
| Voiture de location | | 7 | |
| Correspondance à partir d'un autre véhicule assurant un service régulier inter villes* | | 8 | |
| Autres *(précisez)* | | 9 | |

**Si vous avez pris une correspondance à partir d'un autre véhicule assurant un service régulier inter villes, vous n'avez pas à répondre aux questions 8 et 9.*

8. Combien de minutes à peu près avez vous mis pour aller de votre point de départ à la station? — 40 42

_________ minutes

9. Combien cela vous a-t-il coûté pour aller de votre point de départ à la station? *(Si vous avez conduit ou partagé une voiture privée ou une voiture de location ou si vous avez partagé un taxi évaluez votre dépense ou votre participation.)* — 43 46

$______ . ____

10. Combien de minutes avant le départ êtes vous arrivés à cette station? *(Si vous êtes encore en train d'attendre, de combien de minutes, pensez vous, aura été votre attente totale? )* — 47 49

_________ minutes

11. Quelle est la raison principale de votre voyage aujourd'hui? *(Ne cochez qu'une case s'il vous plaît)*

| | | | |
|---|---|---|---|
| Vacances/Tourisme | | 1 | |
| Visites à des amis ou des parents | | 2 | |
| Achats/manifestation culturelle ou sportive | | 3 | |
| Trajet journalier entre la résidence et le lieu de travail | | 4 | 50 |
| Voyage d'affaires pour votre société | | 5 | Fin — 1 |
| Voyage d'affaires personnel | | 6 | |
| Autres (précisez s'il vous plaît) | | 7 | |

Réservé à l'Administration

12. À quelle station quitterez-vous *ce* véhicule? 14 15

Station: ______________________________

13. À la station où vous quitterez *ce* véhicule, quelle sera votre destination? 16

Ville: ______________________________

Croisement de rues le plus proche ______________________________ 21

14. Comment irez-vous de cette station à votre destination?

*(Ne cochez qu'une case représentant la partie la plus longue de votre voyage de correspondance)*

| | | |
|---|---|---|
| Métro | | 1 |
| Bus ou Tramway | | 2 |
| À pied tout le long du trajet | | 3 |
| Taxi ou limousine | | 4 |
| Voiture garée à la station | | 5 |
| On viendra vous chercher en voiture | | 6 |
| Vous louerez une voiture | | 7 |
| Correspondance avec un autre véhicule assurant un service inter villes* | | 8 |
| Autres | | 9 |

22

**Si vous allez prendre un autre véhicule assurant un service inter villes, vous n'avez pas à répondre aux questions 15 et 16.* 23

15. Combien de minutes, pensez-vous, vous faudra-t-il à peu près pour aller de la station à votre destination finale? 25

____________ minutes 26

16. Combien pensez-vous cela vous coûtera-t-il pour aller de la station ou vous quitterez ce véhicule à votre destination finale? *(Si vous utilisez une voiture privée, estimez la dépense)* 29

$______ . ______

---

*POUR NOUS AIDER À CLASSER LES QUESTIONS CI-DESSUS NOUS AIMERIONS AVOIR QUELQUES INFORMATIONS PERSONNELLES. NOUS NE DEMANDONS NI VOTRE NOM NI VOTRE ADRESSE ET TOUTE INFORMATION SERA TRAITÉE COMME STRICTEMENT CONFIDENTIELLE.*

17. Pouvez-vous nous dire quelle(s) langue(s) vous parlez?

| | | |
|---|---|---|
| Je ne parle que français | | 2 |
| Je parle principalement anglais et suis un peu bilingue | | 3 |
| Je parle principalement français et suis un peu bilingue | | 4 |
| Je parle principalement anglais et suis complètement bilingue | | 5 |
| Je parle principalement français et suis complètement bilingue | | 6 |
| Je ne parle la plupart du temps ni anglais ni français | | 7 |

30

18. Quel a été le *revenu total de votre famille* l'année dernière?

| | | | |
|---|---|---|---|
| Moins de | 3000 $ par an | | 1 |
| Entre | 3001 – 5000 | | 2 |
| " | 5001 – 7000 | | 3 |
| " | 7001 – 9000 | | 4 |
| " | 9001 – 11000 | | 5 |
| " | 11001 – 13000 | | 6 |
| " | 13001 – 15000 | | 7 |
| " | 15001 – 20000 | | 8 |
| | plus de 20000 | | 9 |

31

Réservé à l'Administration

12. À quelle station quitterez-vous *ce* véhicule? | 14 15

Station: ______________________

13. À la station où vous quitterez *ce* véhicule, quelle sera votre destination? | 16

Ville: ______________________

Croisement de rues le plus proche ______________________ | 21

14. Comment irez-vous de cette station à votre destination?

*(Ne cochez qu'une case représentant la partie la plus longue de votre voyage de correspondance)*

| | | |
|---|---|---|
| Métro | | 1 |
| Bus ou Tramway | | 2 |
| À pied tout le long du trajet | | 3 |
| Taxi ou limousine | | 4 |
| Voiture garée à la station | | 5 |
| On viendra vous chercher en voiture | | 6 |
| Vous louerez une voiture | | 7 |
| Correspondance avec un autre véhicule assurant un service inter villes* | | 8 |
| Autres | | 9 |

22

**Si vous allez prendre un autre véhicule assurant un service inter villes, vous n'avez pas à répondre aux questions 15 et 16.*

23 25

15. Combien de minutes, pensez-vous, vous faudra-t-il à peu près pour aller de la station à votre destination finale?

__________ minutes

26

16. Combien pensez-vous cela vous coûtera-t-il pour aller de la station ou vous quitterez ce véhicule à votre destination finale? *(Si vous utilisez une voiture privée, estimez la dépense)*

$______.______

29

*POUR NOUS AIDER À CLASSER LES QUESTIONS CI-DESSUS NOUS AIMERIONS AVOIR QUELQUES INFORMATIONS PERSONNELLES. NOUS NE DEMANDONS NI VOTRE NOM NI VOTRE ADRESSE ET TOUTE INFORMATION SERA TRAITÉE COMME STRICTEMENT CONFIDENTIELLE.*

17. Pouvez-vous nous dire quelle(s) langue(s) vous parlez?

| | | |
|---|---|---|
| Je ne parle que français | | 2 |
| Je parle principalement anglais et suis un peu bilingue | | 3 |
| Je parle principalement français et suis un peu bilingue | | 4 |
| Je parle principalement anglais et suis complètement bilingue | | 5 |
| Je parle principalement français et suis complètement bilingue | | 6 |
| Je ne parle la plupart du temps ni anglais ni français | | 7 |

30

18. Quel a été le *revenu total de votre famille* l'année dernière?

| | | | |
|---|---|---|---|
| Moins de | 3000 $ par an | | 1 |
| Entre | 3001 – 5000 | | 2 |
| " | 5001 – 7000 | | 3 |
| " | 7001 – 9000 | | 4 |
| " | 9001 – 11000 | | 5 |
| " | 11001 – 13000 | | 6 |
| " | 13001 – 15000 | | 7 |
| " | 15001 – 20000 | | 8 |
| | plus de 20000 | | 9 |

31

CANADIAN TRANSPORT COMMISSION
COMMISSION CANADIENNE DES TRANSPORTS