Evanston Oct. 71

PROCEEDINGS —

Twelfth Annual Meeting

"Changing Times and Keeping Up"

October 18-19-20, 1971
Sheraton Hotel
Philadelphia, Pennsylvania

Volume XII • Number 1 1971

T
R
F

TRANSPORTATION RESEARCH FORUM

Comparison of Strategies For Development of Intercity Transport

by George A. Clark*

ACKNOWLEDGEMENTS

The author is indebted to E. K. Culley, T. E. Parkinson and the entire Study group for direct and indirect contributions to this paper.

INTRODUCTION

DEVELOPMENT of heavily-populated regions in the United States, Japan and other countries has led to severe congestion of regional transport systems and a need for immediate solutions to complex and growing problems. In many cases conditions are such that operational improvements to the existing transport system would not relieve these problems; solutions must involve development of new transport technology tailored to regional needs. The Intercity Passenger Transport Study (ref. 1) was undertaken as a preliminary assessment of the role of new or developing technology in meeting future demand for passenger transportation in Canada. The Study is intended as the first phase of continuing research designed to produce a data and information base which will contribute to planned and timely development of the transport system.

With this broad objective in mind, the Study concentrated on the most heavily developed region in Canada—the 700-mile corridor between Quebec City and Windsor. Detailed analysis centered on development of the transport links between Toronto, Ottawa and Montreal through addition of high-speed rail services, tracked air cushion vehicles (TACV), and short-takeoff-and-landing aircraft (STOL).

ANALYSIS AND EVALUATION

The early stages of the Corridor Study were directed toward an understanding of the existing transportation system and the character of the intercity traveller. In the summer of 1969 an origin-destination survey was conducted on the common carrier links between Quebec City, Montreal, Ottawa and Toronto. The survey produced some 50,000 responses from air, rail and bus travellers on these links and provided extensive data on traveller and trip characteristics. Together with the characteristics of the Corridor cities and the transport network, the survey data was used to develop a mathematical model of demand for intercity passenger transportation.[1]

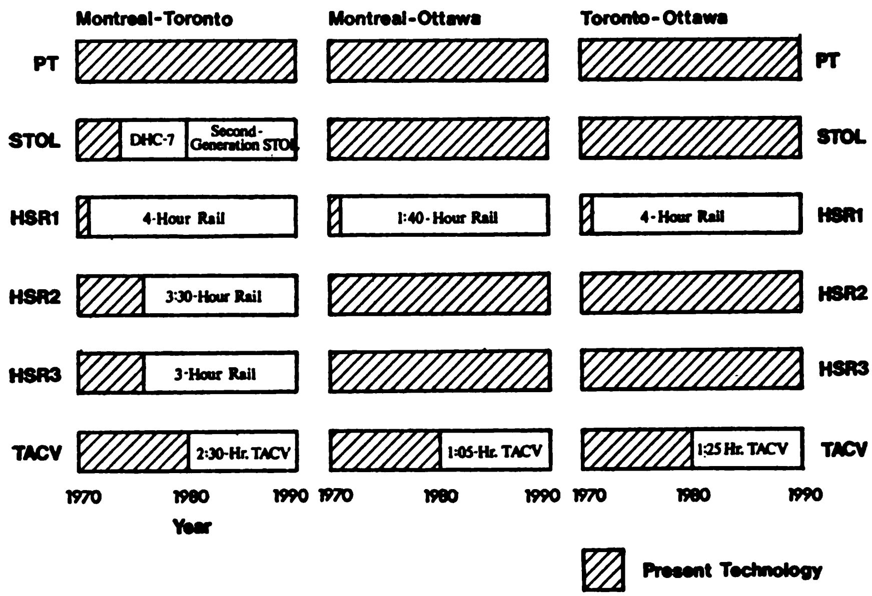
At the outset it was determined that surveys and analysis of automobile

**Research Branch, Canadian Transport Commission*

[1] **This model is described in: Forecasting Intercity Travel, a paper presented at the Canadian Transportation Research Forum by E. K. Culley, in May 1970, and published in Papers of the Transportation Research Forum, 1970 (ref. 2).**

travel were beyond the resources of the Study. For this reason the demand model was formulated in such a way that it could be calibrated without knowing the origin-destination character of automobile travel. The model predicts only the common carrier segment of intercity travel. The automobile enters the model only as a basis for comparing the performance of alternative modes. Through this comparison the model predicts the diversion of travel from automobile to common carrier modes as a result of improvements in the common carrier system.

The potential impact of new technology on intercity travel was evaluated by comparing the performance of six development strategies. These alternatives are illustrated in Figure 1 and summarized as follows:



DEVELOPMENT STRATEGIES

PT	Present Technology
STOL	Short Takeoff and Landing Aircraft
HSR1	High Speed Rail – Existing Track
HSR2	High Speed Rail – 3½ Hrs. Mont.-Tor.
HSR3	High Speed Rail – 3 Hrs. Mont.-Tor.
TACV	Tracked Air Cushion Vehicles

Summary of Development Strategies

FIGURE 1

1. The present technology (PT) strategy: this strategy is taken as the basis for comparison and assumes that performance of the transport links between Montreal, Ottawa and Toronto remains unchanged to 1990.

2a. Short-takeoff-and-landing aircraft (STOL): this strategy involves three system changes:

   i) introduction of downtown-to-downtown STOL service in 1974 between Montreal and Toronto using first-generation STOL aircraft,

   ii) revision of this service in 1980 by replacement of first-generation aircraft with more advanced STOL aircraft, and

   iii) improvement of conventional (CTOL) air services with introduction of competing STOL services in 1980. (These improvements were assumed to reduce time spent in air terminals by the average business traveller from 80 minutes to 50 minutes).

2b. A variation of the STOL strategy (STOLA) in which the first-generation STOL service is not provided. A STOL service is operated between Montreal and Toronto beginning in 1980 in competition with an improved CTOL service as described for the STOL strategy.

2c. A variation of the STOL strategy (STOLB) intended to illustrate the effects of individual changes: all STOL services are eliminated, leaving only the improvements in CTOL services.

3. High-speed rail service on existing track (HSR1): this strategy would introduce faster rail service between Montreal, Ottawa and Toronto through use of rail equipment capable of higher speeds on existing track.

4. High-speed rail service, improved track (HSR2): with investments in track improvements estimated at $200-million, this strategy would reduce rail schedules between Montreal and Toronto from 5 hours to 3½ hours, effective in 1976.

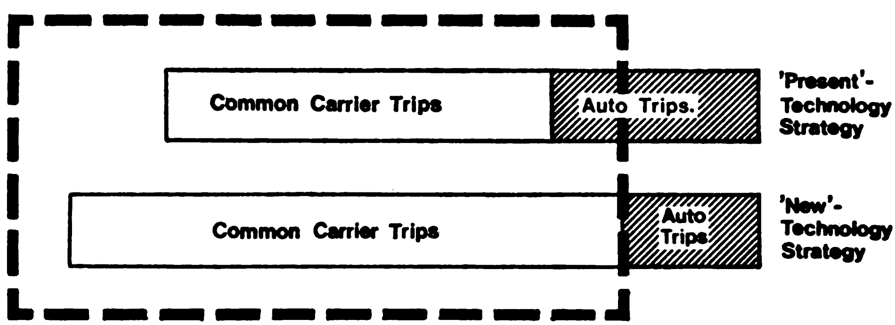
5. High-speed rail service, improved track (HSR3): as in the HSR2 strategy, Montreal-Toronto rail schedules are reduced to 3 hours in 1976 through a $500-million investment in track improvements.

6. Tracked-air-cushion-vehicle strategy (TACV): a TACV system introduced in 1980 on a Montreal-Ottawa-Toronto alignment would replace rail services between these centres and require a $520-million investment in track, terminals and other facilities.

Many extensions and variations of these basic strategies could be considered. In fact, certain of the development plans which were treated as alternatives in this analysis could be developed as complementary systems. Since only a limited number of alternatives could be evaluated in the Study, strategies were selected to give adequate coverage to the developing transport technologies, and to ensure that the effects of each strategy would be easily related to individual changes in the transport system. For example, although STOL and high-speed rail services are not mutually exclusive, it would be difficult to determine the impact of each if they were both combined in a single strategy. It was recognized that such a combined strategy might prove to be a "better" alternative and that analysis of the basic strategies would indicate whether or not such a combined strategy should be considered in future study. Once the basic form of the strategies had been selected, the details were determined by the anticipated performance of the new technologies, the present stage of development of these technologies, and the length of time required to plan and construct the proposed facilities.

Although the Study includes a limited assessment of the effects of the strategies on users and on individual modes, the financial viability of the entire transport system was adopted as the basic measure of the performance of the alternative strategies. This measure has two fundamental shortcomings: it fails to consider the many non-financial impacts of changes in the transport system; and the effects on the various sectors of the transport industry and the user population are concealed by aggregation. In spite of these shortcomings, comparison of financial viability was considered to be the most practical means of identifying the more feasible alternatives and the areas in which more intensive research is required.

Each new-technology strategy was assessed by comparing its performance with that of the present-technology strategy. For the 20-year period to 1990 the costs and revenues involved in the operation of each alternative were discounted to a 'present value' in 1969. Analysis was simplified by working with *differences* in costs rather than total costs, thereby eliminating those elements of cost that were common to all strategies. Similarly, in using this approach there was no need to consider highway travel that was common to all strategies. As illustrated in Figure 2, improved common car-



Comparison of Strategy Volumes

FIGURE 2

rier services produce new common carrier traffic through generation of new trips and diversion of travel from the automobile to other modes. Those trips which are made by automobile in both the present- and new-technology strategies (i.e., trips which are outside the heavy frame of Figure 2) are unaffected by the choice of strategy[2] and can be ignored.

The financial viability of the alternative strategies was taken as the difference between the revenue accruing to the system and the (avoidable or incremental) cost of building and operating the transport system. The advantage of a new-technology strategy over the present-technology case is given by:

$$\begin{aligned}&\text{Strategy Financial Advantage}\\&= OR_{nt} - OR_{pt} + (PC_{nt} - PC_{pt})\\&\quad - AOC_{nt} + AOC_{pt} - (HAOC_{nt} - HAOC_{pt})\\&\quad - (ACAP_{nt} - ACAP_{pt})\end{aligned}$$

where: OR = operating revenue, common carrier services

PC = perceived cost of highway trips

AOC = avoidable operating costs, common carrier services

HAOC = avoidable operating costs of highway trips

ACAP = avoidable capital costs of fixed facilities

$_{nt}$ = new-technology system

$_{pt}$ = present-technology system

Each element of this comparison represents the 20-year stream of costs or revenues related to travel with origin and destination at Montreal, Ottawa or Toronto. "Revenue" from the transport system is taken as the sum of fares paid to the common carriers plus the "perceived" cost of travel by automobile. Just as fares reflect the traveller's willingness to pay for transportation services, a decision to travel by automobile implies a "willingness to pay" that is equal to the traveller's subconscious estimate of the cost of that automobile trip. It is generally accepted that out-of-pocket driving costs are a reasonable measure of this perceived cost of automobile travel. (In this study perceived cost was estimated as the total of fuel, oil and tire costs.) In effect, it was assumed that persons travelling by automobile "pay" into the transport system an amount equal to the perceived cost of their travel. Since this

2 This would not be true if diversion of highway traffic to the common carrier modes resulted in relief of highway congestion. On the three links considered here, highway capacity is largely determined by "local" traffic; large diversion of intercity traffic would have a small effect on highway volumes.

input is less than the actual operating costs involved, the automobile mode operates at a loss with the individual user absorbing these operating losses.

It was assumed that there are no avoidable capital costs associated with the present-technology strategy. In other words, the investment in facilities such as highways and airports would be unaffected by the choice of development strategy. As illustrated in later discussion of the TACV strategy, the validity of this assumption was reviewed in the course of the strategy comparison.

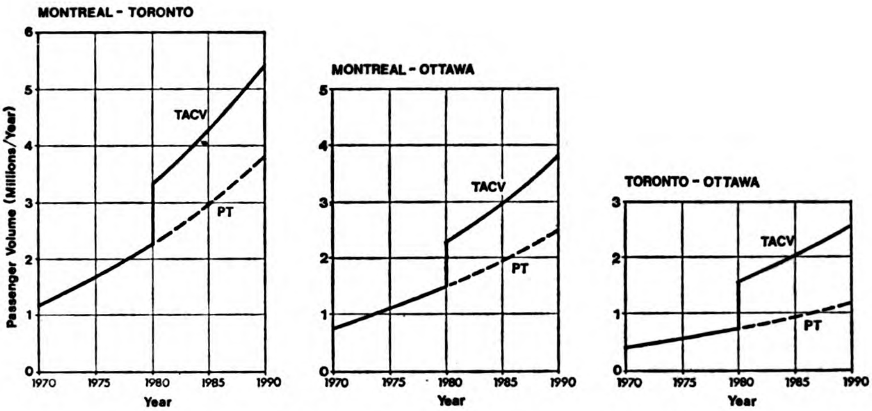
The evaluation of alternative strategies and new technologies was limited to the three intercity links between Montreal, Ottawa and Toronto. The Study did not include an assessment of additional functions which the basic intercity system might perform. An example of such a complementary role would be the use of an intercity TACV system as a mode of access to major airports.

AN EXAMPLE — THE TACV STRATEGY

The comparison and evaluation of alternative strategies is illustrated in this section using the TACV case as an example. In the TACV concept, single or coupled passenger units are supported and guided by a cushion of air and operate at high speed on an elevated track structure. The analysis was based on the performance of the Aerotrain I-80 system which is now under development in France (ref. 3). The Aerotrain I-80 is a propeller-driven vehicle with a capacity of 80 passengers and a cruising speed of 155 mph. (Second-generation systems are now under development which will be propelled by linear induction motors at cruise speeds of 200 mph. In addition to speed, this more advanced TACV technology will have other operating advantages over first-generation vehicles. Indications are that operating costs of second-generation systems will be of the same order as those now estimated for first-generation systems.)

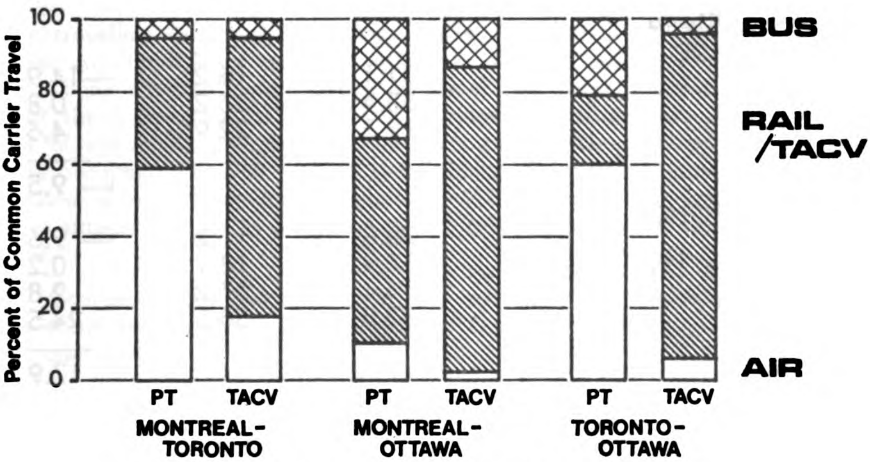
Delineation of a tentative alignment linking Toronto, Ottawa and Montreal was a first step in assessing the TACV strategy. On the basis of this alignment the costs of track construction were estimated as $450 million with terminals and other fixed facilities bringing total capital costs to $520 million (ref. 4). Costs of vehicles and operation were estimated from data provided by developers of the Aerotrain concept. Because of the high costs involved in track and other infrastructure, average operating costs are highly dependent on the number of passengers using the system—by doubling utilization from 1.2 to 2.4 billion passenger-miles per year, passenger-mile costs are reduced by about 25 percent.

In the TACV strategy, railway passenger service between Montreal, Ottawa and Toronto would be replaced with the tracked-air-cushion-vehicle system in 1980. Air and bus services would continue unchanged except for appropriate adjustment of capacity. Figure 3 shows the estimated effect of the TACV service on the volume of travel by the common carrier modes. Figure 4 compares the modal split in 1980 for the PT and TACV strategies. The effect of these volume changes and shifts between modes on estimated revenues and avoidable operating costs is summarized in Table 1 for the



Common Carrier Origin-Destination Volumes—'PT' and 'TACV' Strategies

FIGURE 3



Modal Split for the PT and TACV Strategies

FIGURE 4

common carrier modes. All dollar values are the present worth (in 1969) of 20 years of operation using a 10-percent rate of discount and a 3-percent rate of inflation. The present worth of revenue from fares on the common carrier modes amounts to $664 million and $853 million for the PT and TACV strategies respectively. Avoidable operating costs of the common carrier modes are estimated as $571 million in the case of the PT strategy and $617 million for the TACV strategy.

The TACV strategy involves a capital investment of some $520 million

REVENUES AND AVOIDABLE OPERATING COSTS FOR THE PT AND TACV STRATEGIES
(Present Worth, Millions of Dollars)

Rate of Interest = 10%
Rate of Inflation = ..3%

Montreal-Toronto	Cost	Revenue	Difference
PT Strategy			
Air	292.8	349.2	56.4
Rail	57.6	101.7	44.1
Bus	12.3	13.8	1.5
			102.0
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
Montreal-Ottawa			
PT Strategy			
Air	31.1	16.2	—14.9
Rail	35.4	36.2	0.8
Bus	18.3	22.9	4.6
			— 9.5
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			
PT Strategy			
Air	98.7	96.3	— 2.4
Rail	12.8	12.9	0.1
Bus	11.9	14.6	2.7
			0.4
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

TABLE 1

for fixed facilities.[8] If this investment is amortized over a 25-year period from 1980 on an equal-annual-payments basis, the present worth of capital charges up to and including the year 1990 amounts to $206 million. These investment costs would be recovered from two classes of TACV users:

1) trips with origin and destination at Montreal, Ottawa or Toronto ("specific O-D" traffic), and

2) trips with origin or destination at points other than these centres.

The strategy comparison is concerned with only the "specific O-D" segment of TACV traffic or an estimated 84 percent of total travel on the TACV system. Using this estimate of utilization as a basis for allocation of investment costs, $173 million in cost-of-capital charges must be recovered from the TACV strategy.

With the introduction of new or improved transportation services, travel is attracted to the up-graded mode from all other modes. One such effect is the diversion of travel from the highway or automobile mode as a result of improvements in common carrier services. Of the strategies considered in this Study, the TACV alternative results in the largest diversion of highway travellers to a new-technology mode. The extent of this diversion is shown in Figure 5 as estimated using the demand model. For example, in 1980 some 830,000 trips between Montreal and Toronto would be diverted from the automobile to the TACV service. Assuming that the avoidable cost of automobile operation is five cents per vehicle-mile and average vehicle occupancy is 2.15 persons per vehicle, the present value of the cost of these diverted auto trips amounts to $55 million. The perceived cost of these automobile trips is estimated as $33 million, the total of fuel, oil and tire costs.

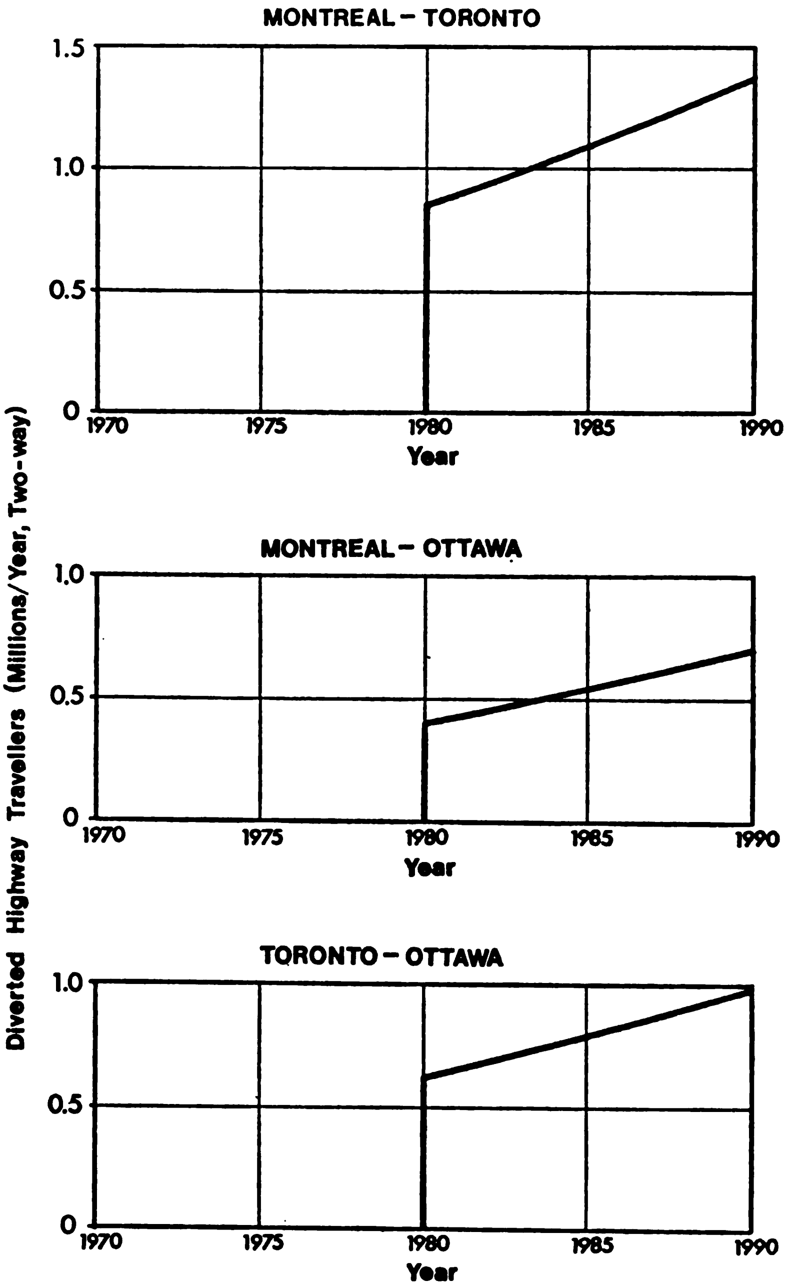
Combining the above revenue and cost data in a comparison of the two strategies, the financial advantage of the TACV strategy relative to the PT case is:

Financial Advantage, TACV Strategy vs. PT Strategy

$$= 853 - 664 + (-33)$$
$$- 617 + 571 - (-55)$$
$$- 173$$
$$= - 8 \text{ million dollars.}$$

As indicated earlier, this estimate does not account for capital expenditure which is required for the PT strategy but avoided in the TACV alternative. One would expect that diversion of travel from highway and air modes to the TACV would result in smaller investment in highway and airport facili-

8 This figure does not include the cost of the vehicles themselves. The purchase of vehicles was treated as an "avoidable operating cost" and would amount to about $86 million for the capacity requirements estimated for 1980.



Highway Travellers Diverted to the TACV System

FIGURE 5

ties. In the case of highways, the volume of diverted traffic is small in comparison with available capacity. For example, the Montreal-Toronto travel shifted from automobile to TACV in 1980 would amount to a peak-hour volume of 65 vehicles per hour in each direction. Comparing this with freeway capacities in excess of 1200 vehicles per hour per lane, such a change in highway travel would have a negligible effect on highway construction programs.

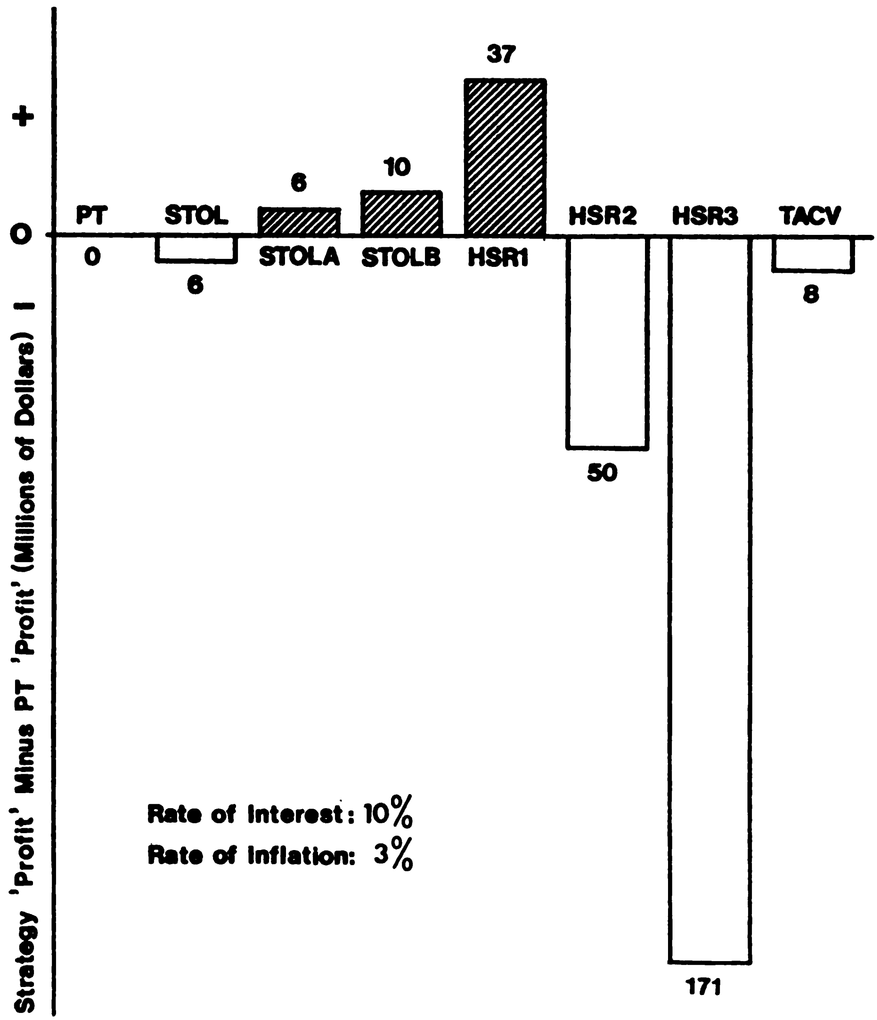
The impact of the TACV system on airport construction would be far more significant. The diversion of air travellers to the TACV could affect the construction program for both the second Montreal airport at Ste. Scholastique and the new Toronto airport. Although this Study did not include a detailed estimate of the extent of this rescheduling or the cost savings which might result, the possible effects of the TACV are easily illustrated. Introduction of an intercity TACV service would reduce the total number of passengers handled at Toronto airports by an estimated 8 or 9 percent in 1980. If, as the result of this traffic reduction, a $500-million investment in airport facilities was delayed from 1980 to 1981, the present worth of that investment would be reduced by $11 million (assuming a 10-percent rate of interest and a 3-percent rate of inflation).

The TACV holds promise as a mode of access to major airports and considerable economies could result from combined use of the TACV infrastructure by both airport-access services and intercity operations. Since the proposed TACV alignment passes near the site of the new Montreal airport at Ste. Scholastique, the capital costs involved in serving the airport would be relatively small. The combination of airport and intercity services would spread capital costs over a greatly increased volume of traffic, tending to decrease average passenger-mile costs. However, a first-generation TACV system would not provide adequate capacity for this higher level of traffic; second-generation vehicles would be required and these would operate as multiple units in peak periods. The Corridor Study did not include an evaluation of the effect of airport traffic on the viability of the TACV strategy.

As illustrated in the next section, the TACV strategy is highly sensitive to change in assumptions and parameters. It involves heavy investment in infrastructure which would have no alternative application if the service proved to be unsuccessful. On the other hand, a large fraction of intercity travellers would benefit from the TACV through reductions in trip cost and travel time. By designing the TACV system to allow intermediate stops, the accessibility (and development) of selected areas within the region could be substantially altered.

THE STRATEGY COMPARISON

The comparison of the alternative development strategies is summarized in Figure 6. For purposes of this illustration all capital investment in fixed facilities such as track, terminals and STOLports is amortized over a 25-year period. The financial comparison relates only to trips which start and end in Montreal, Ottawa or Toronto. Where appropriate, a portion of capital costs has been allocated to other traffic expected to use the new intercity links. In the STOL and STOLA strategies it was assumed that STOLports in Mon-



Strategy Comparison (Present Worth, 1970-1990)

FIGURE 6

treal and Toronto served only a Montreal-Toronto link. The addition of other STOL links into these cities would place the STOL and STOLA strategies in a more favourable position by spreading capital costs over a greater volume of traffic.

On the basis of this strategy comparison, the Study produced three main conclusions:

1. Using the Montreal-Toronto link as an example, major improvements in railway service by heavy investment in track recon-

struction cannot be justified. The resulting increases in revenue fall far short of compensating for the capital outlay.

2. Using the financial measures adopted for this Study, the strategy which produces the highest return is based on modest improvement of the existing railway system through use of advanced rolling equipment such as the Turbotrain.

3. Given the uncertainties of long range estimates and the relatively small differences between the financial performance of certain of the strategies, there is a need for continuing and more detailed study of the STOL and TACV technologies.

The strategy comparison and these broad conclusions should be considered in the light of the sensitivity of the analysis to changes in assumptions. Figure 7 shows the sensitivity of the comparison to change in passenger volumes, capital costs, interest rate and depreciation period. Clearly, sensitivity varies greatly between strategies. For example, a 10-percent difference in predicted travel volumes would change the TACV/PT comparison by $17 million while the position of all other strategies would shift by less than $5 million. Study of sensitivity is perhaps most important for the STOL and TACV strategies since, in the financial comparison of Figure 6, the performance of the STOL, TACV and PT strategies is very much the same.

Comparison of financial performance is meaningless unless it is related to the investment or other risk involved in the alternative strategies. Figure 8 shows the strategy comparison in relation to the investment costs[4] (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. Although the TACV and STOL alternatives are rated equally in the strategy comparison, Figure 8 shows that the (financial) return on investment is far different in the two cases.

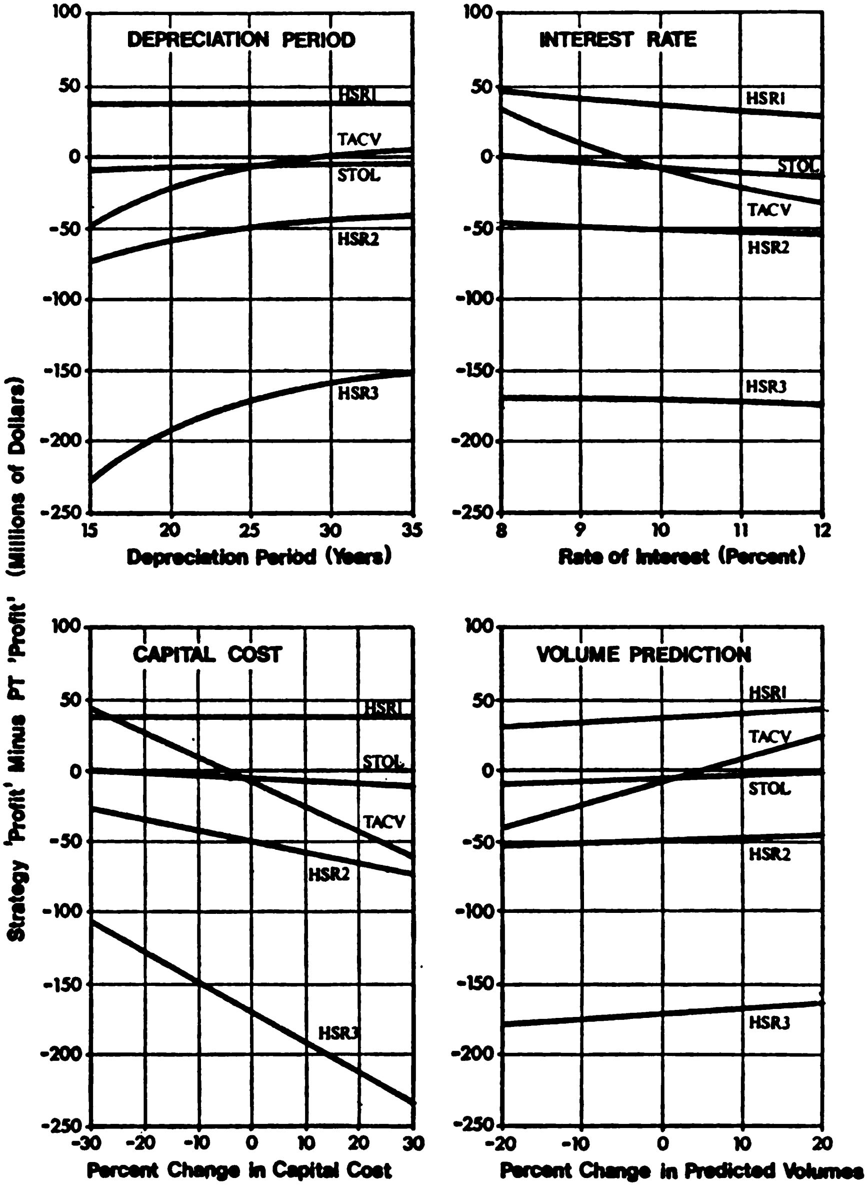
As this paper has illustrated, comparison of transport development alternatives is a complex matter even where the strategies are simple and comparison is limited to their direct financial consequences. Although the limitations of the evaluation procedures and criteria used in the Intercity Passenger Transport Study are all too clear, the Study has provided a basis for a more refined evaluation of transport alternatives. In addition, it has identified aspects of the more promising alternatives that should be subjected to continuing study with a view to development of an information base for passenger transport policy.

4 These values are the present worth of investment costs within the study period. "Investment cost" includes only the cost of fixed facilities; the cost of vehicles and aircraft is omitted since this investment can be tailored to a demonstrated demand for service.

REFERENCES

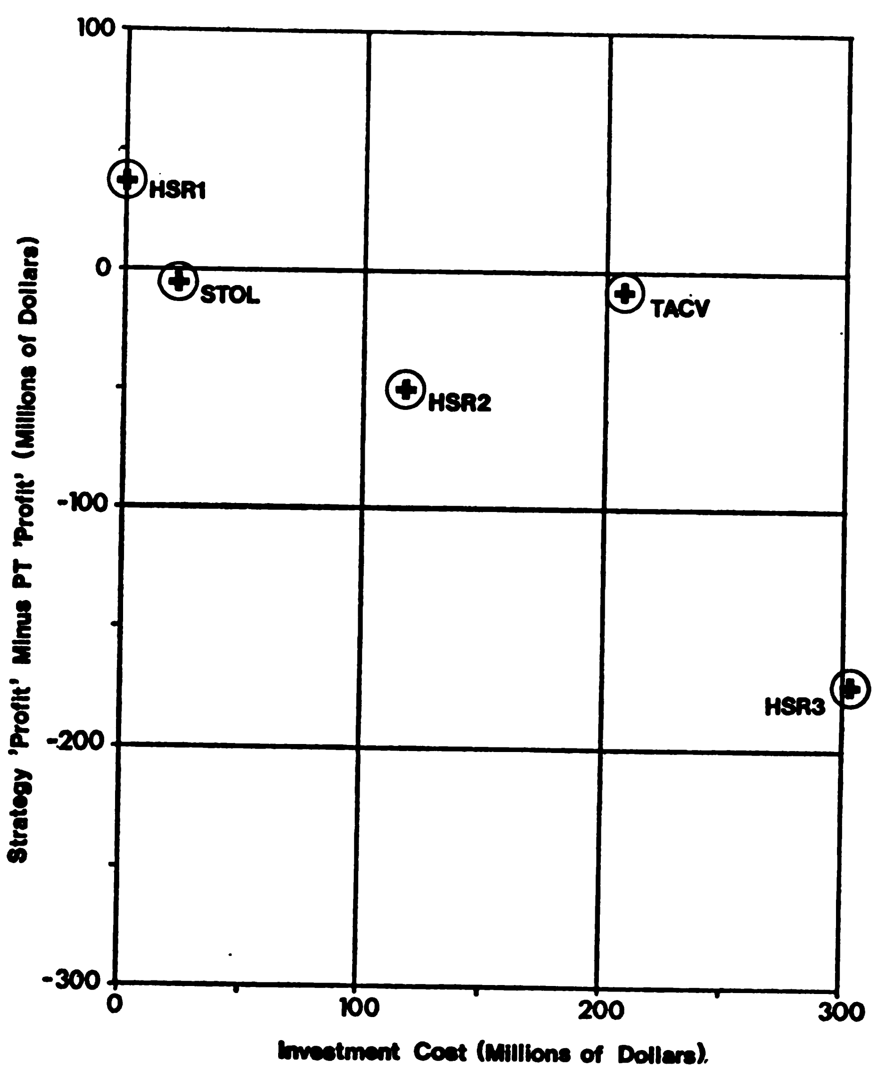
1. Canadian Transport Commission. *Intercity Passenger Transport Study*, Ottawa, Information Canada, September 1970.
2. Culley, E. K. "Forecasting Intercity Travel." *Papers of the Transportation Research Forum*, May 1970, pp. 49-67.
3. Parkinson, T. E., ed. *Tracked Air Cushion Vehicles in the Canadian Cor-*

ridor. Ottawa, Canadian Transport Commission, April 1971.
4. De Leuw, Cather and Company for the Canadian Transport Commission. *Evaluation of the Aerotrain Guideway*. January 1970. Reproduced in Reference 3.



Sensitivity of the Strategy Comparison

FIGURE 7



Strategy Comparison vs. Investment Cost (Present Worth)

FIGURE 8