Transportation systems management; Alternatives to capital investment in a period of uncertainty

by
STEIN G. JAHNSEN
Alberta Transportation, Canada
and
JOHN F. MORRALL
The University of Calgary, Canada

Transportation Systems Management alternatives are considered to be those options that relate to improving the utilization and efficiency of existing transportation facilities to accommodate demand, as against supplying more transportation facility capacity to accommodate demand.

INTRODUCTION

At a time when numerous future uncertainties are facing the transportation industry, such as energy and its availability, requirements and policy directions; introduction of new or improved technology; a lack of co-ordination in policymaking between different departments and levels of governments; a shortage of and competing demand for capital in the face of substantial new investment requirements for transport all over the world; and the role of the public transport modes vis-a-vis the automobile, it is important for government and operators to know when *not* to make a decision involving large capital investments.

Rather, until the nature of these and other uncertainties are better understood, or until they are reduced, interim measures to maintain and improve the efficiency of existing systems should be undertaken in order to avoid sub-optimal investments. As such, Transportation Systems Management alternatives are much less risky and a more viable strategy than Capital Investments at this highly uncertain state in the history of transportation. As well as being alternatives to capital investment, Transportation Systems Management alternatives can also be used in a multi-modal fashion to support and enhance capital investment in a particular mode of transport. One advantage of considering Transportation Systems Management is that the analysis will indicate for how long the investment decision can be delayed, thus giving the decisionmaker a much better perspective of the overall situation, including how to treat the uncertainties.

In this paper, the evaluation and use of Transportation Systems Management alternatives are undertaken at a multi-modal level for passenger transportation in the low-to-medium density Edmonton-Calgary corridor, and are based on work performed in the recently completed Edmonton-Calgary Corridor Transportation Study. The analysis is directed towards the key issues, strategic choices and policy problems that will prevail or surface in various time periods in the study area. Before discussing in detail the TSM alternatives that were considered, a description of the study area and the issues will be presented.

THE CORRIDOR SETTING AND THE PRESENT TRANSPORTATION SYSTEM

The Edmonton-Calgary Corridor is situated in the Province of Alberta in Western Canada (see Figure 1). The Corridor Study Region boundaries define a rectangular area of about 300 km by 160 km. Within these 48 000 km^2, or 7% of Alberta's surface area, are located six of Alberta's ten cities. The central axis of this study area is the major north-south highway, a four lane rural expressway. The corridor or Corridor Spine is immediately adjacent to this route and contains most of the major communities in the region. The Corridor Spine also contains a single track rail line which links a number of corridor communities with transcontinental rail lines which pass through Edmonton and Calgary. The populations of the communities in the study area vary widely, with Edmonton and Calgary each approaching one half million while the next largest community Red Deer, has approximately 28 000. The combined Edmonton and Calgary population accounts for 82% of Corridor Region population of 1,1 million, which in turn accounts for 68% of the provincial total. This distribution is rapidly changing as Edmonton and Calgary account for almost all new growth while the rural population is declining. This trend suggests even further concentration in the two main metropolitan areas, which would imply even more investment in intercity transportation services and facilities.

THE PRESENT TRANSPORTATION SYSTEM

The four modes of travel available in the Corridor Region - rail, bus, air and automobile - offer a variety of both regional services and express services, the latter being non-stop service between Edmonton and Calgary. Of the total Edmonton/Calgary travel, 24% consists of intercity travel with the remainder intercentre travel, or trips from other corridor communities to Edmonton and Calgary. The automobile captures the predominant share of the *total* travel market accounting for 93% of the travel. Bus contributed 3%, air 4% and rail less than 1% of the total. The modal split for Edmonton-Calgary *intercity* trips is 66% automobile, 21% air, 12% bus and less than 1% rail. If no changes are made in the system, the intercity market shares are expected to be 59% automobile, 29% air, 12% bus, and less than 1% rail by 1983.

The present rail service in the Corridor caters to intercity, intercentre, and short local trips. Four runs are made every weekday between Edmonton and Calgary making four intermediate stops. The rail diesel cars cover the 314 track kilometres in 3 hours and 25 minutes at an average speed of 92 km/h. The present service is uneconomic and unattractive for a number of reasons. Low quality service is offered, travel times are longer than for any other mode, fares relatively high and only two departures a day provided in each direction. In addition, the equipment used is old, generally not attractive and does not take advantage of the express capabilities that rail is usually assumed to have. The net result is low demand, in turn resulting in high per-passenger system costs, high per-passenger energy consumption and high levels of direct federal subsidies, approximately Can. $700 000 in 1974.

There is fairly extensive bus service in the Corridor Region, with both regional and express services offered. Eighteen Edmonton-Calgary express runs and twelve intercentre express runs are provided per day with travel times slightly lower than rail. In addition, the regional bus routes provide service to most of the communities in the Corridor Region. In all cases the bus provides the user with a low-cost mode of transportation, and from society's point of view, is a mode of transportation that has low system cost, requiring no subsidy. As a conse-

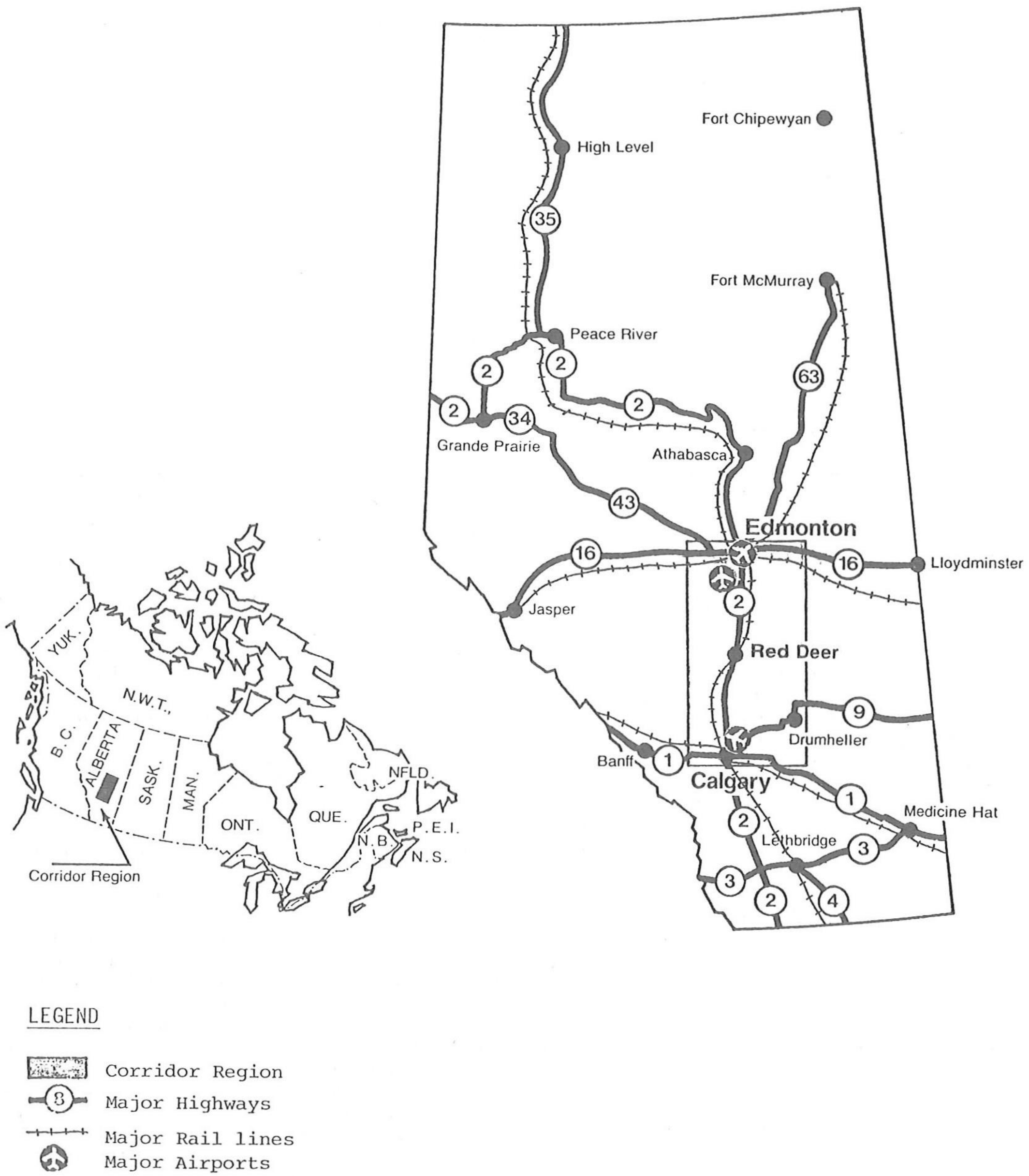

Figure 1 - The Edmonton-Calgary Corridor Region: National and Provincial Setting

quence of being the least comfortable mode with fairly long travel times it is generally used by low-income, non-business travellers, although some business travel does occur on the bus.

The Airbus between Edmonton and Calgary is a highly successful service providng thirty flights eack weekday and caters to over 1 600 passengers per day who are mainly high-income business travellers. Use is made of a downtown airport in Edmonton rather than the international airport, resulting in a relatively fast CBD-CBD total travel time of 1 hour and 35 minutes, of which 35 minutes represent the actual air line haul. The airbus is profitable for the operator, but indirect subsidies of approximately Can. $5.5 million are being paid to the service.

With over 93% of all Edmonton/Calgary travel, the automobile is by far the major mode of travel in the Corridor Region. The high use of the automobile is due to its many attractive features. The highway network covers all parts of the Corridor Region and hence provides access between all communities and for many, but not all users, it is a very inexpensive mode of travel. In addition the auto is the most flexible of all modes offering maximum convenience for departure times and maximum privacy when travelling. The high use of the auto is also attributed to the fact that there are many travellers who are captive to the automobile. This includes those who have no alternative, those for whom travel by common carrier is too expensive in terms of time or money, and those who require the use of their cars at the destination end. The auto mode requires little or no subsidy, with fuel taxes and licence fees covering the auto share of highway infrastructure costs. It is the fastest of all the surface modes, completing the CBD-CBD intercity trip in 3 hours and 20 minutes

In summary the intercity traveller has the best choice of modes available and the best choice of service levels; from the slower but inexpensive bus service to the very fast and much more expensive air service. The air traveller (mainly expense account travellers) make up the bulk of the common-carrier express passengers. While receiving the best level of service and paying consequently the highest fares, the air travellers also receives the bulk of the transportation subsidy that is paid to travellers in the Corridor Region. The regional travellers, on the other hand, have little or no choice of mode, particularly away from the Corridor Spine. Furthermore, the service offered is the lowest in terms of comfort, frequency, and reliability. Finally, it is the regional traveller (who is particularly conscious of the cost of travelling) who receives little or no subsidy and hence pays for most of his travel costs.

THE ISSUES FACING TRANSPORT DECISION MAKERS

The issues facing transport decisionmakers in the Corridor Region are related to general questions concerning land use, development policies, environmental factors, equity in transportation services, level of service, economic efficiency, multi-modal planning and future uncertainties. In order to allow transportation planners and decisionmakers focus on both short-term operational management decisions as well as middle range planning decisions the future was divided into three time periods on a functional basis as follows:

(i) Immediate Period (1976-1977) - a two-year period, when management and operational decisions involving non-capital investment can be implemented.

(ii) Planning Period (1978-1983) - the period during which decisionmakers should be in a position to commit new funds and implement new systems and during which the trend future is likely to hold.

(iii) Long Range Period (1984 and beyond) - characterized by uncertain forecasts, limited knowledge of the effects of new technologies, and incomplete information on which to base transportation planning decisions.

It is particularly for the Planning Period that Transportation System Management (TSM) alternatives can be most beneficial and used to good advantage, in order to reduce uncertainty and not to preclude any option that may become viable in the early and mid-1980's.

The major issues, modal opportunities, and the TSM and investment alternatives in the corridor region are listed in Table I for the Planning and Long Range Period. The general future uncertainties to which these issues are related are given in Table II. The issues in Table I are only a partial list of those uncovered in the Edmonton-Calgary Corridor Transportation Study, and only a few of these will be selected for detailed discussion in this paper.

As noted earlier, the automobile is the most heavily used and the most flexible of all modes, and because of its popularity tampering with it entails some risk for governments. Still, the decision must be faced in the relatively near future of whether to encourage and make auto travel more efficient, or to discourage auto travel and place more emhasis on common carriers. Since any improved common carrier service depends upon drawing from the automobile for additional patronage, detailed TSM measures to discourage auto travel must accompany any such improvements. On the other hand, considerable system improvements are possible by making auto travel more efficient, without necessarily adding more highway infrastructure.

Rail is the transportation mode where the most obvious problems exist. First, there are the high costs and subsidies involved in providing the service to only about 16 000 travellers per year. Second, there are access problems related to the Edmonton station because of its poor location. Additional problems with this mode include a lack of incentive for the operator to improve service, the high number of grade crossings between Edmonton and Calgary, and a failure to achieve economies in energy because of low load factors.

While the regional bus service could be more extensive and more frequent than at present, it is noted that it is currently operating at a loss, being cross-subsidized by the operator from the profitable intercity express service. Thus, any improvement in regional services would require government subsidies to be implemented. Other problems are related to productivity because of restrictions in vehicle length and urban traffic congestion in Edmonton and Calgary.

Problems with the intercity air service concern the substantial indirect subsidy given to high-income business travellers, and alternative uses of the downtown Edmonton airport land. As well, questions of noise and safety arise.

Closely related to the transportation issues in the planning period are likely growth patterns that will emerge and solidify in the long range period. Whereas the Alberta Government has general policy statements espousing regional development, growth and decentralization, these must be much more clearly defined before any firm infrastructure and service planning can be undertaken.

TRANSPORTATION SYSTEM MANAGEMENT ALTERNATIVES TO REDUCE UNCERTAINTY

The TSM alternatives will be discussed in terms of the uncertainties in Table II, and reference will be made as to how they will affect the issues described in Table I.

Table 1 - Selected list of issues, modal opportunities and alternatives by time period

	Main issues	Modal opportunities	TSM and investment alternatives
Planning Period (1978-1983)	**1. Private transportation** **(a) Automobile** Auto Efficiency, energy consumption, roadway requirements, What is the role of the automobile in the region?	Ai: Encourage auto travel, but make it more efficient Aii: Discourage auto travel	Ai: **TSM:** Increase auto occupancy rate, auto sharing programs, Aii: **TSM:** Impose 90 km/h speed limit, road user taxes, congestion costs, gasoline and licence price increase
	2. Private transportation vs. the common carrier (a) Can patronage be shifted from the auto to common carrier? What benefits can be gained from such a shift? What are the consequences for the common carriers if the shift from auto is too rapid, i.e. equipment shortages, service levels, etc? (b) **Intercity Market** Which mode should capture what share of the intercity market	A. Define modal roles for a "planned" multi-modal intercity transportation system.	A. **TSM** and/or **CAPITAL:** Dependent upon the specific roles that will be defined.
	3. Common carriers (a) **Rail** What is the purpose of rail service? What market segment should this mode be designed to capture? Is the improved service worth the large expenditures involved? What are the benefits of passenger rail service? Would the loss of rail service be unacceptable?	A. **Rail** i. Discontinue rail services ii: Upgrade present rail service	Ai. **TSM:** discontinue present rail service ii: **CAPITAL** – 145 km/h conventional service - Can. $10,1 million – 145 km/h Improved service - Can. $17,9 million – 200 km/h improved service - Can. $37,9 million with supporting **TSM:** Peak or premium fares on air and bus, 90 km/h. speed limit, road user tax, gasoline and licence price increases, congestion costs, restrict landings at Edmonton downtown airport
	(b) **Bus** Should this mode be encouraged to continue to offer low cost service? Would improved rail adversely affect regional and/or express bus service? Should regional bus service be subsidized?	B. **Bus** i: Subsidize regional bus services	Bi: **CAPITAL:** Subsidy payments to bus operator
	(c) **Air** Should the air mode continue to receive large indirect subsidies? A substantial increase of jet flights into the downtown Edmonton Industrial airport which is really what makes the intercity air service successful might not be allowed. Would moving the service out to the International airport (32 km. distance) hurt the air market share?	C. **Air** i: continue present service ii: Pricing of present service iii: Continue present service but restrict landings at Edmonton downtown airport iv: Move present service to Edmonton International airport and continue using present equipment (Boeing 737) v: Continue using the down-town Edmonton airport, but buy RTOL (A300) equipment vi: Discontinue present service and replace with downtown-downtown STOL service	Cii, iii: **CAPITAL:** Rail investment alternatives 145 km/h conventional, improved or 200 km/h improved with supporting TSM as for Rail **or** **CAPITAL:** Upgrade spine highway to 6 lane divided Civ, vi: **TSM:** Impose 90 km/h Speed limit and **do not** implement any rail improvement
	4. Highway congestion congestion is experienced on highways within the 40 km. commuter shed of Edmonton and Calgary	Alleviate peaking problems in morning and afternoon rush hours	TSM: Activity rescheduling such as; staggered work hours, flex time four-day work week to change travel patterns, car pooling. and/or **CAPITAL:** Implement subsidized commuter bus services
Long Range Period (1984 and beyond)	**5. Development patterns and policies** (a) Growth concentrated in Edmonton and Calgary	A. Greatly improved common carrier intercity system **or** Increased importance of automobile	A. High-speed rail, CTOL, RTOL, or VTOL air services with supporting **TSM** to restrict auto travel, **or** Upgrade spine highway from 4 to 6 lane divided standard.
	(b) Growth concentrated in linear spine between Edmonton and Calgary	B. Improved common carrier system **or** Increased importance of automobile	B. Improved rail, bus, and/or STOL air service with **TSM** to restrict auto travel, **or** Upgrade spine highway from 4 to 6 lane divided standard
	(c) Regional and/or New Corridor Growth	C. Increased dependence upon automobile with some scope for limited common carrier improvements	C. New corridor highways to the east and west of the spine, and regional bus services and STOL air services.

Table II - Selected future uncertainties

Selected uncertainties	Time frame in which a strategic choice is required	Issue(s) in Table I to which it is related	Nature of uncertainties	Strategic choice facing decisionmaker
Rail Passenger Service	1977 - 1983	1a, 2a & b; 3a, b & c	National rail passenger policy uncertain; Purpose of rail service uncertain; Market segment designed to capture uncertain; Benefits of improved rail service are unknown; Uncertainty surrounding termination of the present service	Terminate the service, *or,* improve the service at a cost of $2 million or more per year
Future of Airbus Service	1980 - 1984	3a, c; 5a	Uncertainty as to number of landings and take-offs that will be allowed at downtown airport; Alternative uses of scarce downtown land; Safety and pollution aspects of jet service over downtown area	Continue present service but use larger equipment (A300), *or,* relocate to International airport, *or* implement improved rail alternatives
Role of the automobile	1980 - 1985	1a; 2a & b; 3a, b, c; 5a, b & c	Uncertain as to the minimum level of service acceptable and public reaction to schemes to discourage auto usage; Ultimate technological and management efficiencies are unknown; The importance of the automobile in shaping growth patterns	To encourage or discourage auto travel. Decisions are required to conduct TSM experiments related to energy savings, level of service and potential diversion factors - both to get more out of the existing highway system as well as making the common carriers more viable
Energy	1976 - 1980	1a; 2a & b; 3a, b & c	Uncertain Supply situation; Unclear government positions; Energy priorities undefined; Type of energy mix for future transportation system uncertain; New energy sources uncertain	Take interim measures to delay investment decisions until the energy picture has clarified, and at the same time take whatever action is necessary to maintain a full range of future options
Technology	1977 - 1983	1a; 3a & c; 5a	Several new or improved technologies emerging; No single new technology has been proven operationally; Relationship between new technology and energy; Suitability of new technology to various demand levels; Timing of new technology and government industrial strategies	Invest in conventional equipment, or, invest in technology showing the most promise, or, delay decision and take interim measures until a proven new technology is introduced
Need for Future Transportation Corridors	1977 - 1980	5a, b & c	Transportation systems/corridors required to support land-use/development policies - both are unknown	Reserve right-of-ways for highways and high speed ground transportation system
Transport-related Government Policies	1977 - 1980	5a, b & c	Most government policies directly and indirectly related to Corridor transportation are very vague and often working at cross-purposes	Government development and transportation policies need to be clearly defined and co-ordinated

Table III - Summary of energy savings through automobile strategies for intercity trips
Edmonton-Calgary Corridor Region, Planning Period

Strategy	Annual Energy Savings, 1980 [1] Absolute (Litres/Year) x 10^6	As a % of Intercity Consumption Indicated by Trend	Resulting Delay in Growth of Intercity Auto Traffic	Investment Associated with Each Strategy	Risk Associated with Each Strategy
Imposition of a 90 km/h Speed Limit [1]	4,860	8,7%	–	Very low	Little
Doubling Present/ Automobile Occupancy [2]	15,165	27,3%	12 years	Very low	Risky
Utilization of Full Automobile Capacity	17,595	31,6%	15 years	Very low	Risky
10% Shift from Automobile to Bus	2,340	4,2%	2 years	Moderate	Risky

[1] Using an 8 km/litre average for the automobile
[2] Present occupancy is 2.1 persons per auto

Energy

There is substantial scope for improvement in total energy consumption of the transportation system in the corridor. For demonstration purposes, only one year, 1980, will be selected rather than presenting a time series. In that year, assuming trend forecasts and no significant changes in travel patterns, total energy (gasoline) consumption will be 55,6 million liters for all intercity travel. Since automobile is the dominant mode in the corridor, it is also there that the largest savings can be effected. Table III depicts the savings possible through various auto strategies.

Imposing a 90 km/h speed limit (the present speed limit is 112 km/h) will result in a savinf of 4,86 million litres per year, or 8,7% of total intercity consumption. Other than changing highway signs, there is hardly any investment or expenditures associated with this strategy, and politically it is virtually a non-risk situation, having already been proven elsewhere. Since auto travel time would still be the lowest of all the surface modes, no changes in travel patterns would be likely to occur.

Doubling present average auto occupancy from 2,1 to 4,2 persons per auto gives even better results, with a maximum saving of 15,165 million litres per year, or 27,3% of the annual total consumption. This strategy would have the additional benefit of delaying highway growth for 12 years. This is particularly important because large sections of the Highway 2 corridor spine will be congested by 1983 and the government will have to make an upgrading decision by about 1980. If this TSM alternative was implemented, energy savings would be substantial, and the upgrading decision could probably be delayed to about 1990. By that time, the whole energy picture, as well as the role of the automobile should be clarified. There are several ways such as strategy of doubling auto occupancy can be implemented. Official hitch-hiking centres can be established, as well as "trip registration centres" where passengers and drivers with similar trip origins and destinations can register. Depending upon how important the program was deemed to be, some kind of policing system could be established with automatic fines imposed on a driver with less than a predetermined number of people in his automobile.

Again, the investment required would be quite minor, but the political risk could be quite major. Basically, the government would be imposing travel restrictions on anybody using the automobile and restrict somewhat the freedom to chose from available modes. This strategy might also divert some travel to the common carriers, because the convenience of the automobile would be somewhat curtailed.

The potential effects of this strategy are very complex, in that a shift to common carriers is a possible result, and depending upon the magnitude of such a shift, potential savings in energy consumption may be considerably less than those expected. Because of potential adverse public reaction, extreme caution must be exercised in implementing this strategy.

The greatest energy saving can be affected by a TSM that is probably unattainable, that of achieving full auto occupancy. This would save 17,595 million litres per year, or 31,6% of total system consumption. However, this is probably more utopia than anything that can realistically be expected.

The best energy saving measure by shifting people from auto to a common carrier was found to be a 10% shift from auto to bus. However, this would only result in a saving of 2,34 million litres per year, or 4,2% of total consumption, which is much inferior to any pure automobile TSM strategy. Moreover, highway growth would only be delayed for two years, and the highway upgrading decision would still have to be made. A wide range of TSM measures would likely be required to affect such a shift, including a 90 km/h speed limit for autos only, substantial road user charges, gasoline and license price increases. Such extensive measures would surely meet with adverse reactions from most, if not all, auto owners, and could thus be classified as politically risky in an auto-oriented society.

The investment required by such a shift would be mostly for additional buses, since the shift would mean a 52% increase in bus patronage.

Rail is generally contended to be very energy intensive. However, in the Edmonton-Calgary corridor region a shift from auto to either the present rail service or some of the suggested new rail services would result in an actual increase in total consumption.

In conclusion, if energy savings are desired, the best strategy is to implement TSM alternatives that affect the automobile only.

Upgraded Rail Passenger Service

If the rail passenger service is to be improved, multi-modal TSM alternatives to support the capital investment are essential. For the rail alternatives discussed here to break even, a 60% average load factor is required. Because of the low total demand in the corridor, this is probably unattainable. However, if it is implemented it would be for societal reasons rather than a profit motive, i.e. rail is more efficient than air in that it uses less total resources, and multi-modal TSM can help it achieve a respectable demand level.

The 145 km/h conventional rail service will not be discussed here, since even extensive use of multi-modal TSM will not help it to achieve a reasonable level of demand.

145 km/h. Improved Rail Service

This alternative involves a total investment of Can. $17,9 million (1974 dollars), of which $11,1 million is infrastructure and $6,8 million for locomotive hauled tilting coach trains with a top speed of 200 km/h. Club and coach car services would be offered, with airline-type on-board services. Ten runs per day would be offered and the ticket prices would be $12 for coach car and $18 for club car service, which would allow the service to break even at a 60% load factor. CBD-CBD travel time for this alternative would be 3 hours and 05 minutes at an average of 102 km/h. The line haul travel time would be 2 hours and 25 minutes at an average speed of 130 km/h. One intermediate stop is assumed at Red Deer, and the start-up year is 1983.

The following TSM support strategies are used to enhance rail's viability; 90 km/h highway speed limit, restricted landings at the downtown Edmonton airport, peak or premium fares for the air service. As well, it should be mentioned that the new Calgary air terminal will be located further away from the city, adding about 10 minutes to the air travel time. With the TSM in place, comparable BD-CBD travel times will be 1 hour and 45 minutes air, 3 hours and 05 minutes rail, 3 hours and 50 minutes auto and 4 hours and 25 minutes bus. It should be noted that the rail travel time is still somewhat excessive (for making a daily return business trip), but at least there is potential for picking up one direction of the trip.

Even though bus is still cheaper than the improved rail by about $4, it can be assumed that the savings in travel time (1 hr. 20 min.) and improved on-board services will cause all bus business travellers to switch to rail. Bus business travel is currently 18% of total bus demand, and by 1983 this would represent 73 000 intercity and 22 000 Red Deer trips, for a total diversion of 94 500 bus business trips. It is very unlikely that any other bus travellers will switch to rail, because the majority of them have very low incomes, 53% making less than $5 000 per year, and 76% making less than $10 000 per year.

Assuming that the number of landings and take-offs at the Edmonton downtown airport is restricted to its present level, the airbus will run with a 100% load factor on all its flights in 1983. Presently the load factor is close to 100% for the morning and afternoon peak periods, but the average for the service is only 50%. In practice this means that patrons are turned away and are probably flying mid-morning and in the evening. Presently 73% of total demand is represented by high-income business travellers and 10% are making connecting flights for holidays. About 43% of all air users earn more than $20 000/ year, and 62% make more than $15 000. Only 30% are making a daily round trip, leaving 70% staying over for at least a day.

In terms of why people use air, surveys have indicated that a total of 83% use it because of either convenient schedules, best connections, fastest way to destination or the only mode suitable to the travel circumstances. Since rail would be inferior on all those counts, it is assumed that these people (at least for this rail alternative) are captive to air. Thus, the potential for an air to rail switch is a maximum of 17% of total air demand.

The TSM premium air fare is assumed here to be $36 (in 1974 dollars) or three times the cost of the coach car rail service. If the 17% potential shift to rail is made up of non-business travellers, and it is assumed that the great majority of these are staying over for at least a day, then the conversion to rail should be quite high. Whereas the Edmonton-Calgary Corridor Study did not determine exactly how many would switch, additional work now being performed within Alberta Transportation indicates that about half of the 17% would switch. This gives a conversion rate from air to rail of about 8,5%, representing 84 000 persons in 1983.

These TSM strategies result in a total conversion from other common carriers to the 145 km/h improved rail service of 194 000 people, including users of the present rail service.

The total auto intercity demand will be about 2 million person trips in 1983. Of these, 700 000, or 35% are business auto trips. The most important reasons why auto business trips are undertaken are convenience of schedule, door-to-door travel time, and, to a lesser extent, the convenience of having an automobile at the destination. Thus, cost is not a factor for the business auto user. For non-business trips, the most important reason for going by car are convenience of schedule, door-to-door travel time and cost. The actual cost of going by automobile is $23 per vehicle, but the percived cost (oil and gas only) is only $14 per vehicle. Thus, with anything more than one person per automobile, the actual cost of taking the trip by car will be less than the rail fare. The door-to-door travel time for auto, as mentioned earlier, is 45 minutes slower than rail if the 90 km/h limit is imposed. However, it is very likely that as costs increase in the future, travel cost will become an extremely important factor in making a modal choice (at least for non-business group travel), and consequently little if any diversion from non-business auto to rail can be expected. Because the improved rail service offer a more convenient schedule, and its door-to-door travel time is faster, it was estimated that 1% of non-business auto, or 13 000 person trips would be diverted.

For the business auto user, the 145 km/h improved rail service can be said to be an extremely attractive offering. The rail schedule is much improved, offering 5 departures from each city daily, and the door-to-door travel time is greatly reduced. One will still not have an auto at the destination, but the Calgary terminal is in the heart of downtown, so an auto would probably not be required on one end of the trip for those persons who do business in the downtown areas. As well, even buying the comfort and servic of the club car one would be paying less than for auto, and substantially less than for air. Additional work now being undertaken by Alberta Transportation indicates that the shift from business auto would be in the order of 15% of all intercity auto business trips, at least initially. Nothing is known about whether this would be a novelty effect, or if the diversion would be stable at that level. The 15% diversion represents 105 000 person trips. Including the non-business switch, the total diversion from auto would be 118 000 person trips per year, which represent 6% of total intercity auto travel.

The total diversion to the 145 km/h improved rail service would thus be 312 000 trips per year, which works out to an average load factor of 38%. At such a load factor the rail service would still require substantial subsidies, with losses running at slightly more than $1 million/year. Even so, the implementation of this rail service will result in a more balanced corridor transportation system, the market shares being changed to 55% auto, 26% air, 9% rail, and 9% bus. If a larger diversion is desired, then TSM alternatives such as road user taxes, gasoline and license price increases, and congestion costs (increased travel times and costs) could be gradually introduced to effect a larger transfer from the automobile mode. The congestion cost alternative is particularly appropriate, in that the spine highway will experience congestion by 1983, and the 6% total diversion from auto to rail will only delay growth in auto traffic for one year.

There are two main advantages to implementing the 145 km/h improved rail alternative. First, it provides an intermediate level of service in terms of cost and travel times, and an acceptable alternative mode is available if the present air service should be curtailed or relocated. Secondly, since the 145 km/h equipment is the same as for the 200 km/h alternative, the rail service can be upgraded in the future if conditions and demand are conducive to such a strategy. It must be kept in mind, however, that TSM is an indispensable support tool to capital investment, especially in low-to-medium density corridors with a limited total demand from which to draw.

On some of the other issues listed in Table I, such as regional services, air services, and high-speed ground transportation systems, decisions need not be made soon, but they must always be taken into account in the planning and decision making process. The main action required now is the selection and reservation of a right-of-way for a high-speed ground transportation system and future highways. This can very easily be done by using a TSM alternative such as classifying the areas where these systems are most likely to be located as Restricted Development Areas, where only those developments compatible with transportation land use would be allowed. To a limited extent, this technique is already being employed by the Government of Alberta.

DISCUSSION

It has been demonstrated, through two specific examples, how TSM alternatives can be used in isolation to effect efficiencies in the transportation system and delay decision horizons, and how, coupled with a capital investment, they can be used (in this case) to reduce the risks of such investments. Many more examples can be selected from Table I, but hopefully the use of TSM has already been amply demonstrated.

In working the various alternatives listed in Table I, the authors have come to realize that the information requirements for using TSM and getting meaningful results, are much higher than what has traditionally been collected for multi-modal transportation planning. A detailed market segmentation analysis is essential, the first step being a breakdown between modal captives and those who can make a choice, and whether or not there are specific situations which make them captive for any particular trip purpose. To complement and enhance this information, knowledge about public attitudes towards the various modes, why the various modes are used for particular trip purposes and how often, perceived modal improvements that would increase demand, and travel patterns and behavior is extremely useful. This is very expensive to obtain, since extensive public attitude surveys are required, but such information will greatly contribute to the successful use of Transportation Systems Management alternatives. Furthermore, since TSM is involved with effecting efficiences and "fine tuning" in a specific system, general attitude information is often not applicable to the area being studied.

Undoubtedly, TSM is most valuable in areas where limited demand must cover a wide range of services, particularly in supporting investment decisions. However, TSM should also be very useful for high-density corridors with high total demand, particularly in making the existing system more efficient by exploiting its capacity. This was demonstrated earlier by the fact that if auto occupancy rates were improved, not only would energy consumption improve, but a multi-million dollar decision of whether or not to upgrade the spine highway could be delayed for as much as ten years. By that time, the decision may be redundant if the energy picture, the future role of the automobile, and new technology availability have been clarified.

THE FUTURE OF TSM

As capital resources become more scarce, Transportation Systems Management alternatives should become increasingly more important tools for transportation planners. Ever-increasing operating costs for the various modes also dictate that systems effeciency measures are of paramount importance for existing services.

A substantial amount of work is still required to determine systems-wide effects of multi-modal Transportation Systems Management alternatives. There is perhaps a requirement for experimentation with existing systems to get a detailed understanding of these effects, particularly as they affect the auto mode. This requires substantial understanding and good-will on the part of governments, operators and the general public, because temporary disruptions in the system would certainly occur. However, the potential pay-offs should be well worth the effort, in that considerable capital may be saved and planners would gain superior knowledge of the systems for which they are responsible.

On a more detailed, level, there seems to be considerable scope for TSM analysis of the effects of travel substitutes, particularly new communication technology such as audio-visual communication, fascimile transmission, remote commuter centres and various cable-based systems. Some work has already been done in this area, but our understanding of the issue is extremely limited. However, it is a distinct possibility that total travel (especially business travel) could decrease substantially when a mass-introduction of this technology occurs. If that is the case, and in view of the numerous other uncertainties that remain unsolved, we may even today be over-investing in our present and new transportation systems.

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