PROCEEDINGS —

Twenty-fourth Annual Meeting

Volume XXIV • Number 1 1983

TRANSPORTATION RESEARCH FORUM

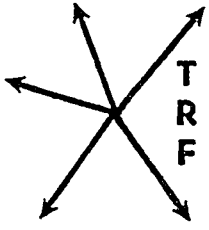
PROCEEDINGS —
Twenty-fourth Annual Meeting

Theme:

"Transportation Management, Policy and Technology"

November 2-5, 1983
Marriott Crystal City Hotel
Marriott Crystal Gateway Hotel
Arlington, VA

Volume XXIV • Number 1 1983



TRANSPORTATION RESEARCH FORUM

Road Transportation Requirements To the Year 2000

*by J. R. Sutherland** and *M. U. Hassan***

THIS PAPER presents an overview of the present and future role of the road mode in Canada with emphasis on the provincial highway system. It briefly describes the trends in road transportation demand and supply: looks at future demand and in general terms identifies the infrastructure and provincial financial requirements to the year 2000.

The private car will keep its dominant role in passenger travel which is expected to grow at 2% per year. The infrastructure will require capacity expansion on primary highways, upgrading of surfacing standards on secondary highways and timely rehabilitation and maintenance. These improvements will require estimated provincial expenditure of $6.3 billion per year (in 1982 dollars) compared to the current expenditure of $5.2 billion per year. To make best use of available funds, highway managers will have to use measures such as attempting to reduce demand, 'staging' capacity and strength improvements, making more efficient use of existing infrastructure and improving public awareness of infrastructure costs.

PURPOSE AND SCOPE OF THE PAPER

The road is the most pervasive of all transport modes in Canada. More than 80% of passenger travel occurs on roads and streets. Most of what we eat or wear moves by truck. Automobile-related industries directly or indirectly account for one job in six in Ontario and one job in seven throughout Canada. The average family spends 11% of its budget on the family car (and only 2% on other means of transportation).

Road vehicles consume nearly 80% of the energy consumed by all transportation, cause nearly 90% of all transportation deaths and account for 60% of urban air pollution.

Roads thus have critical importance in our nation's economy and lifestyle. If we are to avoid the experience of the state of disrepair of the U.S. highway system due to lack of timely investment and the resulting damage to the economy, it is important that the state of Canada's road system be seriously monitored and appropriate measures taken.

The purpose of this paper is to present an overview of the role of the road mode in Canada with emphasis on the provincial highway system. The paper briefly describes the trends in road transportation demand and supply: it looks at future demand and in general terms identifies the infrastructure and financial requirements. Some alternatives to infrastructure expansion are also briefly outlined.

Forecasting the future of roads in Canada is particularly difficult because of lack or inadequacy of data. Since almost all roads are a provincial or municipal responsibility in Canada, no national data bank of road statistics exists. Major deficiencies, inconsistencies and lack of uniformity exist in our knowledge of road transport demand and supply. The overview presented in this paper is not based on any fresh analyses of the available limited data but relies on previous studies and analyses conducted by Transport Canada supplemented, where possible, by Statistics Canada data and information obtained from various provincial departments of transportation.

PAST TRENDS IN DEMAND AND SUPPLY OF ROAD TRANSPORTATION

Trends in Demand

Passenger Travel Trends: Canadians are the most mobile nation in the world next to the Americans. Our propensity to own and use cars, and the characteristics of this use, have created demand for an extensive system of urban and rural roads totalling almost 1,000,000 km. Over the past three decades, personal disposable incomes have risen faster and the cost of owning and operating vehicles slower than general inflation—this being generally true even for the overall period since the 1973 oil price crisis. (3).

Therefore the trends in car ownership,

**Deputy Minister, Saskatchewan Highways and Transportation, Regina, Saskatchewan.*

***Assistant Director of Planning, Saskatchewan Highways and Transportation, Regina, Saskatchewan.*

travel and fuel consumption shown in Figure 1 and Table 1 come as no surprise. The car is by far the dominant means of passenger transportation, accounting for 82% of the passenger-kilometres. For intercity and rural trips, the car's share is over 90% and in large urban areas about 75%.

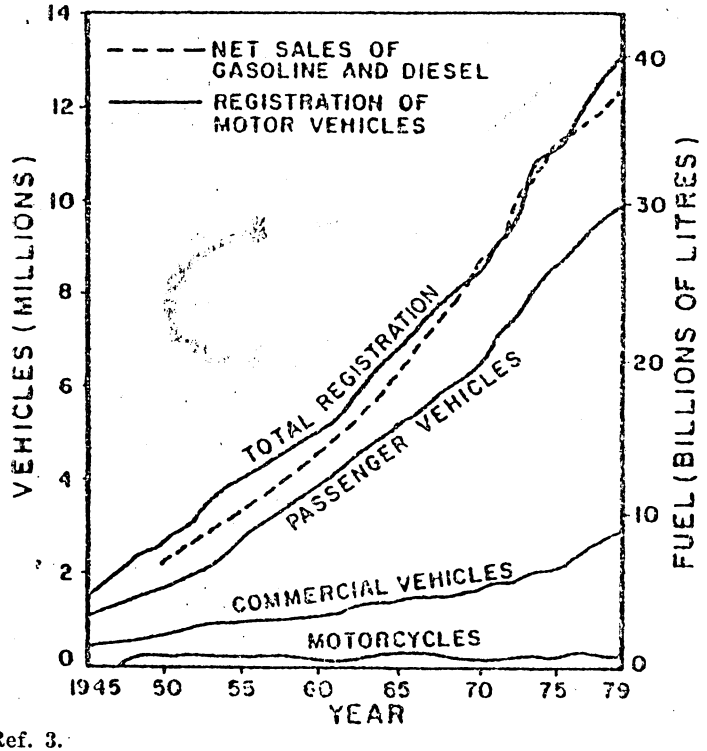
Car travel increased at an average annual rate of 4.5% during the 1970s in the country as a whole (see Table 1). Since transportation demand can have uniquely local characteristics, the growth rates for various provinces, and parts of provinces, varied widely from the national average. Reflecting the economic recession, most provinces experienced a temporary decline in travel of between 1 to 4% in 1981 or 1982.

The distribution of traffic volumes, which is an indication of demand for roads, over the entire 1,000,000 km road and street system is not available. Table 2 shows the estimated 1970 and 1980 traffic volume distribution on 61,500 km of the 'Canadian Highway System' (6.4% of the total length of roads and streets in Canada) as defined in the next section.

The total length of the system has not increased significantly, therefore the movement to the higher volume classification means that the increase in travel is being accommodated on the existing network. Greater capacity may be needed to accommodate increasing traffic volumes, particularly in and around major areas.

Traffic volume distribution on highways and roads not included in Table 2 will be different in each province, but we can assume that these roads have relatively low traffic volumes. However, the public expects a maximum of convenience, comfort and safety even on low volume roads.

Freight Movement Trends. After experiencing significant growth in market share between 1960 and 1970, the for-hire truck mode experienced an overall



Source: Ref. 3.

FIGURE 1

decrease in the number of tonne-kilometres and a significant loss of market share to the rail and pipeline modes (see Table 3).

This is a reflection mainly of the increase in both the quantities and lengths of haul of bulk commodities such as iron ore, coal, forest products, potash and grain that move by rail. However, the average revenue per tonne-kilometre for trucking is four to five times that for rail (due to shorter hauls, smaller shipments and preponderence of general cargo). Thus, for-hire trucks accounted for 47% of the total operating revenues of Canadian freight carriers (excluding pipelines compared to 38% for rail (2).

Figure 2 shows that a vast majority (88%) of the tonnage is carried internally in each of the five economic regions of the country. The figure also indicates the dominant role (56% of tonnage) of Ontario and Quebec in trucking activity.

Trucks normally constitute less than 20% of total highway traffic. Also, truck traffic is much less peaked than car traffic. Therefore, trucks are not normally a major consumer of highway capacity.

On the other hand, the number of

TABLE 1

ESTIMATED PASSENGER-KILOMETERS IN CANADA BY MODE FOR 1969 and 1979

	1969 Billions	%	1979 Billions	%	1969-79 Annual Average Increase (Decrease)	%
Automobile	160	87	250	82	4.6	
Bus and Urban Transit	5.5	3	6.3	2	1.0	
Rail	3.5	2	3.2	1	(1.0)	
Air	14.0	8	45.5	15	12.5	
Total	183	100	305	100	5.2	

Source: Based on Ref. 2.

TABLE 2

THE "CANADIAN HIGHWAY SYSTEM": ESTIMATED LENGTH BY TRAFFIC VOLUME—1979 and 1980

AADT (Vehicles per Day)	1970 %	1980 km	1980 %
less than 500	30.9	14,770	24.0
500 - 2,000	41.8	20,320	33.0
2,001 - 5,000	21.8	16,900	27.5
5,001 - 15,000	4.7	6,910	11.2
15,001 - 40,000	0.7	2,430	4.0
40,000 +	0.2	190	0.3
Total	100.0	61,520	100.0

Source: Ref. 3.

TABLE 3

FREIGHT TONNE-KILOMETERS IN CANADA BY MODE FOR 1970 and 1979

	1970 Billions	1970 %	1979 Billions	1979 %	1969-79 Annual Average Increase (Decrease) %
For-Hire Truck	52.3	11.5	42.4	6.9	(2.4)
Rail	160.6	35.3	233.8	38.1	4.3
Water	115.1	25.3	157.0	25.6	3.5
Pipeline	126.9	27.9	179.5	29.2	3.9
Air	N/A	N/A	0.9	0.1	N/A
Total	454.9	100.0	613.6	100.0	3.4

Source: Ref. 3.

axle-weights of trucks determine the pavement thickness required. Overweight trucks are a major cause of pavement deterioration.

Trends in the Supply of Road Infrastructure

System Size. In terms of jurisdiction of the road mode, the provincial governments provide infrastructure and regulate the road motor vehicle transport. Municipal governments play a similar role although the infrastructure supply is much more pronounced. The federal government regulates vehicle energy efficiency, safety and exhaust emission standards and can be considered to be responsible for infrastructure supply in national parks, Indian Reserves and the Yukon and Northwest Territories.

To fulfill the rising demand for road infrastructure, the length of roads and streets in Canada increased from 600,000 km in 1945 to 960,000 km in 1980 (see Figure 3). More importantly, over the same time period the length of paved roads increased ten-fold from 30,000 km to 300,000; two-thirds of this increase occurred since 1960. These figures suggest that the Canadian road system is relatively mature in terms of length and, except for roads to resources, the current and likely future demand is generally not for system extension but for wider, safer, stronger and more comfortable paved roads.

Table 4 shows the jurisdictional road lengths (provincial, urban or rural municipal and federal) in each province and territory. Overall, 33% of roads are provincial, 11% urban municipal, 54% rural municipal and 2% federal. (Of the 300,000 km of paved roads, an estimated 180,000 km (60%) are provincial and the remainder municipal). However, the jurisdictional split and financial responsibilities vary from province to province. For example, the Atlantic Provinces are responsible for all roads in their boundaries except those in certain urban areas. On the other extreme, in Ontario and the Prairie Provinces the provincial governments are responsible for only a tenth to a fourth of the roads. All provinces provide some degree of assistance for municipal roads. (For details see Ref. 3.)

In addition to having different institutional and financial responsibilities, the provinces use differing road classifications. Therefore it is difficult to designate a 'national' highway system. A recent Transport Canada Study (3) defined 61,500 (6.4% of the public roadways in Canada), as the "Canadian Highway System" linking major population centres, resource areas, defence establishments and recreational 'nodes.' The study defined 25,500 km as primary highways, (shown in Figure 5), 23,500 km as secondary and 12,500 km as access highways. These definitions would not necessarily agree with those of individual provinces. Estimated lengths by standards are: 5,700 km four-lane paved, 46,100 km two-lane paved, 8,900 km gravel and 800 km seasonal. Traffic volumes in 1970 and 1980 are shown in Table 2.

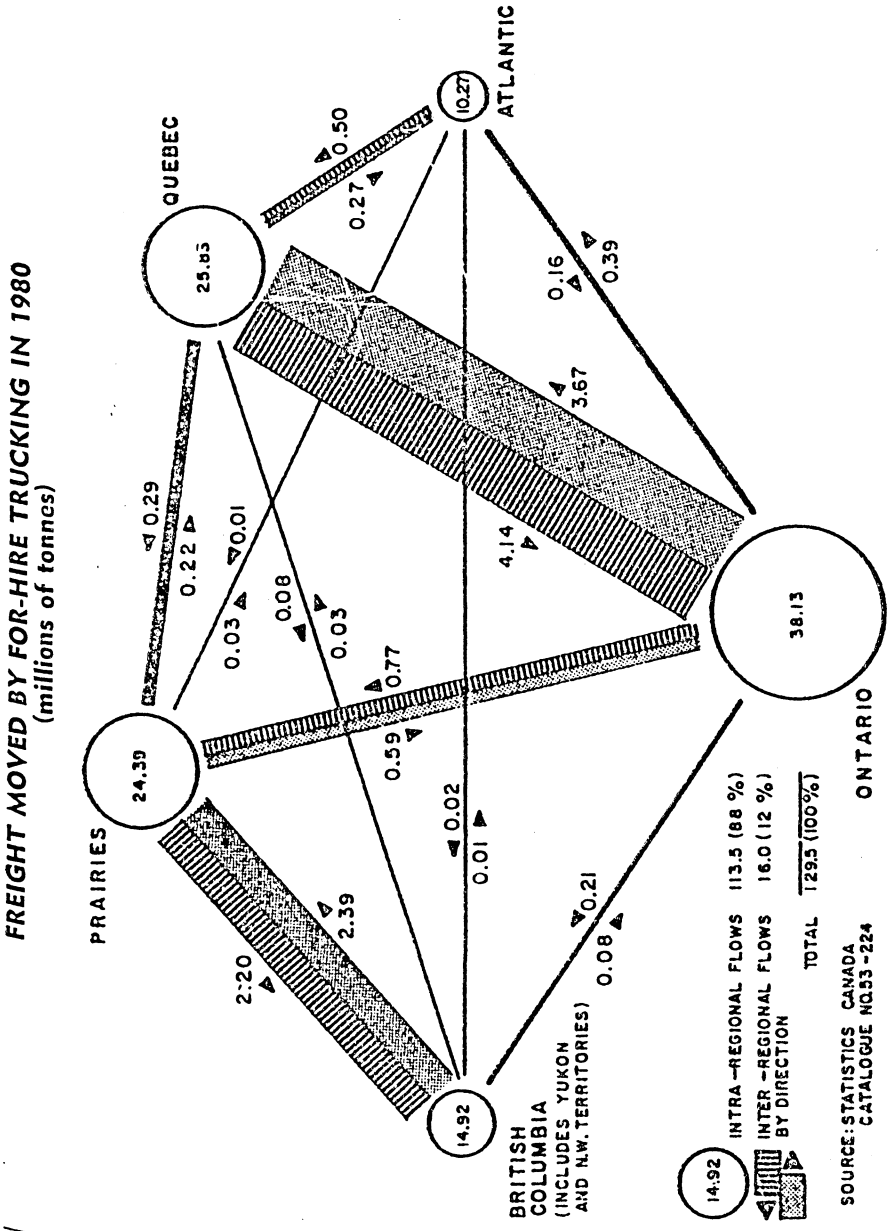


FIGURE 2

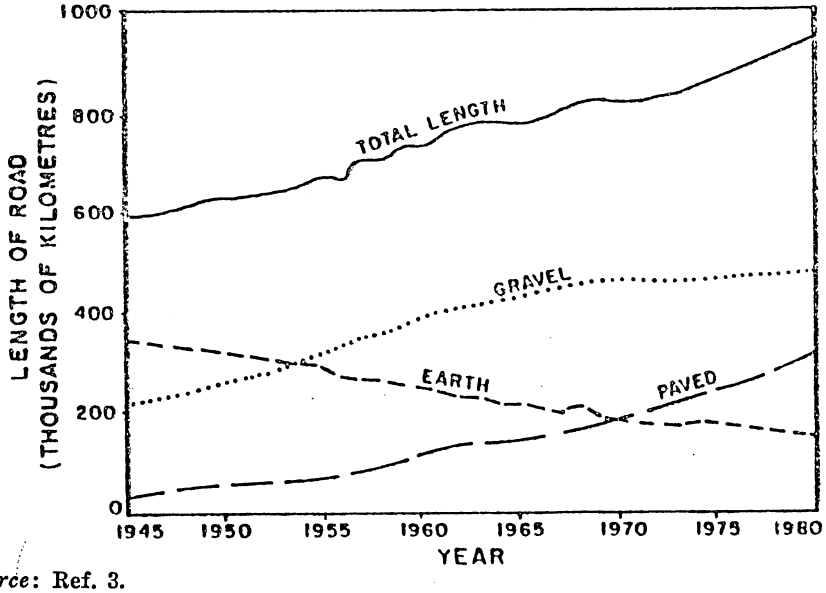
Infrastructure Expenditure Trends. Transportation costs are incurred by the agencies that provide, maintain and administer the infrastructure and by the owners of the vehicles using it. Table 5 shows the infrastructure and 'vehicle' costs for air, marine, road and rail modes in Canada in 1979. Also shown are the revenues earned by all government levels from air, marine and road-related fuel taxes (if levied), registration fees, etc.

Some interesting conclusions can be drawn from Table 5:

(a) The road mode accounts for 77% of the total cost of transportation in Canada.

(b) Out of the total road mode costs of

LENGTH OF PUBLIC ROADS AND STREETS 1945-1980



Source: Ref. 3.

FIGURE 3

TABLE 4

ESTIMATED PUBLIC ROAD LENGTHS AND ADMINISTRATIVE JURISDICTIONS IN 1981

Jurisdiction / Province	Provincial Government[1] km	%	Urban Municipalities km	%	Rural Municipalities km	%	Federal Government km	%	Total km	%
British Columbia	45,800	68.9	8,800	13.2	9,200	13.8	2,700	4.1	66,500	100
Alberta	27,500	16.3	14,500	8.6	123,000	72.8	3,900	2.3	168,900	100
Saskatchewan	23,000	11.1	8,000	3.9	174,000	84.0	2,200	1.0	207,200	100
Manitoba	21,400	23.3	5,700	6.2	64,000	69.5	900	1.0	92,000	100
Ontario	32,900	18.9	34,700	19.9	105,000	60.2	1,700	1.0	174,300	100
Quebec	104,700	61.5	20,000[2]	11.8	45,000[2]	26.4	500	0.3	170,200	100
New Brunswick	25,200	84.3	4,400	14.7	-	-	300	1.0	29,900	100
Nova Scotia	26,100	91.6	2,100	7.4	-	-	300	1.0	28,500	100
Prince Edward Island	5,000	87.7	600	10.5	-	-	100	1.8	5,700	100
Newfoundland	10,900	75.2	3,300	22.8	-	-	300	2.0	14,500	100
Yukon	-	-	-	-	-	-	4,300	100	4,300	100
Northwest Territories	-	-	-	-	-	-	2,900	100	2,900	100
Total	322,500	33.4	102,100	10.6	520,200	53.9	20,100	2.1	964,900	100

1) Roads administered by provincial departments or agencies.
2) Rough estimate from Ref. 3.

Source: Ref. 3, 7.

TABLE 5

TRANSPORTATION INFRASTRUCTURE COSTS AND REVENUES AND VEHICLE COSTS FOR VARIOUS MODES IN CANADA IN 1979 (using book values)

(Millions of Dollars)

Mode	Infra-structure Costs	Vehicle Costs	Total Modal Costs	Modal Costs as a Percent of Total Transport Costs (%)	Gross* Govern-ment Revenue	Gross Revenues/ Infra-structure Cost Ratio (%)
Air	819	3,241	4,060	7	378	46
Marine	901	3,476	4,377	8	251	28
Road	6,034	38,667	44,701	77	3,237	54
Rail	1,308	3,913	4,769	8	N/A	N/A
Total	9,062	48,577	57,907	100	N/A	N/A

*Gross revenue denotes revenue earned by any level of government from a given mode even though the expenditure may be incurred by another level of government.

Source: Based on Ref. 17.

$44.7 billion, nearly 87% are incurred in vehicle costs and only 13% in infrastructure costs. Thus, improvements in capacity, geometrics, rideability and strength that may proportionately reduce the vehicle costs would obviously be beneficial from a total societal viewpoint.

(c) Road-related revenues covered 54% of infrastructure costs which was a greater proportion than for air (46%) or marine (28%). The remainder was financed from provincial or municipal government general taxation.

In 1979 the total road infrastructure costs were borne: 63% by provinces, 31% by municipalities and 6% by the federal government. The provinces are thus by far the major providers of road infrastructure.

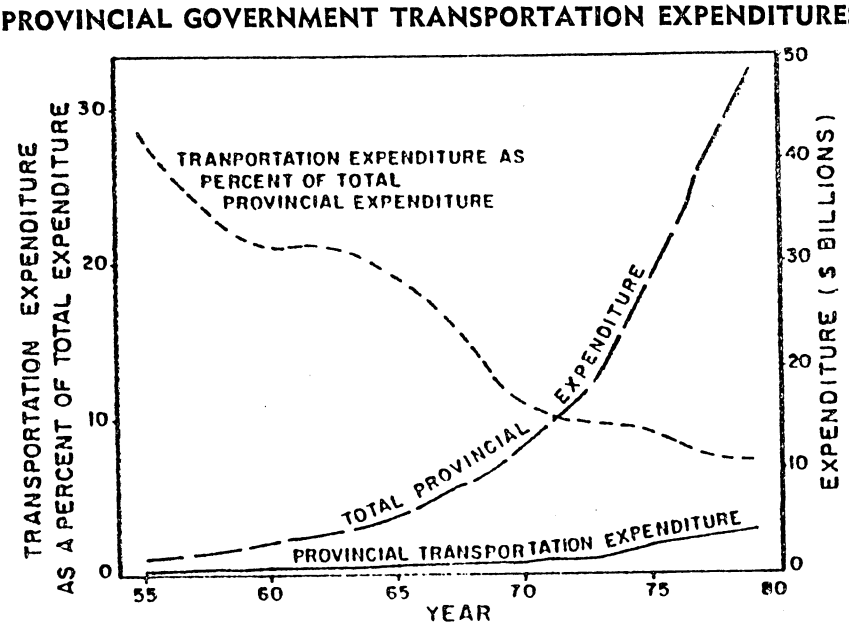
As shown in Figure 4, while provincial expenditure on transportation increased steadily in absolute terms, the transportation proportion of total provincial expenditures decreased from an average of almost 30% in 1955 to 7% in 1979 (there were large variances from province to province). This is mainly a reflection of other expenditures taking priority over transportation and partly of a maturing highway system. In 1955 transportation was the single largest item in provincial budgets. By 1961 the cost of education had overtaken transportation; health accomplished that in 1965 and social welfare programs in 1971 (3).

During the 1970s, highway construction expenditure costs in Canada increased much faster than capital expenditures. Most provincial highway agencies have experienced a significant reduction in actual capital work and have had to allocate an increasing proportion of the total budget to maintenance, a trend likely to continue. Even with that, maintenance costs have shown a slight decrease in real terms (1).

FUTURE DEMAND AND SUPPLY

Demand Forecast

Transport Canada's recent macroeconomic forecasts, as reported by Mayes and Welch (7), indicate that the overall outlook for the Canadian econ-



Source: Ref. 3.

FIGURE 4

omy to the year 2000 is fairly good. After a gradual recovery in 1983 and 1984, the growth will be strong from 1985 to 1990 and moderate from 1990 to 2000. The personal disposable income per capita is forecast to increase 2.5% per year between 1985 and 1990 and 2.1% per year between 1990 and 2000. The price of oil will show a slight decline in real terms to 1990 after which it will start increasing.

These factors and expected improvement in vehicular fuel economy will mean the rate of increase in vehicle operating costs would not be much higher than general inflation rate to 1990 and perhaps even to 2000.

The population of car drivers and first-time car owners is expanding. This, coupled with the high growth rate of household formation (mostly in urban areas) and small family size will result in the growth of car ownership of about 2% per year to 1990 (6).

Thus, to the year 2000, intercity rural and urban passenger travel will be dominated by the automobile.

Based on somewhat different macroeconomic assumptions, Transport Canada in early 1982 had forecast an annual average growth of 2.1% in car-person trips and 2.3% in bus-person trips between 1980 and 1991 in Canada as a whole, with wide variation among regions (15). Passenger travel in the Prairies was forecast to grow 4.1% per year to 1991 compared to 2.2% per year in Quebec.

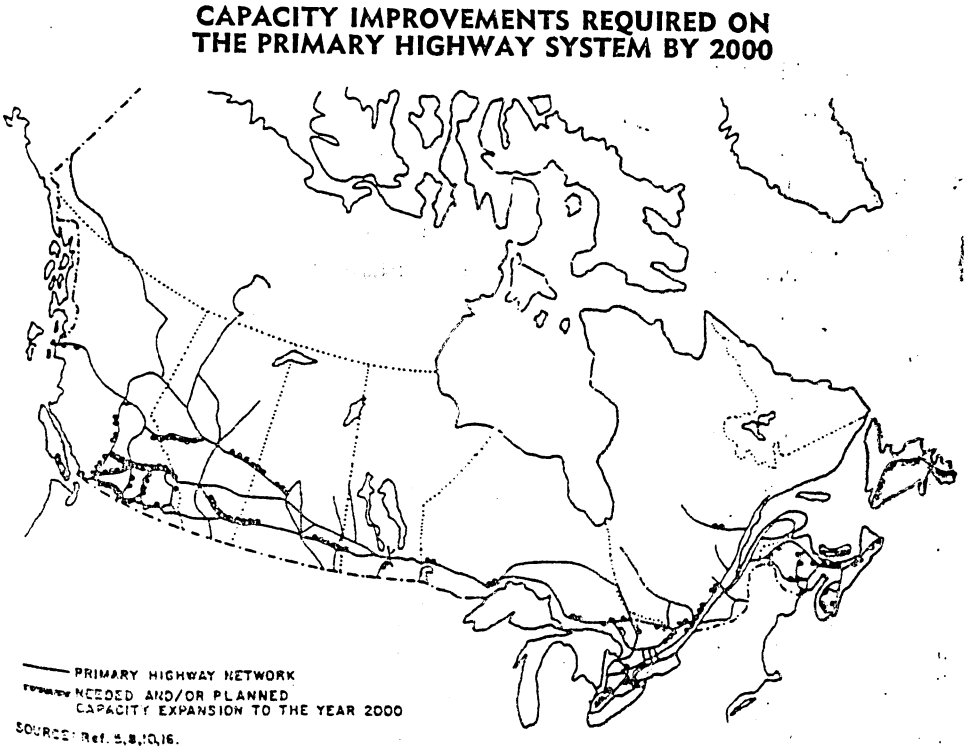
For-hire truck traffic was forecast to increase at an average annual rate of 2.4% for Canada, 1.7% for Ontario and Quebec and 3.7% for the rest of the country.

In view of the 1981 and 1982 decline in travel, these forecasts appear high. However, most of the provincial transportation officials believe this decline to be temporary and that travel will resume growth as the economy recovers. The forecast rate of increase of just over 2% per year seems plausible compared to 4.5% during the 1970s.

Between 1990 and 2000 freight traffic will grow perhaps less rapidly. However, passenger traffic should remain quite strong in view of the continued moderate growth in real disposable income and the demographic characteristics mentioned above.

Future Infrastructure Requirements

The major future requirements for provincial road infrastructure can be



Source: Ref. 5, 8, 10, 16.

FIGURE 5

categorized as: a) expansion of capacity on primary highways by widening, twinning, realignment, b) pavement rehabilitation to restore strength and riding comfort, c) upgrading of surfacing standard secondary highways, d) system extension by construction of new links to serve new developments, and e) provision of maintenance to provide acceptable rideability.

Most provinces prepare five-year capital improvement programs. Ontario is perhaps the only province that prepares a proposed 20-year plan. Highway planning and needs studies to the year 2000 are not available on a consistent basis for the entire country. Transport Canada has collaborated with the Prairie and Atlantic provinces in recent years to study primary highway system needs (5, 16). Detailed future highway plans are kept confidential in most provinces. Because of that and of this paper being a general overview, the following is a sketchy outline of the future infrastructure requirements compiled from published reports and discussions with some provincial officials.

Capacity Expansion on Primary Highways

Figure 5 gives a general view of the primary highway links considered deficient or that will become deficient in capacity by the year 2000. The figure has been compiled from disparate sources as discussed below; original sources should be consulted for details.

Western Provinces. Table 6, based on the Pacific Rim Study, shows that of the 12,024 km defined as primary highways in the four Western Provinces, 67% operated at level of service A or T, 19% at C. Only 14%, 1,623 km in British Columbia and the National Parks were deficient in capacity with a level of service D or lower.

Although Table 6 shows that the primary highways in Alberta, Saskatchewan and Manitoba were not considered to be capacity deficient, discussions with

TABLE 6

LEVEL OF SERVICE BY CATEGORY AND WESTERN PROVINCES, 1976

Level of Service	B.C. km	%	Nat. Parks km	%	Alta. km	%	Sask. km	%	Man. km	%	Total km	%
A	–	–	6	–	980	34	1,384	61	872	77	3,243	27
B	1,955	37	89	24	1,759	61	819	37	249	22	4,852	40
C	1,971	37	109	30	159	5	50	2	16	1	2,306	19
D	772	14	142	39							929	8
E	563	10	10	3							573	5
F	108	2	13	4							121	1
	5,369	100	369	100	2,898	100	2,253	100	1,137	100	12,024	100

Source: Ref. 16.

transportation officials in these provinces indicate that, due to strong public pressures, it is probable that the Trans-Canada Highway will be a four-lane divided highway across Manitoba, Saskatchewan and Alberta by the year 2000. British Columbia also propose to twin or provide passing zones on the portion between Golden and Merritt.

The Alberta government is also committed to twinning the Yellowhead Highway. The Saskatoon to Lloydminster portion of the Yellowhead in Saskatchewan will probably see some twinning before the year 2000.

Ontario. The expansions needed and planned in Ontario are too numerous to list here (8). In general, the planned improvements are widening of the freeways and highways in the southwestern region, extension of freeways to Parry Sound and toward North Bay and numerous widenings or twinning projects near urban areas.

Maritime Provinces. The recently completed Maritime Provinces Primary Highway System Needs Study: 1981-2000 (5) identified capacity, strength and rideability deficiencies in 2000 based on a moderate traffic growth. Table 7 indicates that by the year 2000, out of the total primary system length of 3,467 km, 1,076 km (31%) will be deficient in level of service, 992 km (29%) in pavement strength and 1,478 (43%) in rideability. It will require over $1.4 billion (1982 dollars) by 2000 to correct the deficiencies.

Quebec, Newfoundland. No updated information could be obtained for Quebec and Newfoundland. The deficiencies indicated in Figure 5 for these provinces are based on Ref. 10.

Future Expenditures for Capacity Expansion. Without costing individual projects, it is almost impossible to estimate the total future financial requirements for road infrastructure to the year 2000. In 1975 Transport Canada had forecast an expenditure of $9 billion over 15 years ($0.6 billion per year) required for expanding the capacity of deficient links on the primary highway system (10). This translates into approximately $1 billion per year in 1982 dollars. A comparison of Figure 5 with the deficient links identified in the 1975 Transport Canada study indicates that this level of expenditure will probably have to be sustained to the year 2000 to upgrade capacity deficient links.

Pavement Rehabilitation

Pavement rehabilitation is required to restore strength or rideability. An assessment of the strength and rideability deficiencies on all primary highways is not available. Discussions with various highway officials indicate that due to lack of funds, a backlog of required pavement rehabilitation is building up in all provinces.

If we assume an average life of 15 years for pavements, then one-fifteenth of the 100,000 km of paved provincial

TABLE 7

MARITIME PROVINCES PRIMARY HIGHWAY SYSTEM DEFICIENCIES IN THE YEAR 2000

Province	Length km	No. of Kilometres of Deficiencies: Level of Service L of S<LevelC	Pavement* Strength (Def.>0.045)	** Rideability (R.C.I.≤5.5)	Cost of Correcting Deficiencies ($ Million - 1982): Level of Service	Pavement Strength	Rideability	Total Cost
New Brunswick	1,774	449	695	380	449	122	38	69
Nova Scotia	1,229	550	65	943	563	7	73	643
Prince Edward Island	464	77	232	155	76	63	16	155
Total Maritime Provinces Highway System	3,467	1,076	992	1,478	1,088	192	127	1,407

*Pavement strength is depicted here as the number of kilometres of highway deficient in pavement strength excluding certain sections of highway with level of service deficiencies.
**Rideability is depicted here as the number of kilometres of highway deficient in riding comfort excluding certain sections of highway with level of service and strength deficiencies.

Source: Ref. 5.

roads in Canada, i.e. 12,000 km, should be rehabilitated each year. At an average cost of $80,000/km in 1982 dollars, this would amount to nearly $1 billion per year indefinitely.

Upgraded Standards On Secondary Highways

All highway departments are familiar with public demands to get them "out of the dust." This pressure to pave gravel roads and to generally upgrade the standards on secondary (collector and local) highways is likely to continue.

The Canadian Highway System Study (as reported in Ref. 11) estimated that 63% of provincial highway expenditures between 1972 and 1982 would occur on the primary highway network and the remaining 37% on the secondary system. This ratio would vary among the provinces. In Saskatchewan, for example, nearly 75% of the capital budget for rural highways was spent on secondary highways in the five-year period 1976-81.

Estimates on future provincial expenditures on secondary highways are not available. If we assume that 60:40 ratio of primary and secondary highway expenditure will continue to the year 2000, and apply it to the projected $1 billion in primary highway capacity expansion, the estimated expenditure on secondary highways would be $40 \div 60 \times \$1$ billion equalling $670 million per year. This expenditure level is quite plausible when we compare it to the history of activity on secondary highways. As shown in Figure 3, the length of paved roads increased at approximately 10,000 km per year between 1960 and 1980. If we assume that the future average rate of reconstruction of gravel secondary highways to paved standard would be only 3,000 km per year at an estimated 1982 cost of $200,000/km for grading and paving, then the cost to highway departments would be $600 million per year. Other improvements to the secondary system would be in addition to this sum. The above two calculations suggest that an annual expenditure of $0.7 billion on secondary highway upgrading to 2000 would not be out of line.

New Links

Most of the new highway links to be built by the year 2000 will be in northern areas to service mineral or industrial development. Examples include extensions to and off the Dempster and Mackenzie Highways in the Northwest Territories and Yukon and resource development roads in northern areas of British Columbia, Alberta and Saskatchewan. Also, construction of the cut-off between Hope and Merritt in B.C. will extend the divided highway from Vancouver to Merritt. An interior island highway on Vancouver Island is also being considered.

Beyond the year 2000, one can perhaps expect completion of the Quebec-Labrador-Newfoundland Highway, new freeways in Montreal and Toronto area such as Highway 407 to Peterborough.

Summary of Future Financial Requirements

Table 8 presents a summary of the estimated future annual requirements for provincial expenditure on transportation to the year 2000. The estimated 1981-82 expenditure is also shown.

On the assumption that the transfer payments and non-highway expenditures would not increase, and that operation and maintenance expenditure will on average be somewhat higher than present levels, Table 8 shows that gross provincial expenditure of $6.3 billion per year (1982 dollars) will be required to the year 2000, compared to a 1981 actual expenditure of $5.2 billion indicating a shortfall of at least $1 billion per year for highway expenditure, excluding the cost of extension to the highway system. In other words, provincial highway funding needs to be increased by at least 20% in real terms over present expenditure level.

Based on past expenditure trends, the municipal governments will require an additional $3 billion per year, and the federal government about $0.5 billion per year for the road mode.

These figures are a guesstimate but do indicate that very large investments will have to be made in our road system over the next 20 years. In view of the economic conditions and the demand for funds for social programs, provincial highway budgets are not likely to be increased to meet the forecast road needs.

No attempt was made to forecast the financial requirements for vehicles. It

TABLE 8

SUMMARY OF GUESSTIMATED ANNUAL PROVINCIAL FINANCIAL REQUIREMENT FOR TRANSPORTATION INFRASTRUCTURE TO THE YEAR 2000

Type of Work	Estimated 1981-82 Expenditure (billions of 1981 dollars)	Guesstimated Annual Requirements to 2000 (billions of 1982 dollars)
Provincial Highways		
Capital		
System Extension	not available	N/A
Capacity Expansion on Primary Highways		1
Upgrading of Secondary Highways		0.7
Rehabilitation		1
Sub-total Capital	1.94	2.7
Operations and Maintenance	1.60	1.8
Total Provincial Highways	3.54	4.5
Transfer Payments (to municipalities)		
Roads	0.66	0.7
Transit	0.69	0.7
Air, Water and Rail Modes	0.35	0.4
Total Transportation Expenditure	5.24*	6.3

*Includes $0.14 billion of federal contributions.

Source: Ref. 13 for 1981-82 expenditures.

can be presumed that, in view of rising real incomes, people will be able to afford to buy and operate cars, and that tracking companies will have enough capital to replace their rolling stock every 10 years or so.

ALTERNATIVES TO INFRASTRUCTURE CAPACITY EXPANSION

General

It is by now obvious that money will not be available to fulfill all demands for road infrastructure. Methods to increase road revenues such as higher gasoline taxes (e.g. the recent five cents per gallon increase in U.S. federal tax) and higher registration fees are not likely to be popular. In fact, Alberta and Saskatchewan removed their gasoline taxes in 1978 and 1982, respectively. Also, too high a gasoline tax may create equity problems requiring rebate mechanisms for low income groups. In any event, these measures are political decisions and generally out of control of highway managers.

However, highway managers can present a better case for more funds for highway improvements by making the public and the political decision-makers more aware of the economic importance of good highways. In this vein, a recent U.S. Department of Transportation study (19) concluded with deteriorating highway performance would "reduce the economic welfare of the nation in terms of higher prices and lower levels of production, employment, disposable income, consumption and productivity" and would divert resources away from desirable sectors of the economy.

To make best use of the available funds, the highway manager will have to use a combination of: a) 'staging' the provision of capacity and strength; b) reducing demand, particularly in the peak period; c) making more efficient use of existing infrastructure; and d) making the public more aware of the costs of road infrastructure with a view to moderating their demands.

Staging

Studies in Alberta have shown that provision of strategically located passing zones on two-lane highways will help delay twinning for a considerable time. This approach is not new. Climbing lanes and passing zones are frequently used in mountainous terrain. Their value on relatively high volume highways in flat terrain will perhaps depend upon public perception of their safety.

Staging of pavement thickness offers another means of effective use of available funding. By initially building a thin pavement (say N-5) and then overlaying it as and when warranted will avoid cases where an N-15 or N-20 pavement would be overdesigned for much of its life. Thinner pavements likely will be more expensive to maintain. However, economic analyses based on Saskatchewan's experience with staging of pavement thickness show it to be cheaper than non-staging on a life cycle cost basis. Indeed, on thousands of kilometres of Saskatchewan highways with low volumes (less than 600 AADT) very thin (20 to 50 mm asphalt mix mat on subgrade) have provided an acceptable quality of service, albeit requiring extensive maintenance.

Reduction of lane or shoulder width on low volume roads is another cost saving method worth considering.

Reducing Transportation Demand

In the short term, few practical measures are available for reducing the demand for highway travel. A significant shift to bus or rail cannot be expected for reasons discussed earlier. Even the shift of a small proportion of car travellers to rail or bus would require enormous increase in the capacity of these latter modes—something that cannot be achieved quickly.

A shorter work week and staggering of working hours has already been shown to spread out the peaks on highways near cities. Higher weekend fees at parks and campsites may help encourage weekday use of such facilities and thus reduce the weekend peaking. Piggybacking will remove some trucks from intercity highways but not from urban roads. Prohibition of recreational vehicles from certain highways during certain times would help even out the peaks but may not be acceptable to the public.

Some of the longer term measures for reducing highway travel demand that may be necessary by 2000 are:

—Some fixed costs of car use may be converted to variable costs, e.g. insurance could be charged on a per kilometre basis.

—The pattern of summer and school holidays could be changed to even out the summer peaking of highway traffic.

—Renting/leasing and shared car ownership (automobile cooperatives in Sweden) could reduce car ownership and use (6).

—Road pricing (tolls) or higher fuel taxes would either be relatively ineffective or unacceptable to the public.
—Substantially reduced speed limits would not be acceptable to the public either.
—Although the sprawl of our urban areas and the development of bedroom communities are facts of life in Canada, an attempt to keep urban areas compact would reduce the congestion on nearby highways.

Making Better Use of Existing Infrastructure

General. "Transportation System Management" types of improvement (such as one-way streets, contra-flow lanes, traffic signal coordination, car pooling and parking management) have been successfully applied in urban areas to increase the utilization of existing street space. Few of these measures can be applied to rural highways.

Any shift to high-occupancy vehicles such as buses, or increasing the occupancy of cars, or using trucks that can carry more freight per vehicle will make better use of the road capacity. The unlikelihood of a shift of car users to buses was discussed earlier.

Truck Weights and Dimensions. Improvements are being made in truck design to reduce tare weight resulting in improved economy, payload gains and productivity. Examples include use of lighter materials and use of the double draw bar dolly converter for combination vehicles thus removing one point of articulation in the A-train configuration.

Improved operating efficiency can be obtained through computerization, consolidation of terminals and routes, automated terminals, intermodal terminals and containerization.

In the future, increased productivity within a framework of given regulations and a greater shipper flexibility should favour a gradual increase in the use of multiple trailers. Public opinion, pavement and bridge requirements and safety considerations will be the factors retarding the growth to longer vehicles.

Vehicle weight regulations are being studied by a national committee of Roads and Transportation Association of Canada and the Canadian Council of Motor Transport Administrators in hope of developing uniform regulations. In Western Canada considerable uniformity has been achieved and the provinces are trying to improve this even further. However, each provincial infrastructure has built-in constraints in bridges which cannot be overcome quickly.

In order to make better use of existing infrastructure through changes in technology and regulations, development of close liaison and cooperation between the motor vehicle and trailer manufacturing industry, trucking companies and the regulating agencies in research, development and settling of regulations is of utmost importance.

Most provinces have attempted to address vehicle weight and dimension regulations with a view to maximizing efficiency in cooperation with the transportation industry. An example is Saskatchewan's winter weight policy. Initially secondary highway weights were increased to allow primary highway weights during the winter period. This change provided an economic benefit of nearly $3 million per year to the trucking industry with no appreciable increase in pavement damage. In the second stage, the weights on the primary highways were increased by 10% on all axles except the steering axles and for all vehicles except for combination vehicle trains which are at the overall maximum gross vehicle weight. On a standard semi-trailer unit this results in an increase of 3,200 kg in payload without any increase in damage on the highway pavements. For a secondary highway this means a total increased payload of 6,200 kg. The second stage is expected to yield even greater economic benefits to trucking.

Another example of industry cooperation is Saskatchewan's bulk commodity policy. Under this policy, any manufacturer shipping 30,000 t or more per year can enter into an agreement with the government whereby he is allowed special vehicle dimensions and weights, provided he pays incremental road damage costs this haul causes to the highway system. Some stringent safety requirements for vehicles and operators must be met. Where the haul is deemed competitive with rail, the incremental cost is deemed to be the total cost of the haul. The government may absorb part of the cost if there is a large direct economic benefit to the province. If the haul is not deemed competitive with rail, then the cost is only the incremental cost incurred over the damage which could result if the movement took place at regulation loadings.

Improved System Management. Highway managers can effect economies and make better use of the infrastructure by implementing measures such as more cost-effective methods of road construction and maintenance, substitution of

asphalt pavements by granular pavements on low volume roads, reduction in the number of overweight trucks by stricter enforcement and implementation of better management information systems, e.g. pavement management system.

A well-designed pavement management system can help decide the optimum rehabilitation and maintenance strategies to save money and at the same time provide a better service on paved highways.

Public Awareness. The Canadian public expects and has been willing to pay for a high level of service on our roads. This ability to pay is diminishing without a corresponding lessening of expectations. For example, governments in the Prairie Provinces have been under strong public pressure to twin highways at 3,000 AADT. Perceived safety hazards of two-lane highways have often been cited as reasons.

In view of shrinking budgets, highway managers will have to devise ways to inform the public of the costs of highway improvements and present the public and the political decision-makers with a range of alternative solutions, showing the cost-effectiveness and pros and cons of each in a simple manner. For example, twinning a highway is perhaps the least cost-effective means of reducing traffic deaths and mandatory safety belt usage the most cost-effective.

SUMMARY AND CONCLUSIONS

This paper has presented an overview of the present and future role of the road mode in Canada with emphasis on the provincial highway system.

The major points or conclusions in the paper are:

1. The private car carries more than 80% of passenger travel in Canada. For-hire trucks are the dominant mode for short-haul general freight. These roles of the car and truck will be maintained beyond the year 2000.
2. Car travel which grew at an average annual rate of 4.5% during the 1970s is expected to grow at just over 2% per year to 2000.
3. For-hire truck tonnage is forecast to increase by 2.4% per year to 1990 and somewhat less rapidly after that.
4. Provinces bear 63% of the road infrastructure costs, municipalities 31% and the federal government 6%. Provinces will continue to be the major providers of road infrastructure in the future.
5. Infrastructure requirements on provincial highways and roads to 2000 are forecast to entail: capacity expansion on primary highways costing $1 billion per year 1982 dollars); pavement rehabilitation—$1 billion; upgrading of standards on secondary highways—$0.7 billion; and operation and maintenance—$1.8 billion. Cost of any extension to the highway system will be in addition. Allowing for expenditure on other modes and for transfer payments to municipalities, $6.3 billion per year will be required for gross provincial expenditure on transportation. Compared to the 1981 expenditure of $5.2 billion, this represents a shortfall of at least $1 billion or 20%.
6. To make best use of available funds, highway managers will have to use measures such as: a) 'staging' of highway capacity and strength; b) reducing demand particularly in the peak periods; c) making better use of existing facilities by improvements in infrastructure and vehicle technology, uniform truck weights and dimensions and implementation of pavement management systems; and d) making the public more aware of the costs of highways with a view to lessening their expectations.
7. Major deficiencies, inconsistencies and lack of uniformity exist in our knowledge of road transport demand and supply in Canada. A major cooperative effort is required to first establish a national 'bank' of existing statistics and then to bring about uniformity in classification, vehicle standards and accounting systems and provinces.

REFERENCES

1. Barton, R. Highway Expenditures and Trends in Canada During the 1970's, RTAC Forum, Vol. 3, No. 2:77-81, 1981.
2. Canadian Transport Commission. Transport Review: Trends and Selected Issues, 1981. Ottawa, 1981.
3. DelCan Ltd. A Profile of the Canadian Highway System—1981, Ottawa, Transport Canada, 1982.
4. Energy and Mines Canada. Transport Energy Data Book, Report No. TE-82-5, Ottawa, 1982.
5. Federal-Provincial Maritime Provinces Transportation Planning Committee. Maritime Provinces Primary Highway System Needs Study (1981-2000), Ottawa, Transport Canada, 1983.
6. Khan, A. M. Future Role of the

Automobile in Canada, Report No. TP3759, Transport Canada, Ottawa, 1982.
7. Mayes, R. R. and Welch, J. R. Transportation Energy Requirements to the Year 2000, Proceedings, Canadian Transportation Research Forum Conference, Regina, Saskatchewan, June 1983.
8. Ministry of Transportation and Communications. 'Provincial Highways Long-Range Plan 1983-1987,' and 'Future Perspectives, Provincial Highways 1981-2001,' Toronto, 1983 and 1981.
9. Roads and Transportation Association of Canada. Highway Statistics Project Committee Final Report, Ottawa, 1982.
10. Transport Canada. An Interim Report on Freight Transportation in Canada, Ottawa, 1975.
11. Transport Canada. An Interim Report on Intercity Passenger Movement in Canada, Ottawa, 1975.
12. Transport Canada. Canadian Freight Transportation System Performance and Issues, Report No. TP3010E, Ottawa, 1981.
13. Transport Canada. Federal and Provincial Government Transportation Expenditures by Province 1974-75 to 1981-82, Report No. TP2726, Ottawa, 1982.
14. Transport Canada. The Future of the Automobile in Canada, Report No. TP1148, Ottawa, 1979.
15. Transport Canada. Transport Canada Freight and Passenger Forecasts, 1982, Ottawa, 1982.
16. Transport Canada. Pacific Rim Highway Access Study, Phase I, Report No. TP1639, Ottawa, 1978.
17. Transport Canada. Transport Costs and Revenues in Canada 1969-1979, Report No. TP3737E, Ottawa, 1982.
18. Science Council of Canada. Transportation in a Resource-Conscious Future: Intercity Passenger Travel in Canada, Ottawa, Ministry of Supply and Services, 1982.
19. Butler, S. E. et al. Highways and the Economy, Report No. SS-42-U9-1, Cambridge, Mass., U.S. Department of Transport, January 1983.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance and cooperation of officials of various provincial departments of transportation and Transport Canada. The views expressed in the paper are those of the authors and do not necessarily represent the views or policies of provincial or federal governments.