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THE COST EFFICIENCY OF INTERCITY RAIL AND BUS TRANSPORTATION

IN THE

QUEBEC CITY - WINDSOR CORRIDOR

BY

MARTHAND NOOKALA, B.TECH.

(REGIONAL ENGINEERING COLLEGE, WARANGAL, INDIA)

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ABSTRACT

This study was undertaken to determine the cost-efficiency of selected high speed rail and bus technologies for the Quebec - Windsor corridor routes. An examination of rail and bus developments in Canada was made. Problems with the Conventional train are discussed and the variables that affect the cost of operation are identified for both rail and bus technologies.

A system of eight intercity links for rail and six links for bus technology were selected for location analysis. The cost-efficiency of Bi-level Rail Car (BRC), Self Propelled Vehicle - 2000 (SPV-2000), and the Light, Rapid and Comfortable train (LRC) were calculated by using the Route Supply Model and compared with that of the Conventional train. Cost efficiencies of Articulated bus, Double Deck bus, Articulated Double Deck bus (Jumbo bus) along with the Standard bus were estimated by using the Route Supply Model and Incremental Supply Model. Estimates of cost of operation, cost per train.km/bus.km and cost per seat.km were obtained on a system basis as well as on a link basis.

The results show that the BRC, as compared to other technologies produces lower cost/seat.km on all the routes.

The next promising option is the LRC train. The Conventional train, as expected, is the least cost-efficient option. An analysis of the bus results shows that depending upon travel demand the high capacity bus could be a cost-efficient option. Trade-offs between standard bus and high capacity bus are reported in this thesis.

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CHAPTER 1

1.0 INTRODUCTION

1.1 BACKGROUND

In the recent years, there has been a growing concern about the future transportation needs between urban areas in medium and high density corridors. This has been stimulated by the increasing demand for intercity travel by common carrier (Table 1.1) and the desire to provide improved level of service between cities. Intercity passenger transport studies (4,5,43) have frequently been undertaken to estimate the intercity transport needs and to suggest and evaluate alternative approaches to meet these needs. Two basic approaches are usually followed. The first one is to provide good quality of service in the existing transport system by increasing the travel speeds, frequency, etc, and the second approach is the introduction of innovative vehicles and systems into the service.

Presently, the attention is being focussed on improving the service and quality of the existing common carrier modes, especially rail and bus systems. Substantial investments are required to provide improved services. It would, therefore, appear highly desirable to plan and design the transport system in such a way that its economic viability is maximized or economic losses are minimized.

Table 1.1
 Intercity Travel Demand - Selected City Pairs
 Windsor Quebec City Corridor
 (Passengers X 10³)

Year & Mode	Toronto- Montreal	Toronto- Ottawa	Ottawa- Montreal	Montreal- Quebec(1975)	*Toronto- London	Toronto- Windsor	Toronto- Sudbury
1976 STOL	-	-	22.98	-	-	-	-
CTOL	948.4	479.8	61.20	112.9	30	97	90
Rail	416.2	70.1	172.50	145.7	293	-	31
Bus	207	283	672.70	693.9	135	45	122
Auto	750	1,100	2,553	4,621	2,141	789	300

1985 CTOL	2,084	851	197	126	70	115	299
Rail	608	93***	229***	177	358	422	170
Bus	176	254	1,332	387	339	208	123
Auto	2,087	1,160	5,169	1,397	1,455	561	674

1990 CTOL	2,742	1,014	256	136	75	122	560
Rail	704	108	265	206	457	239	170
Bus	232	313	1,732	494	433	265	157
Auto	2,725	1,492	6,665	1,783	1,857	716	860

Overall Source: TDC Montreal (1977) (Ref.16)

*1975, May include non O-D traffic Source: TDC, "Corridor Rail Passenger Project Market Assessment, Preliminary Report" (Oct. 1976)

**Toronto-Windsor/Detroit: CTOL 150,000, Rail 231,000, Bus 88,000, Auto 1,620,000

***Transport Canada (1978)

****Present Service projected.

STOL service between Ottawa and Montreal was discontinued in April 1976.

Rail: Toronto-London-Windsor, 1976 O-D = 452,000.

Corridor studies have been popular in the past. In Canada two important corridors exist, namely the relatively higher travel density Windsor - Quebec City corridor and the lightly travelled Edmonton - Calgary corridor. In a study conducted by Khan et. al, it has been indicated that the latter corridor does not exhibit major transportation problem in comparison to the former corridor, which contains nearly half of the Canadian population (15).

The National Transportation Act introduced a policy of subsidizing (80% of operating costs) the railways in the year 1967, but its implementation commenced in the year 1969. In spite of subsidies to Canada's passenger rail services, service quality continued to deteriorate, traffic volume continued to decline (by almost 40% between 1967 and 1975, from 4.8 to 2.88 billion passenger-kilometres), and losses continued to escalate (29,30). Since 1975 the trend of declining passenger train ridership has reversed.

In an attempt to establish an integrated railway passenger operation, VIA Rail Canada was incorporated in January 1977, with a separate Board of Directors and separate financial reporting. In late 1977, the CTC declared VIA Rail as a class I railway. According to the new institutional arrangement and policy, authority was given to contract at 100% of the net cost of operating passenger services plus incentives (15).

In recent years many groups expressed their dissatisfaction with rail services in Canada. From Table 1.2 it can be seen that travelling public is concerned with the level of service (i.e., slower speeds and low frequency and schedules) and the quality of equipment used (15).

In comparison to Canada, higher speed trains are being operated in several countries. The Japan National Railway's high speed train in the Tokyo - Osaka corridor operates up to 240 Km/h. Many European intercity train services operate at speeds between 160 Km/h to 200 Km/h, while the SNCF (French National Railways) holds the world rail speed record of 325 Km/h (18). The SNCF's new TGV service between Paris and Lyon operates at an average speed of 307 Km/h.

Recent Federal initiatives in the intercity passenger transport have been directed towards the rationalization and revitalization of passenger railway services. The objectives include :

-- reduction and control of escalating rail passenger

service subsidies; and

-- improvement in service quality and cost efficiency

through the introduction of fast and reliable

rail passenger equipment.

Table 1.2

Interest Groups and Their Concerns

Interest Group	Interest	Issue
Users of passenger railway	-Availability of service of acceptable quality at reasonable cost	-Slow speed, inconvenient service (low frequency and inconvenient schedules) -Quality of equipment during peak times on certain routes
Supplier/Operator of service-- VIA Rail	-To provide attractive, convenient passenger train service while reducing the net cost to the government.	-Legislative, institutional and management framework within which VIA operates is inadequate -Lack of resources for equipment modernization and infrastructure improvements.
Public and special interest groups		
- Consumers groups	-Protection of consumers interest in case of excessive price increases or lack of service	-Concerns over price increases, service abandonments, inefficient operation, slow pace of service modernization.
- Environmental and resource groups	-Concerns about energy, pollution and land conservation (public interest approach to national development).	
Impact groups		
- Communities across Canada served by passenger rail	-Service to communities.	-Concern over service abandonment
- Intercity bus transportation	-Minimization of the impacts of VIA's pricing and marketing (promotional) efforts potentially adverse to the bus industry	-Concern over VIA's marketing and fare policies. -Concern over governments subsidy levels for passenger railway.

cont'd.

Table I.2 (cont'd)
Interest Groups and Their Concerns

Interest Group	Interest	Issue
Impact groups (cont'd)		
-Railway employees	-To minimize adverse effects of service changes and modernization.	-Concern over the impacts of service rationalization (i.e. loss of job, dislocation).

Governments		
-Federal government	-To ensure that Canadians are provided attractive, convenient passenger train services at minimum cost	-Concern with very high degree of subsidization.
-Provincial governments	-To ensure the continuity and efficiency of passenger rail service, balanced transportation -Positive externalities including industrial and employment benefits.	-Concern over lack of adequate service to communities -Intermodal transportation opportunities.

Source : Ref. 15

To fulfill the above objectives, it is believed that innovative and new rail technologies such as LRC (Light, Rapid and Comfortable train), BRC (Bi-level Rail Car) etc, can play a role. However, so far no serious work has been done to study the cost efficiency of these new technologies for the Quebec - Windsor corridor.

Similarly, the intercity bus design and development in Canada and United States has been at a virtual standstill for many years now. This is a result of fewer bus sales and less capital with which to conduct research and development. Bus development in Japan, England and Western Europe has been progressing at a much faster pace and they have been successful in widening their markets which include North America. Lack of investment in proper areas of research and government indifference to intercity bus operations has left Canada lagging behind in new designs.

More comfortable buses at higher frequencies between major urban centres could replace passenger trains and may woo more riders from the private automobile (43). Most operators have come to realize that changes in bus design must be brought about in Canada. It has been noted that the increase in seating capacity helped the carriers by increasing driver productivity, which in turn reduces operating costs.

In the year 1949, buses in Canada carried a total of 145 million intercity passengers - which was four times greater than the total

passengers carried by rail and air modes. This figure dropped to less than 65 million by 1959 and to less than 45 million by 1965. By 1976 total intercity passengers carried was 33 million (31). This trend and the related issue of improving cost-efficiency have created the need for further research in new design which can improve service and reduce the cost of operation.

1.2 RESEARCH OBJECTIVES

The primary objective of this thesis is to identify the cost efficiency of intercity transport of rail and bus technologies which have the greatest potential on the Canadian scene. Working on the assumption that the new bus and rail technologies are more efficient in producing low operating cost per seat.km on the high demand routes, analysis has been carried out for the highest density corridor in the country, namely between Quebec City and Windsor. By assessing performance of different forms of technology the objective is to identify those technologies of bus and rail which look most promising and which should be the focus of further research, development and implementation.

1.3 THESIS ORGANIZATION

This thesis consists of seven chapters. In chapter 2, the definition of the problem and the general research frame work is

presented.

In chapter 3, history and the background of rail and bus technologies are presented and the details of new technological developments are discussed.

Chapter 4 discusses the various system cost components and the relationship between variables.

Chapter 5 illustrates the study corridor and the routes selected for the purpose of bus and rail analysis. It also includes the methodology with the descriptions of Route Supply Model for rail and bus technologies, Incremental Demand Model for bus and the inputs for the above models.

Chapter 6 includes the discussion of the results of the selected rail and bus technologies.

Finally, Chapter 7 includes Summary, Conclusions and Recommendations.

CHAPTER 2

2.0 PROBLEM DEFINITION AND RESEARCH FRAMEWORK

The present status of passenger rail in Canada can be characterized as follows :

a) In 1973 the average trip length was 452 Km and in the year 1980 it dropped to 388 Km (29). Today it is the least used mode among all other modes and it accounts for less than 2% of passenger - km. Even the intercity bus produces 25% more passenger - km and carries about twice as many passengers as railways (19).

b) The decline in the passenger rail traffic has been paralleled by decreasing revenues and mounting losses. In 1974, the cost of passenger rail services amounted to \$257 million, of which only \$90 million or 35% were recovered in revenues. In 1980, the total expenses amounted to \$456 million. VIA rail spent \$3.33 for each \$1 revenue (11).

c) The quality of service available has been steadily deteriorating, not only in terms of train frequency, but also with regards to speed, punctuality and comfort (19).

A number of interrelated factors are responsible for the declining ridership which in turn causes heavy financial losses. These

include technological factors, system factors, and competition from other modes. In the present context, the first two factors are discussed.

Technological factors

Obsolete rail services have been maintained at a greater cost even on intercity routes which are adequately served by other modes. The Edmonton - Calgary and Montreal - Quebec services will be considered as representative examples for this situation. The cost of locomotive hauled train exceeds the revenue generating capacity of the train, even if all seats are filled. Rail service will have to rely on cost, comfort and frequency to attract the auto user.

System factors

The CTC requires the railways merely to submit "a statement as to the feasibility of continuing to operate all or part of the service by changing the methods of operating or by interconnection or coordination with other (passenger) services" (Order No R-1421, Feb 9, 1968). The CTC does not consider the quality of service and volume of traffic. Railways are not requested to supply information on the punctuality of trains and on the actual trip time (speed), and on improvements which could be envisaged through better management and superior technology (18).

Both CN and CP did not make serious steps to modernize their passenger rail operations in terms of quality of service (speed and punctuality). Instead, their attempts at improvements, were limited to superficial aspects like appearance, marketing, advertising and public relations. Regarding the equipment, they relied on American designs, technically obsolete when compared with modern European and Japanese designs. CN's turbotrain was, however, a significant improvement over Conventional trains.

The Federal government has proposed that the current program to modernize rail facilities should be accelerated to improve the productivity and efficiency of the total system for passenger transportation. As a part of railway modernization, this study considers different new technologies of rail such as Self Propelled Vehicle (SPV-2000), Light, Rapid and Comfortable train (LRC) and Bi-level Rail Car as alternatives. These technologies can provide higher speeds, which in turn can increase the ridership. The workability and usefulness of the methodology is demonstrated by means of applying it to eight routes on Quebec - Windsor corridor.

The North American bus industry has faced the similar situation over the past 30 years. In the year 1950 most bus manufacturers ceased production of smaller vehicles. The dramatic increase in labour costs during the post-war period encouraged carriers to go for larger coaches with 43 or more seats. Recent studies in the bus industry suggest that smaller vehicles should be introduced on low volume routes (25).

Present day buses are upto 12 m (40 ft) long , and 2.55 m (8.5 ft) wide. They tend to optimize the size permitted on highways often equipped with three axles and powered upto 400 hp. by a V-12 diesel engine. Intercity Buses are noted for their ability to reach and maintain a speed of 112 Km/h. Thus there has been increasing interest in high capacity buses. Very high capacity buses, including two-level (Double Decker) and jointed (Articulated) coaches with a capacity of 144 seats have been in use for several years. In the late 1950's two articulated buses from Germany were imported by Continental Trailways and tested on the Denver-Colorado Spring-Pueblo route but did not last long. Their failure has been attributed to a lack of baggage space and no air conditioning (6).

In Canada, Voyageur Bus company tested an articulated bus between Ottawa - Montreal for about three month period during the summer of 1982. This service ran into difficulties because of the problems with the articulated joint and other engineering designs.

The present European articulated buses have substantial baggage space and in addition, because of the nature of European production techniques, assurance was given by the manufacturers to build buses which suit Canadian conditions. For this reason this study considers an Articulated bus, Double Decker and an Articulated Double Decker bus for their economic feasibility in Canada as against the standard bus.

The basic systems analysis structure is shown in Figure 2.1. The main phases of the structure are a) Socio economic environment, b) Problem definition, c) Solution generation, d) Solution analysis, e) Evaluation, and f) Choice. The definition and description of these phases are provided in the following paragraphs.

2.1 Socio economic environment

The Socio economic environment is the aggregate of all external conditions and influences affecting the system. The socio economic environment of a region is the regional structure in terms of people, economy, geography and the institutions.

The following concerns are responsible for the system objectives.

a) Government concerns : The government's interest is to reduce the subsidies. This is possible only when new technology comes into operation, which can produce low operating costs.

b) Operator concerns : Operators are interested in providing a good and reliable service at a lower cost per seat.km and to maximize profit or minimize losses.

c) User concerns : The passengers are concerned about frequent, comfortable, high speed and low price mode of travel.

Figure. 2.1 The Framework for the study of the Efficiency of Intercity Rail and Bus transportation systems

2.2 Problem Definition

The purpose of the problem definition is to define the interface between the system and the environment. This requires to identify all the pertinent factors involved in considering transport systems planning and evaluation. These factors are,

1. System objectives
2. System constraints
3. System inputs
4. System outputs
5. Decision criteria

2.2.1 System objectives

It may be defined as a set of operational definitions that identify the social and economic needs that a system must attempt to satisfy.

A large number of objectives for a transport system can be defined. An appropriate list of objectives for this research is given

below (17).

i) To develop a transport system which is the fastest, safest, cheapest and most convenient for the movement of people between all points of the corridor;

ii) To provide the transport system which will be the least expensive in terms of capital cost, maintenance cost etc.,

iii) To give passengers the best possible choice of mode.

2.2.2 System constraints

These may be regarded as those characteristics of the environment that limit the extent of feasible solutions. Transport systems may be subject to physical, historical, political, economical and technological constraints. The exact nature of these constraints is a function of the particular region under study.

Economic constraints

The budget given to most public modes generally do not suffice to cover all possible investments. The most reasonable allocation of a given budget among competing demands (for budget) would seem to be that which maximizes the benefits to be obtained. Inturn, that investment budget should be so chosen which results in maximizing the benefits

from all investment expenditures, public and private undertaken within the economy.

Technological constraints

The generation of alternative systems is constrained by the technological features of transport industry and such attributes of the system as operating policies, pricing policies and ownership regulations. Also the existing transport system acts as a constraint on the feasible alternatives.

Various components of transport technology, which influence the options open to planner could be listed as

1. The available modes and their operating characteristics such as propulsion, guidance, and relation between vehicle and supporting medium.
2. Link characteristics such as location, capacity and other operating characteristics.

2.2.3 System inputs

The inputs to the system are those characteristics of the environment that a system must transform into outputs in the light of the system objectives. The inputs to a regional transport system are the demands for the movement of persons between various locations. In order to understand the nature of this demand, the basic forces responsible for its generation should be understood.

2.2.4 System outputs

These may be defined as those functional properties of a system which influence the environment. The outputs associated with a regional transport system can be identified into three categories : a) user benefits, costs and related impacts, b) socio economic impacts, and c) capital costs and other physical impacts.

2.2.5 Decision criteria

It is a set of rules or standards for evaluating alternative systems such that the best system will be chosen for implementation.

2.3 Solution Generation

In this phase of the systems analysis structure feasible alternatives are generated which satisfy the system objectives to an extent possible and do not violate the system constraints. The process

of solution generation must take into account the system objectives and constraints. In this study three new rail and three new bus technologies are considered in order to test their cost-efficiency characteristics in the Quebec - Windsor corridor.

2.4 Solution Analysis

The objective of this phase is to estimate the effects upon the real-world which an alternative technology would have if it were implemented. The costs for all the rail and bus options are developed on a vehicle/km basis and are used as inputs to the Route Supply Model. Mathematical equations were developed for certain variables which are dependent on speed and technological variable, e.g. rolling stock maintenance cost etc.,.

Intercity travellers have a better choice of competing modes in high density routes and have more freedom in deciding whether or not to travel than an Urban or Suburban traveller. In Canada, Quebec - Windsor corridor is in the most densely populated area and offers a large number of intercity links. The data availability appeared more complete on this corridor. This thesis therefore, focusses on the Quebec - Windsor corridor to test the cost-efficiency of different rail and bus technologies.

2.5 Evaluation

The objectives of this phase is to operate upon the predicted consequences (the output variables) of an alternative system in order to compare these consequences to the system objectives. In this thesis, Route Supply Model has been used for rail and bus evaluation process and in the case of bus alternatives Incremental Supply Model is also used. The costs developed in solution analysis phase has been used as inputs for all the models. These models are tested on eight routes in the case of rail and six routes in the case of bus on Quebec - Windsor corridor.

2.6 Choice

This phase of the systems analysis structure would pose questions to the transportation planner about selection of optimal technology among the alternatives evaluated.

Details of analysis framework is shown in Figure 2.2.

Figure 2.2 : Analysis of Technological, Route and System alternatives

CHAPTER 3

3.0 DEVELOPMENT OF RAIL AND BUS SERVICES

3.1 RAIL TECHNOLOGY AND SERVICES

The first Canadian rail road was opened for traffic in the year 1836. In 1837 an engine called the "Dorchester" was brought from England with an engineer (22) and it raced forward at a speed of 32 kmph. The steam railway era had begun in Canada.

Steam locomotive - the prime mover of the railways has been superseded in North America between 1940 and 1960 by diesel traction. In Europe and Japan, electric as well as diesel traction has supplemented the steam power. In recent years, gas turbines have been used to propel fast passenger trains in the Toronto - Montreal corridor.

Since 1945 passenger rail lost irrevocably the attribute of a natural monopoly: it has been subjected to competition with air and road modes and has become highly uneconomic (19). Table 3.1 shows the change in modal usage. In the late 1940's the railways ordered more new cars to replace the 1930's equipment. Canadian railways have struggled to maintain the obsolete rail services at great expense.

Table 3.1

Change in Modal use* 1960 - 1977

Year	CAR	BUS	RAIL	AIR	TOTAL
1960	6,254	500	205	240	7,197
1970	8,498	495	171	719	9,883
1973	9,801	660	116	932	11,559
1977	11,113	742	127	1,170	13,152

* Annual Passenger - Kilometers per capita by mode 1960 - 1977

Source: Transport Canada, Strategic Planning Group
 Passenger and Goods Transportation, TP 3039, 1981.

Passenger transportation by all modes linking cities Montreal - Quebec, Edmonton - Calgary are presented in Table 3.2. On the Montreal - Quebec route, rail is the slowest, less frequent and considerably more expensive than any other mode (19).

In order to counteract the decline of passenger traffic and to stem the rising losses, CN and CP attempted a number of times to modernize the equipment and to improve the services, during 1950's and 1960's (18). On the technical side, these changes involved the introduction of more glamorous and attractive passenger cars, with the emphasis on appearance.

In December 1968, CN tested the Turbo train on a press run between Toronto and Montreal. Following the trial runs, the CN Turbotrain service between Montreal and Toronto was inaugurated on December 12, 1968, with two round trips daily. A month later Turbotrains had to be withdrawn from service due to a series of cold weather problems. After suitable modifications it has been operated between Toronto - Montreal. It had been observed that the Turbotrain was not economical to operate and the railways totally abandoned the turbotrain service about two years ago.

At present time, increasing attention is being focussed on upgrading the passenger rail services in Canada. The Canadian government is giving serious consideration to up grade the rail

Table 3.2
MONTREAL - QUEBEC AND EDMONTON - CALGARY PASSENGER TRANSPORTATION

	AIR	AUTO	BUS	RAIL
<u>MONTREAL-QUEBEC</u>				
Line-haul time - 1977	0:40	2:40	2:40	2:39-3:25
Runs [*] /day - 1977	26	-	36	10
Passengers carried - 1975 (000's)	113	4621	694	146
(%)	2	82.9	12.5	2.6
Fare, one way-1977 (\$)	34.56	-	6.38 ¹ /10.35	9.75 ² /22.75 ³
Operating loss-1975 (\$Million)	-	-	-	5.36
<u>EDMONTON-CALGARY - 1974</u>				
Line-haul time	0:35	3:10	3:20	3:25
Runs ^{**} /day	28.8	-	15.6	4
Passengers carried ('000s)	523	2210	249	15
(%)	17.5	73.7	8.3	0.5
Fare, one way (\$)	23.1	11.55	7.45	10.45
Operating loss (\$Million)	-	-	-	0.92

* Total no. of Montreal to Quebec, plus Quebec to Montreal trips
 ** Total no. of Edmonton to Calgary, plus Calgary to Edmonton trips
 1 same day return, 2. CN coach; CP coach \$15.10, 3. CN club car

Source: Ref. 19

passenger service in Quebec City - Windsor corridor (3). The objective is to develop better rail system and thereby reduce demands for highways and airports (18). The role that the passenger rail should play in the transportation spectrum has not been defined, and there is no overall R&D policy which would result in modernization and improvement of the railway operations in Canada. In this area, Canada appears to lag behind than other industrialized countries.

The information reviewed adequately characterizes the present passenger rail operations in Canada and indicates the relative cost of maintaining a transportation system which uses conventional technology and provides service of quality inferior to that available on the newer modes. The setting up of VIA rail Canada Inc., (established in 1977) was designed to integrate passenger operation into one corporate structure which would be totally dedicated to the rail passenger. It is experiencing a number of technical, managerial and institutional problems in discharging its role of providing passenger service (45).

If intercity rail service is to survive, the development of new and fast passenger rail has been suggested as a means towards the modernization of passenger transportation in Canada. For this study purpose three new technologies other than conventional train have been considered.

3.1.1 CONVENTIONAL LOCOMOTIVE HAULED TRAINS

After the monopoly of the rail mode in North America, the passenger train underwent its final metamorphosis. In 1950 there were about 4,635 steam locomotives in Canada (7). Only 15 years later they had been replaced by diesel and electric ones (7) on long routes. Figure 3.1 illustrates the number of locomotives in service by power source. These trains are operated on routes of 400 km to 650 km in day service, 650 km to 1600 km on overnight services and upto 480 km on transcontinental services.

Between 1945's and 1955's the passenger train was revitalized due to following developments :

- i. The diesel train with light weight cars were cheaper to operate than the steam hauled train.
- ii. The improvements in coach and low fares attracted many passengers, and
- iii. These trains were operated on long haul routes of over 400 km where no competition existed.

Technological progress also made it possible to increase considerably the average power of diesel locomotives from 1000 hp. in 1945 to 1,917 hp. in 1975. This, in turn made it possible to operate longer, faster trains, which led to a decline in the number of locomotives after 1950 (36). In 1972, AMTRAK'S locomotives average 19

FIGURE. 3.1 NUMBER OF LOCOMOTIVES IN SERVICE BY POWER SOURCE

Source : Ref. 36

years in age and in Canada their average life is 20 years.

The E8 diesel-electric conventional locomotive has been considered in this study. This is 25 year old locomotive and is still in regular scheduled use. However, there are plans to phase them out in the future. Figures 3.2 and 3.3 illustrates the transmission efficiency vs. speed and horsepower vs. fuel consumption (litres/hr) for this locomotive. Transmission efficiency data have been calculated by dividing rail horsepower by traction horsepower at various velocity ratings. Transmission efficiency is a nonlinear function of velocity.

The intercity carriers have curtailed the frequency of trains operated each day on their potential corridor in order to reduce the deficits. Because of the fewer dialy schedules, rail services in Canada are unable to win over other modes of travel especially the automobiles. The operating cost of a locomotive hauled train can only be reduced on a passenger basis when a large number of passengers are carried.

The conventional locomotive is more costly to operate since the weight is more than recent designs. Due to its heavy weight it consumes more fuel. Also, the heavy weight of the locomotive increases the trackway maintenance cost whenever locomotives are operated at high speed.

FIGURE. 3.2 TRANSMISSION EFFICIENCY CURVE FOR CONVENTIONAL
LOCOMOTIVE (E8 DIESEL-ELECTRIC)

Source: Ref. 23

FIGURE 3.3. FUEL CONSUMPTION VS. GROSS HP. OF
CONVENTIONAL LOCOMOTIVE (E8 DIESEL-ELECTRIC)

Source: Ref: 23

Passenger comfort and service quality is poor for Canadian railways. The average speed increase (between Ottawa - Montreal and Montreal - Toronto) over the 1920 - 1973 period was from 5.12 to 7.0 Km/h per decade. Over the past 87 years, the transcontinental speeds have been increased by 3.5 Km/h per decade (18). The average speed of fast trains over distances of upto 560 km is only about 90 Km/h. Much lower speeds are scheduled for longer trips. Speed is the major factor in transportation, and it is clear that the Canadian railways are poorly placed in comparison with their counterparts elsewhere.

In order to reduce the railway operating costs it would be necessary to develop the new rail technologies such as SPV-2000 and BRC, and use new trains such as the LRC.

3.1.2 SELF - PROPELLED VEHICLE - 2000 (SPV-2000)

In 1958, the Budd Company introduced the Rail Diesel Car (RDC) - a coach with its own diesel propulsion units. It represented the most vital change in rail service which provides competition to auto, bus and air transport in the years after world war. The RDC was cheaper than the conventional locomotive train, since it requires less crew than the Conventional train (two for RDC as opposed to five for Conventional train). By 1960, most RDC's operating in commuter services as local services, for which the RDC was bought, had been discontinued (11).

The RDC was designed to be used for short haul services. It was not designed to be a comfortable vehicle for trips of several hours. Nonetheless, the RDC did prove that a mechanically reliable self propelled car could be designed.

In 1970's the Budd Company introduced a modified version of RDC, namely the SPV-2000. According to the Budd Company published data, a saving of less than 5% is possible by replacing the RDC with the SPV (11). Savings accrue from better fuel efficiency and a reduction in equipment maintenance expenses.

3.1.3 SELF PROPELLED BI-LEVEL RAIL CAR (BRC)

BRC is a hybrid vehicle combining the Self-propelled vehicle with two deck passenger car. This vehicle is designed with the following design characteristics (11):

1. an increased seating capacity, which would reduce operating costs;
2. reduces components in an exposed position beneath the RDC/SPV carbody;
3. operational characteristics of comfort and speed that would be sufficient to attract ridership from other modes and,

4. Canadian made Cummins engine model KTA-1150-L would provide a single BRC to operate at a speed of 140 km/h.

A cab would be located at either end of the upper level for the engineer which would enhance safety. Walk through connections to additional cars would be made on the upper level, in the same fashion as is currently designed on the RDC.

Line diagram of BRC is presented in Figure 3.4

3.1.4 LIGHT, RAPID AND COMFORTABLE TRAIN (LRC)

The LRC is a new rail technology developed by a consortium of MLW - Worthington Ltd., Alcan and Dofasco. This project was financed by the Department of Industry, Trade and Commerce. The LRC train is designed to make a substantial reduction in intercity scheduled times while operating within the limiting conditions of present day track structures. The ability to negotiate curves at high speeds is accomplished by an active banking system, which is a mechanism that tilts the car body so that lateral accelerations are not felt by the passengers. This train can negotiate curves at speeds upto 40% higher than trains with conventional suspensions. The designs of the LRC train could be described as a refinement of conventional diesel traction technology. Light alloys are used in the structure of locomotive and passenger cars. Their shapes are streamlined and undersides are cowed

FIGURE 3.4: LINE DIAGRAM OF DIESEL-ELECTRIC

BILEVEL RAILCAR

Length	: 30m (100ft)	Truck centre spacing	: 21m (70ft)
Width	: 2.7m (9ft)	Seating capacity	: up to 172 persons
Height	: 4.8m (16ft)		
Weight	: 107 tons (190,000 lbs)	Comments:	dimensions in accordance with A.A.P guidelines

Source: Ref. 28

to reduce aerodynamic drag forces.

The LRC is much heavier than the Turbotrain or the Japanese " New Tokaido Line " electric cars. On the other hand the LRC coaches are much lighter than the standard, Canadian or North American designs, but somewhat heavier than the new European and Japanese equipment. The LRC locomotive is also heavy as compared with state-of-art technology in diesel-electric traction. The LRC train provides travellers with the utmost comfort, safety and convenience.

The LRC has been apparently conceived as a compromise solution which would conform to the standard, Canadian railway practice but allow somewhat higher speeds on existing tracks. Conventional non-articulated coach and locomotive configurations are used, to allow rapid changes in the consist and flexibility of use with standard equipment (18)..

3.2 BUS TECHNOLOGY AND SERVICES

3.2.1 REVIEW OF CURRENT BUS TECHNOLOGY AND SERVICE

The successful development of light high speed internal combustion engine towards the end of the 19th century opened up the way to the power driven road vehicles and made possible the development of modern motor cars, trucks and buses (14).

It is generally said that the modern bus industry in Canada began in 1920's. The first auto buses were simply larger motor cars, or trucks with covered platforms on them. Although people were quick to modify truck chassis to provide the first buses as we know them today. These first vehicles carried around 25 passengers and at first were used only within larger cities. By the late 1920's a large number of companies were created to take advantage of the new transportation method especially to those areas which are not served by the rail lines.

Severe economic conditions and intense competition in the mid 1930's eliminated a number of companies both in the United States and Canada. This period was also marked by consolidation and mergers in the intercity - bus industry, causing marginal operations to fail or be purchased by larger firms. In 1930 Provincial Transport Company purchased Colonial Coach Lines of Ottawa and also the Toronto-Montreal Road Coach Lines and the T-Gill Bus Lines (37). In spite of these great changes the bus industry did not receive a great deal of technological input and as a result the buses built until 1946 were usually of 32 passenger size. After the war the 37 seat buses were introduced and in 1953 the split level semicruiser came into the market. Gasoline rationing during the war greatly restricted the motor car use and added to the popularity of the buses.

During the peak year of 1949, buses in Canada carried a total of 145 million intercity passengers - which was four times greater than

the total of all passengers carried by rail and air modes. This demand dropped to less than 65 million by 1959 and to a low of less than 45 million in the 1965. By the year 1976 total intercity bus passengers were down to just a little over 40 million (1).

3.2.2 MARKET STRUCTURE OF THE INTERCITY - BUS INDUSTRY

The motor coach industry has the most extensive route structure of any public intercity passenger transport in Canada. The Canadian bus guide lists the service of more than 62 carriers linking 3,409 communities across Canada. Of these, 2,808 communities are dependent on the bus as the only public transportation mode available (1). The schedules serve a total of 64,000 route kilometres (1).

The 19 class 1 and 2 intercity bus companies carried 98.7% of 33.2 million fare passengers and earned 98.2% of the \$270,438,000 in operating revenues (31). Table 3.3 presents statistical details of the structure of the intercity passenger bus industry for the year 1980. The three main operators i.e., Greyhound, Voyageur and Gray Coach, including subsidiary operations, carried about two-thirds of the industry's fare passengers and generated about two-thirds of its operating revenues in 1978 (37).

The composition of major carrier groupings has not remained static. The number of class 1 and 2 carriers increased from 18 in 1976

Table 3.3
Structure of the Intercity Passenger Bus Industry
(SIC 508) in Canada, 1980.

Classes (a) (Annual Revenues)	Number of Companies	Total operating Revenues ('000s)	Percentages
Class I and II (\$500,000 and over)	19	\$265,607	98.2
Class III (\$100,000 to \$499,000)	15	\$ 3,946	1.4
Class 4 and 0	20	\$ 885	0.4
Total	54	\$270,438	100%

a. Carriers are classified according to their total returns.

Source: Statistics Canada publication 53-215, passenger and urban transit statistics.

to 22 in 1978 and in 1980 only 19 carriers have reported to Statistics Canada. Most of these 19 carriers provide regional service, but only Greyhound provides east-west service from Toronto to Vancouver.

Power Corporation owns both Voyageur Inc., and Voyageur Colonial Ltd. As shown in figure 3.5, these bus companies are owned through Voyageur Enterprises Ltd., which is managed by the CSL Group Inc. Voyageur also operates on tour operation and parbus, a small parcel service.

The Greyhound Corporation of the United States controls Eastern Canadian Greyhound Lines Ltd. and Canadian Coachways through Greyhound Lines of Canada Ltd. Figure 3.6 gives the details. Greyhound is the only foreign - controlled intercity bus system.

There is considerable public ownership in the intercity bus industry. The federal government, through Canadian National Railways, owns Terra Transport (formerly CN roadcruiser) in Newfoundland. The B.C. government, through B.C. hydro, owns Pacific Coach Lines; the Saskatchewan government owns the Saskatchewan Transport Company, and the Ontario government owns the Ontario Northland Transportation Commission, which has a bus operation. Municipal governments in Toronto and Hamilton own intercity bus companies through their urban transit systems and the regional government on the South Shore in Montreal controls Metropolitan Sud (38).

FIGURE 3.5
CORPORATE STRUCTURE OF POWER CORPORATION OF CANADA
SHOWING VOYAGEUR ENTERPRISES LIMITED

_____ CONTROL

----- MANAGEMENT

Source : Power Corporation of Canada, Limited, Annual Report 1979

FIGURE 3.6

INTERCORPORATE OWNERSHIP CHART OF GREYHOUND CORPORATION
AND ITS CANADIAN SUBSIDIARIES

ALL PERCENTAGES REFER TO PERCENTAGES OF OWNERSHIP

NOTE: COMPANIES ARE CANADIAN UNLESS OTHERWISE MARKED

SOURCE: STATISTICS CANADA PUBLICATION; INTERCORPORATE OWNERSHIP, 1975, CATALOGUE 61-517

Power Corporation, which has interests in transportation, financial institutions and pulp and paper, has bus operations through Voyageur Enterprises Ltd. The Greyhound Corporation has interested in food processing, pharmaceuticals, leasing and financing and manufacturing, as well as bus transportation. In regards to intermodal ownership, both the Irving group and Power Corporation have trucking and shipping interests. The C.N.R. has interests in rail, trucking and shipping. Ontario Northland has both trucking and air interests (38).

The dynamic structure of the industry may also be due to mergers between existing carriers. In 1976, for instance, Voyageur Inc. purchased Les Autobus Drolet Inc., a class 2 carrier based in Quebec (37).

3.2.3 CANDIDATE BUSES

The early history of the intercity bus industry (section 3.2.1) mentioned the development of prototype buses during the 1920's. By the second world war, air conditioning, internal luggage compartments (in place of roof racks), and toilets were available from manufacturers. The dramatic increase in labour costs during the post-war period induced carriers to turn to larger coaches with 40 or more seats. There has been an increasing interest in larger capacity buses from major intercity carriers.

The desire for large buses and the economics of producing such a unit has been breached by the European bus manufacturers. A high capacity bus is one which can provide a substantial increase in passenger capacity as compared to the standard single deck, three-axle bus commonly in use in North America. High capacity bus include Articulated bus, Double Deck bus, and Articulated Double Deck bus.

Articulated buses achieve greater capacity because they are approximately 60% longer than the standard bus. The Double Deck bus, as the name implies, achieves greater capacity because it has two decks although the length is similar to that for the standard bus.

A summary of the most important characteristic of each of the bus units are presented in Table 3.4. For each unit, there is a range of both seating capacity. It is variable due to options in seat throw (i.e. distance between seats). The range in seat throw is similar to that experienced for the standard buses. These buses have been in use in Europe and thus are a fully developed product.

3.2.4 EUROPEAN AND NORTH AMERICAN OPERATORS EXPERIENCE

The experience of the European operators for high capacity bus with respect to vehicle performance and operating costs had been documented by a study conducted by N.D. Lea & Associates Ltd. This was essential in order to:

Table 3.4
Comparison of Bus Specifications

Design Class	Dimension (m)			Seating	Cost ('000s) 1982 dollars	Number of axles
	H	W	L			
Single Deck	3.3	2.5	12	43-47	200	3
Articulated						
Single Deck	3.5	2.5	18	70-80	350-400	4
Articulated						
Double Deck	4.0	2.5	18	100-140	500	4
Double Deck	3.0	2.5	12	69-80	350-400	3

Source : Ref. 21

--Determine if there is any empirical evidence that supports the advantages of high capacity buses, and

--Identify the operational problems that could limit their usefulness in Canada.

Both Double Deck and Articulated high capacity buses have been operated in Europe for a number of years. Traditionally, the Double Deck buses are used extensively in the United Kingdom, whereas single deck standard or Articulated buses are favoured in most European cities (10).

In the N.D. Lea's survey, it was found that Double Deck (74 or 79 seat capacity), single deck Articulated (72 or 85 seat capacity) and Double Deck Articulated (92 or 95 seat capacity) buses were used by the operators of long distance service. The average annual distance covered by these buses is approximately 100,000 km. Fuel consumption ranged from 30 to 39 l/100-km for an Articulated bus over a flat terrain compared to 28 to 30 l/100-km for a standard intercity bus. The average tire wear is 200,000 km for an Articulated bus operating on flat areas and 35,000 km in mountainous areas. For a Double Deck bus the range is 80,000 - 130,000 kms.

Maintenance cost data reported by the operators is presented in Table 3.5. The maintenance cost of an Articulated bus and Double Deck

Table 3.5

Survey Results of High Capacity Bus Maintenance Costs

Maintenance Component	All HCB's		Articulated Index (%)	Double-Deck Index (%)
	Labour (man-hrs/1000km)	Parts (DM/1000km)		
Engine	0.3 - 3.9 ¹	6 - 300 ¹	100	100
Suspension	0.2 - 0.5	10 - 17	133	100
Steering	0.2 - 1.5 ²	7 - 22	125 ³ 120 ⁴	100 ³ 100 ⁴
Brakes	0.3 - 1.7	7 - 87	150	100
Heating & Air Conditioning	0.04 - 3.2	5 - 40	130	130
Accessories	0.3 - 0.9	2 - 44	120	200
Electrical	0.6 - 3.9	8 - 78	130	130
TOTAL	1.7 - 14.2	72 - 399	133	125

1 older buses (14 yrs) operated primarily in mountainous areas

2 a new system on an articulated transit bus

3 labour

4 parts

Source: Ref. 21

buses are expressed as a percentage of a standard bus maintenance cost. It appears that the maintenance cost of high capacity buses vary from 25% to 33% greater than those of the standard bus. The responses of operators consistently indicated that driver productivity was significantly increased by increase in seating capacity. As far as ride quality was concerned, the reaction of both passenger and operators was reported as very positive by virtually all operators, (21). Most operators also reported that there were no problems related to safety with high capacity buses (HCB's).

The major disadvantages with HCB's are the alterations in vehicle storage, maintenance and exterior cleaning facilities. For an Articulated bus, the alterations are lengthening of the maintenance pits and installing additional hoists whereas the Double Deck buses require higher exterior washing equipment. Another common problem with the Double Deck bus is the obstruction due to tunnels, transmission lines, trees etc., along the route. One operator also reported problems of vandalism in the upper deck.

Finally, the survey results suggest that the major disadvantages of HCB's are increased vehicle operating and maintenance costs and required alterations to storage and maintenance of infrastructure. However, the results of N.D. Lea's study suggest that the improvement in driver productivity and positive passenger response will outweigh these disadvantages. This conclusion is supported by the steady increase in use of HCB's by European operators.

* Total operating and maintenance costs increase but costs per seat.km decrease.

NORTH AMERICAN EXPERIENCE WITH HIGH CAPACITY BUSES (HCB'S)

Interest in HCB's in the United States during the early 1970's led to demonstration tours of European Articulated buses to a number of U.S. cities. These gave a brief exposure to a M-A-N 16.5 m (54ft) Articulated diesel bus and Volvo 18m (60ft) Articulated bus for brief periods during the summer 1974.

Around the same time, the Urban Mass Transportation Administration (UMTA) of the federal Department of Transport, in cooperation with eleven transit operators, undertook a conceptual design study of high capacity buses for the U.S.A. This study, known as 'project super bus' was completed in December, 1974.

Two cities were selected for the Double Deck bus demonstration programme (32). This project demonstrated that there was a very positive reaction to these vehicles from the public, and subject to height clearance restrictions on some routes, they could be used effectively to increase capacity and achieve economies in transit service on arterial services and on express routes.

Continental Trailways conducted two demonstration projects with Articulated buses in the early 1960's. One between Denver, Colorado and a nearby U.S. Airforce Academy and the other between Los Angeles and San Francisco. The Articualted buses used were "Golden Eagle" 1958

models manufactured by Karl Kassbohrer of West Germany. These buses were 18m long, with a seating capacity of 85 passengers, and were equipped with underfloor diesel engines. The main objective of these experiments was simply to determine if the driver productivity could be improved through the use of a bus larger than the standard bus.

In the above study it was found that the driver productivity improved through the use of the Articulated bus. The maintenance cost of the Articulated buses were significantly higher than the standard bus. The main reason for higher costs was the inability of the engines, manufactured by M-A-N of West Germany, to withstand prolonged usage at high speeds. The following conclusions can be made based on the U.S experience.

--There is some evidence that the use of HCB will improve driver productivity. However, this would seem to be highly route dependent.

--Domestic engines are much more cost-effective than European engines.

--Maintenance costs can be curtailed to some extent by using as many standardized parts as possible.

CHAPTER 4

COST ESTIMATION METHODOLOGY

4.1 PASSENGER RAILWAY COSTS

4.1.1 VARIABLES CONSIDERED FOR COST ESTIMATION

Many different cost estimation methods for rail have been used in the past, usually being suited for the specific nature of service. An example of this is the Canadian railway's present system of costing for grain handling in the Prairie Provinces (26). This policy has been developed for the particular purpose of estimating operating costs in that region.

Several important cost categories can be studied and estimated with little difficulty. To develop cost estimates, all categories must be reduced into distinct, preferably independent items. Many accounts lend themselves to simple calculation, while others can only be roughly estimated. Fuel consumption or track wear costs are functions of passenger demand related vehicle value as well as velocity. Clearly, these costs for a given set of inputs can be derived. However, crew costs are an example of a cost category which can be estimated only if detailed information about crew size and wages are known. Wages vary from position to position as well as from region to region. Also crew requirements may vary due to operator's policy.

This chapter will concentrate on several cost categories which can be estimated in an objective manner, and thus develop cost equations for these items. On the other hand, methods for costing of subjective categories will be presented, but the assumptions, conditions and approximations of such analysis must be recognized. The details of each cost category are discussed in the following sections. Table 4.1 gives the cost categories considered in this study.

Table 4.2 shows the technological details of the different rail technologies that are considered in this study (2,23,28). Table 4.3 gives the top speed limits for each technology.

In order to estimate the top speed, the following formula has been used (20).

$$(1.3 T + 29 N + 0.03 TV + CAV^2) * \text{NUMBER OF LOCOMOTIVES}$$

$$+ (1.3 T + 29 N + 0.03 TV + 0.41 V^2) * \text{NO. OF COACHES}$$

$$\leq 375 P\eta / V$$

Where,

T = weight in tons

Table 4.1 Intercity Passenger Rail Cost Categories

1. Rolling stock maintenance cost --- Locomotives and Coaches
2. Fuel cost
3. Trackway maintenance cost ----- ties, rail, signalling etc.
4. Crew cost
5. Onboard services
6. Station services
7. Marketing and reservations
8. Taxes and Insurance
9. Depreciation of locomotives and coaches
10. General Administration cost
11. Interest
12. Cleaning of rolling stocks
13. Train dispatching cost

Table 4.2 Technological details of all types of trains

Conventional Hauled Locomotive train

Weight of the Locomotive	- 154 Tonnes
Weight of the coach	- 71.5 Tonnes
Maximum cross sectional area	- 11.15 sq.m
Number of axles	- 4/unit
Efficiency of transmission	- 0.83
Horsepower	- 3,300

Self Propelled Vehicle (SPV - 2000)

Weight of SPV	- 82.5 Tonnes
Width	- 2.9 m
Height	- 4.57 m
Number of axles	- 4
Efficiency of transmission	- 0.83
Horse power at rail	- 1000

Bi-level Rail Car (BRC)

Weight of BRC	- 117.7 Tonnes
Width	- 2.74 m
Height	- 4.877 m
Length	- 30.48 m
Number of axles	- 4
Horse power at rail	- 1000

Light, Rapid and Comfortable Train (LRC)

Weight of locomotive	- 129.8 Tonnes
Weight of coach	- 48.95
Cross sectional area	- 3.18 X 3.581 m
Number of axles	- 4
Horse power at rail	- 2000

Source : Ref 2,20,23 and 28

Table 4.3 Maximum allowable speeds for different technologies

Technology	Max. speed in km/hr
Conventional Locomotive Train	
1 engine with 2 cars	200
1 engine with 3 cars	195
1 engine with 4 cars	190
1 engine with 5 cars	180
Self Propelled Vehicle - 2000	
One SPV	175
Two SPV's	175
Three SPV's	175
Bi-level Rail Car	
One BRC	175
Two BRC's	175
Three BRC's	175
LRC train	
1 loco with 2 cars	200
1 loco with 3 cars	190
1 loco with 4 cars	180
1 loco with 5 cars	170

N = number of axles

V = speed in mph

A = maximum cross sectional area in sq.ft

C = air resistance parameter for streamlined

locomotives 0.017, otherwise 0.0024

η = transmission efficiency, usually 83 %

P = horsepower

4.1.2 MAINTENANCE OF ROLLING STOCK

Costing of this category involves significant estimation leading to rolling stock maintenance cost rates. Maintenance requirements are uncertain, since mechanical failure can occur at anytime, but requirements for scheduled maintenance can, of course, be determined. Maintenance costs are usually based on historical data. As expected and confirmed by past studies, maintenance costs per km increase as velocity increases.

The following equations have been used in calculating the maintenance costs of locomotives and coaches (26).

Maintenance cost of locomotives = $[0.01064 V - 0.1335]$

in \$/track-mile (1982 dollars).

Maintenance cost of coach = $0.2 (0.025 V - 0.9972)$

in \$/track-mile (1982 dollars).

V = speed in mph.

Increased maintenance costs imply increased wear and thus it would seem reasonable to assume that the expected service life would be reduced as velocity and/or train mileage per year increases.

4.1.3 TRACKWAY MAINTENANCE COSTS

VIA rail pays for the use of tracks owned by other railways in Canada. This category covers maintenance of track (rails, fasteners, ties and ballast), signals and signal operation, communication systems and associated structures. These costs increase as the speed, weight and frequency of trains increase. Table 4.4 indicates the factors affecting the track life (34). Increased track maintenance costs at high speeds are due to the adherence to the much more stringent track geometry tolerance requirements for safe and comfortable operation at high speeds. In this study the track upgrading costs are not included because the cost/vehicle.km will be same for all the rail technologies. By including these costs, there will not be any change in the pattern of the results but there will be a shift in the graphs.

Table 4.4 Factors affecting track life

Track related factors

- rail weight
- type of rail (CWR or jointed)
- rail metallurgy
- condition of rail (new or old)
- type of tie (wood, concrete)
- tie treatment
- condition of tie
- tie spacing
- ballast (type, depth, condition)
- subgrade suitability
- curvature
- gradient
- climate (atmosphere, precipitation, temperature, flooding, icing & frost heave, environment)

Traffic related factors

- tonnage density
- maximum and minimum train speeds
- traffic wheel loading characteristics
- traffic mix
- train frequency
- type of equipment (length, center of gravity, track type, suspension)

Source : Ref. 34

To get the total right-of-way maintenance cost, the routeway-related costs must be added to the track and signal maintenance costs. Routeway maintenance involves drainage and erosion control, vegetation control, litter removal and ditching clean up. The annual trackway maintenance cost was estimated at about \$1500/track-mile (1970 dollars) for the high speed rail scenarios considered in the U.S Northeast corridor (24). These costs are updated to 1982 dollars for this study. In Canada, the trackway cleaning costs were estimated to be \$1000/trip/mile (1978 dollars) (26)

An annual trackway maintenance cost per track-mile can thus be written as follows (12).

$$TKMAIN = 2000(MGT)^{0.585} (0.589 + 0.0022 V^{1.3}) + 3350$$

Where,

TKMAIN = Annual trackway maintenance cost in

\$/track-mile.

MGT = Annual millions of gross tons carried on the track.

V = train speed (mph)

4.1.4 TRAIN CREW COSTS

The present debate between railway management, labour, and others who are interested in the economics of improved passenger train service is, 'what should be the number of people in the train and engine crew?' (44). The determination of the cost of labour is not difficult provided two factors are known. Wage rates and crew requirements per train trip. However, difficulties can arise in determining these quantities. Table 4.5 gives the crew required and number of seats for different technologies (11).

Passenger train crew cost is expressed in practice on a per train - km basis, and it should therefore be possible to calculate the cost of manning trains on any given route by simply knowing the mileage involved. According to Canadian passenger rail experience in 1975, crew cost could be taken as \$2.00/train - mile. This figure has been updated to 1982 dollars by using consumer price index (Table 4.6). These estimates do not include passenger service crew costs since it is assumed that such costs are recovered by service revenues.

4.1.5 TRAIN FUEL CONSUMPTION COST

Fuel consumption is mainly dependent on horsepower requirements and the type of power unit used. Horsepower requirements are a function of velocity as well as the physical properties of the train involved such as weight and size.

Table 4.5 Number of seats and crew required for various technologies

Technology	Number of seats	Crew required
I Self Propelled Vehicle		
One SPV	88	2
Two SPV's	176	3
Three SPV's	264	3
II Conventional Locomotive Train		
Two cars	144	5
Three cars	216	6
Four cars	288	7
Five cars	360	8
III LRC Train		
Two cars	168	5
Three cars	252	6
Four cars	336	7
Five cars	420	8
IV BRC train		
One BRC	132	2
Two BRC's	264	3
Three BRC's	396	3

Source: Ref 11

Table 4.6 Consumer Price Index

Year	C.P.I	C.P.I.D
1972	104.77	104
1973	112.75	112
1974	125.00	124
1975	138.52	137
1976	148.90	147
1977	160.80	158
1978	175.10	170
1979	191.20	186
1980	210.60	205
1981	236.99	228
1982	262.05	250

C.P.I ∇ 1971 = 100

CPI = Consumer Price Index

CPID = Price Deflator for Consumer Expenditure

Source: Ref. 40

$$\text{H.P. required} = [0.798 V + 0.01049 V^2 + 0.0006166 V^3] X$$

$$\begin{aligned} \text{NO. OF LOCOS} &+ [0.5153 V + 0.00397 X V^2 \\ &+ 0.0001215 X V^3] X \text{ NO. OF COACHES} \end{aligned}$$

The above equation is for LRC train. The derivation of the above equation is given in Appendix A. Similar equations were derived for other technologies. Also, fuel consumption in gallons per hour has been derived as shown below (26):

$$\text{fc/hr} = 0.0472 X (\text{H.P required}) + 10.94 (R^2 = 0.995)$$

fuel cost per train - mile

$$= (0.0472 X (\text{H.P required}) + 10.94) X 1/V X.$$

[fuel cost/gallon]

According to Petro Canada, the diesel fuel as sold to VIA/CNR etc., is \$1.87/gallon which is used in calculations.

4.1.6 SWITCHING COSTS

Train switching activities include moving the trains to and from storage or repair tracks, turning the trains and changing the consists. The cost has been taken as \$0.18/train-km (8). Provision of locomotive at each end of the train alleviates the need for turning the trains or using switching engines to or from the loading tracks.

4.1.7 ON BOARD SERVICES

The on board services include labour and supplies for snack, meal, lounge, club/parlor and sleeping car services.

For VIA, this category accounts for 11 percent of all expenses and all are incurred directly. A cost of \$0.306/car.km is considered for this study (8).

4.1.8 STATION SERVICES

This category includes the cost of labour and materials needed for the operation and maintenance of stations, including associated employee benefits and administration.

For VIA this accounts for 10 percent of all expenses. VIA at present owns only a few of the stations in which its employees work, with most of the stations remaining under railway ownership. The cost per car.km is \$0.273 (8).

4.1.9 MARKETING AND RESERVATIONS

This covers labour and supplies related to advertising, promotion, reservations and ticketing. For VIA this accounts for 3 percent of all expenses. The cost per car.km is \$0.093 (8).

4.2.0 TAXES AND INSURANCE

This cost category includes all taxes and insurance requirements.

For VIA rail this amounts to less than 1 percent of its expenses. It is estimated that \$4.1 million of the total railways billings to VIA are for property taxes and this is equivalent to approximately one percent of total VIA direct and indirect cost. In this study, this cost has been taken as \$0.006/car.km (8).

4.2.1 DEPRECIATION

This category includes depreciation and amortization of equipment. Straightline depreciation method has been adopted in this study. For VIA two percent of all expenses are incurred in this category (8).

4.2.2 GENERAL AND ADMINISTRATIVE COSTS

This includes the expenses incurred in running the headquarters organization and other strictly administrative tasks, while

administrative cost more directly related to the provision of service are covered under a general support category.

For VIA, this accounts for 9 percent of all expenses. The cost of \$0.261 per car.km has been taken for this study (8).

4.2.3 (a) INTEREST COSTS

Interest cost category covers loan obligations. For VIA less than 1 percent of all expenses are incurred in this category, all directly. The cost of \$0.019 per car.km has been used for this study (8).

4.2.3 (b) COACH CLEANING COSTS

The coach cleaning cost of \$0.09/car.km has been considered for this study (8).

By using the above relationships and other cost figures, the costs were calculated for all rail technologies. These cost calculations are presented in the form of tables in Appendix B.

4.3 INTERCITY BUS TRANSPORTATION COSTS

4.3.1 COST CALCULATION FOR STANDARD BUS

The following cost categories are considered for this study:

---- Bus cost

---- Driver cost

---- Overhead cost

Table 4.7 illustrates the percentage of total operating costs for each cost category (21). These costs are the average costs across the whole Voyageur fleet.

(a) BUS COSTS

As shown in Table 4.7 this consists of capital cost of the bus, bus operating costs such as tires, fuel, maintenance etc., and bus maintenance costs such as wages and benefits, parts, cleaning etc. The capital cost of the standard bus varies between \$180,000 to \$200,000 (1982 dollars) and the utilization varies between 160 km/year to 240 km/year. The fuel consumption of the standard bus varies from 2.31 to 2.7 kilometres per gallon. For a major company the maintenance costs vary from \$0.15/ veh.km to \$0.20/veh.km of 1982 dollars. Since most of the passengers will be carried by class I & II carriers, the major company costs are considered for this study purpose (31). Table 4.8 gives the operating cost details of the major companies in Canada.

Table 4.7- The percentage cost of bus operation in the year 1978

Cost Item	% of total cost
Driver	
wages and benefits	41.4
expenses	2.1
sub - total	43.5
Bus unit	
leasing	11.3
Bus operation	
tires	2.1
fuel	11.9
insurance	1.5
licensing	1.2
miscellaneous	0.8
sub - total	17.5
Bus maintenance	
wages and benefits	10.2
parts	5.4
cleaning	1.3
exterior repair	2.0
other	1.4
sub - total	20.3
Administration	
overhead	7.4

Source: Ref. 21

Table 4.8 Major Intercity bus carrier costs (1982 dollars)

Capital cost	\$180,000 - \$200,000
Driver cost \$/km	0.5 - 0.6
Interest %	14 - 16
Utilization--number of km/year	160,000 - 240,000
Fuel l /km	0.36 - 0.43
Fuel \$/l	0.31 - 0.44
Maintenance cost \$/km	0.15 - 0.20
Fuel consumption	6.6 - 7.8 mpg 2.31 - 2.74 km/l
Overhead cost \$/km	0.12 - 0.20

Source: Hickling Partners Inc. "Intercity bus design: A route to the future", prepared for Transport Development Centre, Montreal, T.P. 4009, Jan. 1983.

(b) DRIVER COSTS

The present driver costs for a major company vary from \$0.5-\$0.6/km of 1982 dollars. From Statistics Canada's 1980 catalogue the total number of drivers with class I & II carriers in intercity passenger bus establishments are 3,206 and the total compensation was \$85,131,890 and the distance driven by these drivers was 198178039 kms. The driver cost comes to about \$0.43/km. In this study \$0.55/km has been used.

(c) OVERHEAD COSTS

These costs include the administration and general office expenses, salaries and wages, unemployment insurance, pension funds and other employee benefits, repairs and maintenance (office building and grounds), head office rental, depreciation (buildings and equipment), real estate and property taxes and other administrative and general office expenses. In the year 1980, the overhead costs incurred by class I & II carriers were reported to be as \$38,755,098 (31). Therefore, the overhead cost per kilometer were \$0.16/km. This rate has been used in this study.

4.3.2 COST CALCULATIONS FOR HIGH CAPACITY BUSES

BUS COSTS

The capital cost of an Articulated bus is approximately twice that for a Standard bus. The Double Deck bus will also cost the same amount as that of an Articulated bus. In terms of specifications, the greatest flexibility should be given to the manufacturer to produce the least costly bus, consistent with the quality required for intercity service. Greater standardization of components would eliminate costly special modifications for individual operators, whether vehicles are manufactured here or overseas. Since the capital cost of high capacity buses that are going to be manufactured in North America are not known exactly, a range of capital cost from \$300,000 to \$400,000 (1982 dollars) has been considered in this study.

Operating costs such as maintenance and fuel consumption are a function of the quality of the equipment used in the bus body (41). Therefore, there is a direct link between operating costs and capital costs.

Because the High capacity buses will require fewer units to carry the same number of passengers as standard buses, it would be practical to install more diagnostic equipment on each unit. This would reduce the time required to carry out maintenance and result in lower maintenance cost. Similarly, the use of lighter, although more costly, materials would reduce operating costs at the expense of capital costs.

It was estimated that a 10% increase in fuel consumption would be

a reasonable approximation for both Articulated and Double Decker buses and the Articulated Double Deck bus was estimated to incur a 25% increase (21).

(b) DRIVER COST

Results of a recent meeting between Hickling Partners Inc. and several North American operators indicated that the driver wages for high capacity buses will remain the same as that of the Standard bus (21). Therefore, the driver cost of \$0.55/km (1982 dollars) have been considered for all bus technologies.

(c) OVERHEAD COSTS

According to the intercity bus operator's opinion the overhead cost remains the same for both high capacity buses and standard buses. Therefore, the overhead cost of \$0.16/km (1982 dollars) has been used for all technologies.

Table 4.9 gives the details of costs for all bus technologies that are considered in this study.

Table 4.9 . Cost details of standard bus and test buses (1982 dollars)

Item	Standard bus	Articulated or Double Deck bus			Articulated Double Deck bus
Bus cost	\$180,000-\$200,000	\$300,000	\$350,000	\$400,000	\$500,000
Seating	45	61/70/80	61/70/80	61/70/80	100
Interest %	14-16	14-16	14-16	14-16	14-16
Utilization (km/yr)					
(000's)	160-240	160-240	160-240	160-240	160-240
Bus cost \$/km	0.17	0.24	0.28	0.32	0.40
Maintenance cost \$/km	0.18	0.28	0.32	0.37	0.46
Fuel \$/km	0.15	0.17	0.17	0.17	0.19
Total bus cost \$/km	0.50	0.69	0.77	0.86	1.05
Driver cost \$/km	0.55	0.55	0.55	0.55	0.55
Overhead cost \$/km	0.16	0.16	0.16	0.16	0.16
Total cost \$/km	1.21	1.40	1.48	1.57	1.76

Source: Hickling Partners Inc. "Intercity bus design: Aroute to the future", prepared for

Transport Development Centre, Montreal, T.P. 4009, Jan. 1983.

CHAPTER 5

STUDY CORRIDOR AND COST-EFFICIENCY ESTIMATION PROCESS

5.0 SYSTEM AND ROUTES

5.1 QUEBEC CITY - WINDSOR CORRIDOR

More than half of the Canada's population lives along the Quebec City - Windsor corridor (46). Also most of Canada's economic activity is concentrated along this corridor. The network joining the three largest cities in this corridor, namely Toronto, Montreal and Ottawa is the most heavily travelled in the corridor. All these cities are located within a distance of 800 km from each other.

The Windsor - Quebec corridor is a prime candidate for the cost analysis. Figure 5.1 shows the corridor and common carrier flows (9).

5.2 ROUTES CONSIDERED FOR ANALYSIS OF RAIL TECHNOLOGY

The passenger rail offers a lower level of service in the corridor as compared to other modes (except in the Toronto - Montreal link) (16). The \$322 million in subsidies granted to VIA in 1980 exceeds the total revenue of the bus industry, which was \$270 million in 1980 (31). The number of passengers carried by VIA was 5.9 million in 1979.

Common carrier origin - destination flows

FIGURE 5.1 QUEBEC CITY - WINDSOR CORRIDOR

Source : Ref. 9

A survey conducted by Transport Development Centre, on the corridor rail passenger services in 1978, suggests that more passengers were won over to rail from the automobile than from bus and air combined (42). The development of high speed corridor rail services is an alternative to intercity short haul air carriage. However, improvements to the existing roadbed and signalling devices require substantial capital cost.

Modern rail services, such as the LRC train, would provide improved passenger level of service and conserve fuel. Due to Canadian design and manufacturing activities involved, industrial spinoffs would result. High speed rail may eventually attract passengers from the bus and air modes.

In this study the following potential routes have been considered for the estimation of the cost-efficiency of different rail technologies. Figure 5.2 illustrates the Quebec City - Windsor railway network.

1. Quebec City - Montreal

2. Montreal - Ottawa

3. Montreal - Toronto

4. Ottawa - Toronto

Principal intercity railroad passenger routes

FIGURE 5.2 QUEBEC - WINDSOR RAIL NETWORK

Source: Ref. 9

5. Toronto - Kingston
6. Toronto - Windsor
7. Toronto - London - Sarnia
8. Toronto - Niagara Falls

Table 5.1 gives the routes and their respective distances.

5.3 SELECTED ROUTES FOR ANALYSIS OF BUS TECHNOLOGY

The Quebec - Windsor corridor is generally well served by intercity travel modes (16). Freeway type of road facilities link principal centers in the corridor. The automobile and the bus mode offer high levels of service. The principal passenger volumes are generated on the major intercity routes between Quebec city, Montreal, Toronto and Ottawa (50% of total ~~Revenue~~ pass.km). Voyageur is frequently required to operate extra buses during peak times to meet the passenger demand. Thus, a number of these extra sections could be reduced along with the cost of service, if a high capacity bus were available. These routes are therefore, potentially appropriate location for the application of high capacity buses.

For this study, the six major routes were selected for analysis. These high volume routes were selected because of the need for a frequency of departures of more than one bus load to show

Table 5.1 Rail distances between city pairs

Link	Distance in Kilometres
1. Quebec City - Montreal	290
2. Ottawa - Montreal	186
3. Montreal - Toronto	536
4. Ottawa - Toronto	443
5. Toronto - Kingston	253
6. Toronto - Windsor	357
7. Toronto - London - Sarnia	278
8. Toronto - Niagara Falls	131

Source: VIA Rail Corridor Time Table 1982

2

cost-efficiency of the new buses. If the high capacity bus is shown effective on the following routes, then future application of these high capacity buses to other routes could be considered. Table 5.2 gives the routes and their distance. Figure 5.3 illustrates the principal intercity highway network.

5.4 METHODOLOGY ADOPTED FOR RAIL TECHNOLOGY

Figure 5.4 illustrates the detailed methodology used for the cost calculation of different train technologies. The costs developed in chapter 4 are used as input into the Route Analysis Model. In this method for the given passenger demand on the selected routes, this model calculates the number of train sets required to carry the given passenger demand. Then using the input cost information it calculates the total cost for running all the trains for each month from January to December and also it calculates the total expenditure for the entire year. It also calculates the cost per passenger.km, cost per train.km and cost per seat.km. By using weighted average technique, the total cost per passenger.km, cost per train.km and cost per seat.km for the whole year were calculated.

The above calculations were made for the speeds of 70 km/h, 90 km/h, 105 km/h, 120 km/h, 150 km/h and 170 km/h for the Conventional train technology as well as Light, Rapid and Comfortable train technology (LRC). In the case of Self Propelled vehicle and Bi-level Rail Car technologies the speeds used are 80 km/h, 95 km/h, 110 km/h,

Table 5.2 Highway distances between city pairs

City pair	Distance in kilometres
1. Montreal - Quebec City	253
2. Montreal - Ottawa/Hull	195
3. Montreal - Toronto	540
4. Toronto - Ottawa/Hull	395
5. Toronto - Windsor	380
6. Toronto - London	190

Source: Voyageur Bus Time Tables

Principal intercity highway network

FIGURE 5.3 HIGHWAY NETWORK

Source : Ref. 9

130 km/h, 145 km/h, 160 km/h and 175 km/h (the difference in speed ranges is due to the conversion of imperial units to metric units). The cost calculations were made for each speed level noted above on each route and for all technologies. A computer program has been developed to calculate the costs and is presented in Appendix C.

5.5 INPUT DATA FOR RAIL TECHNOLOGY

The data for passenger demand on eight routes shown in Table 5.1 was estimated from the data supplied by Transport Canada, and is presented in Table 5.3. The cost data developed in the previous chapter was used as an input. The constraints are that one Conventional Locomotive or one LRC locomotive can haul five coaches only, and for the sixth coach it is necessary to use another locomotive. The total number of locomotives were calculated by using this constraint. In the case of Self Propelled vehicle or Bi-level Rail Car the maximum limit is three since more than three is uneconomical to run (11). For example a 4-car BRC costs \$14.00/vehicle.km and 5-car Conventional train cost \$13.23/vehicle.km and 5-car LRC train costs \$12.99/vehicle.km.

5.6 METHODOLOGY ADOPTED FOR BUS TECHNOLOGY

In order to estimate the cost efficiency of a new bus unit, two methods are considered.

----- Incremental Supply Model

Table 5.3 Estimated Monthly Passenger Data for the year 1981.

(one way trips)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Toronto and Eastern cities (Ottawa, Montreal, Kingston and Quebec City)	69400	72992	81397	70437	112830	95100	113985	125155	88434	68030	78215	82280
Western part of Toronto (Windsor, London, Sarnia and Niagara Falls)	38206	38843	47364	36703	40544	40283	44999	52246	39503	33192	34285	36864

Source: Transport Canada

Note: In analysis demand figures for each route were used.

----- Route Supply Model

1. INCREMENTAL SUPPLY MODEL

In this method cost per passenger.km of the unit is estimated as passenger loading is simulated. The expectation in this method is that areas of passenger demand can be identified which indicate lower costs than the standard bus. The use of this method can thus indicate if there are any areas in the passenger demand where the high capacity bus would be cheaper to operate than the standard bus. If there are no such areas the high capacity bus option should be dropped.

Figure 5.5 gives a detailed flow chart of the Incremental Supply Model. In this model the costs developed in the previous chapter are used as input to the model. Then, the passenger demand will be varied from 1 to 270. By dividing the total cost with passenger demand gives the cost for base and test buses. The next step is to find the difference in cost between the base bus and test bus and also the percentage difference in per passenger km costs. The current standard bus was assumed to carry 45 passengers which is the average of the current intercity operators fleet. All the candidate buses were then compared to the baseline bus (45 seat standard bus) and the results are plotted in terms of a percentage difference in per passenger km costs. The significance of the percentage difference is, that it gives the difference in cost per seat.km between the standard bus and test bus. To do this a computerized costing model was developed and

FIGURE 5.5 CONCEPTUAL FLOWCHART OF INCREMENTAL BUS SUPPLY MODEL

presented in Appendix C.

2. ROUTE SUPPLY MODEL

Figure 5.6 gives a detailed illustration of the methodology. As far as the procedure is concerned, it works out on the same lines as the one described for rail technology. The only difference is that the data obtained is aggregate in nature for the entire year and there are no speed ranges. A computer program has been developed and presented in Appendix C.

5.7 INPUT DATA FOR BUS TECHNOLOGY

Due to non availability of recent data the bus passenger demand used in this study was for the year 1976. However, according to Statistics Canada catalogues, growth in the bus passenger demand over the years 1965 to 1980 is insignificant. Therefore, cost calculations are made by using 1976 passenger data with the 1982 operating costs. Since the actual capital cost for the high capacity buses is not known, a number of cost estimates were assumed. These are \$300,000, \$350,000, and \$400,000 for an Articulated bus and Double Deck bus. In the case of Articulated Double Deck bus, the capital cost has been assumed as \$500,000 for the purpose of calculations. Comparisons between base bus and test bus were made with all cost calculations of high capacity buses. Table 5.4 gives the bus passenger demand data for the routes

FIGURE 5.6 CONCEPTUAL FLOW CHART FOR BUS ROUTE SUPPLY MODEL

Table 5.4 Origin - Destination Passenger Traffic
(thousands of one-way trips), 1976.

City pair	Bus traffic
1. Montreal - Quebec City	702
2. Montreal - Toronto	207
3. Montreal - Ottawa	675
4. Toronto - Ottawa	283
5. Toronto - Windsor	45
6. Toronto - London	135

Source: Ref. 16

selected in this study.

The above model calculates the cost per pass.km, cost per train.km/bus.km and cost per seat.km for each rail and bus technology and on route-by-route basis. Chapter 6 describes the detailed analysis of all the results.

CHAPTER 6

RESULTS

6.1 ANALYSIS OF RAIL RESULTS

Unit costs for passenger train operations vary considerably depending on such factors as train consist, route length, operating speeds, terminal utilization, and the age of the equipment.

The Route Supply Model described in chapter 5 has been used on each of the selected study routes and the results of each technology for Montreal - Toronto route are presented in Appendix D. For this study, a load factor of 60% was assumed.

Figure 6.0 illustrates the variation of cost/seat.km with increasing passenger demand for all rail technologies. For example, in the case of Conventional train the cost/seat.km at a load of fifty passengers is 13.36 cents but as the passenger load increases the cost decreases. At 100% load factor the cost is 4.65 cents/seat.km. As the passenger demand increases it requires addition of an extra coach which brings about an increase in operating cost to 6 cents/seat.km. Similar graphs are drawn for all technologies.

From Figure 6.0, it can be seen that the BRC technology produces

FIG. 6.0 COST/SEAT.KM VS PASSENGERS

lower operating cost at all load factors. At higher passenger demands LRC produces lower operating cost than SPV-2000 and Conventional train is costlier at all passenger demand levels. In this study monthly aggregate passenger data has been used but from Figure 6.0, it can be seen that even at the disaggregate passenger levels the BRC train produces lower operating cost/seat.km when compare with other technologies.

6.1.1 COST OF A SEAT - KM

The Bi-level Rail Car changes the economics of a passenger train service. The cost per seat-km is substantially lower than LRC, SPV or Conventional Locomotive Train (CL). At the load factor of 60% the cost of three car consist of Bi-level Rail Car at 80 km/h is \$0.035/seat.km (1982 dollars); a five car LRC train costs about \$0.048/seat.km; a three car Self Propelled vehicle is \$0.049/seat.km and a five car Conventional Locomotive train costs \$0.057/seat.km. From these values it has been found that the BRC train is able to produce seat kilometres at a cost substantially lower than other technological options. It is the most productive technology in terms of labour, fuel, maintenance and capital requirements. At a speed of 120 km/h a three car Bi-level Rail Car consist costs \$0.038/seat.km, LRC costs \$0.052/seat.km, three car SPV costs \$0.055/seat.km and a five car Conventional train costs \$0.061/seat.km.

Even at a speed of 160 km/h BRC train produces lower cost per seat.km than other equipment options. However, LRC technology is cheaper than SPV and Conventional train is always costlier than other consists and vehicles. Figures 6.1 to 6.3 indicate the cost/seat.km (1982 dollars) for all technologies with different seating capacities at different speeds. The main reason for the low cost of operation of the BRC technology is its higher seat carrying capacity, less operating crew requirement, and lower wear and tear of the track. The cost-efficiency of all rail technologies on each route is discussed in the following paragraphs. A load factor of 60% is assumed on all routes.

These routes are located within an area referred to as the "corridor" which is densely populated, by Canadian standards. On the other hand, there exists a host of alternative modes such as automobile, bus transit and air transport. The passenger rail must inevitably compete if it is to survive with this market.

6.1.2 MONTREAL - TORONTO ROUTE

This route is the most important route in the Quebec - Windsor corridor due to its high travel volume. As expected, for all technologies the cost per passenger-km is higher than the cost per seat.km, since this is a reflection of a load factor which is less than 100%. The cost per seat.km of a BRC train at a speed of 170 km/h is 26% lower than LRC train, 41.8% lower than SPV-2000 and 49% lower than the

FIGURE 6.1 COST/SEAT. KM AT 80KMPH

FIGURE 6.2 COST/SEAT. KM AT 120KMPH

FIGURE 6.3 COST/SEAT.KM AT 160KMPH

Conventional train. The cost per seat.km .vs.speed (km/h) is shown in figure 6.4.

From these results the following conclusion can be drawn. The BRC is the cheapest mode in comparison with any other technology. Next, LRC is the cheapest mode when compared with SPV and Conventional train. The cost difference between SPV and Conventional train is higher at lower speeds and the difference narrows at higher speeds.

6.1.3 OTTAWA - TORONTO ROUTE

Results show that the cost per seat.km at a speed of 170 km/h for a BRC technology is 23% lower than LRC train, 39.3% lower than SPV and 46.4% lower when compared with Conventional train. Figure 6.5 gives the cost details for all technologies on this route.

6.1.4 TORONTO - KINGSTON

The analysis of this route indicated that cost per seat.km of a BRC train at a speed of 80 km/h is 38% lower than the LRC train, 41% lower than the SPV technology and 63% lower than the Conventional train technology. At lower speed ranges (i.e. upto 75 km/h) SPV cost of operation per seat.km is lower than LRC technology and at higher speeds LRC train produce lower cost per seat.km than SPV and Conventional train technologies. Figure 6.6 illustrates how the cost varies for all

FIGURE 6.4 MONTREAL - TORONTO

FIGURE 6.5 OTTAWA - TORONTO

FIGURE 6.6 TØRØNTØ - KØNGSTØN

technologies.

6.1.5 MONTREAL - OTTAWA

In this case there are two potential routes. The CP's South shore line presents a more attractive improvement alternative. This route is 11 km shorter than the CN route, and has favourable curvature for high speed operation. Figure 6.7 presents the speed vs. cost/seat.km for the given demand of all technological options. On this route at a speed of 170 km/h the cost/seat.km of a BRC train is 23% lower than LRC train, 39% lower than SPV and 46% lower than the Conventional train option.

6.1.6 TORONTO - WINDSOR

From the results shown in Figure 6.8, at a speed of 130 km/h the BRC train produces 29% lower cost per seat.km than the LRC technology, 39% lower than the SPV technology and 53.1% lower than the Conventional train.

6.1.7 TORONTO - LONDON - SARNIA

The variation in cost per seat.km against speed is plotted for all technologies on this route in Figure 6.9. Results show that the BRC is 29% lower than LRC, 39.3% lower than SPV and 55% lower than the Conventional technology. At lower speed ranges the cost difference

FIGURE 6.7 MONTREAL - OTTAWA

FIGURE 6.8 TORONTO - WINDSOR

FIGURE 6.9 TORONTO - SARNIA

between SPV and LRC is small and it gradually increases at higher speed ranges.

6.1.8 TORONTO - NIAGARA FALLS

The BRC train at 130 km/h produces a cost/seat.km which is 32.5% lower than that for LRC train, 41.7% lower than SPV and 57.5% lower than Conventional train. It has been observed that on this route, SPV produces lower cost/seat.km than LRC train up to a speed of 75 km/h, but at higher speed ranges LRC produces lower cost/seat.km than SPV. The cost difference between SPV and Conventional train is more at lower speed ranges and very small difference at higher speed ranges. The details are shown in Figure 6.10.

6.1.9 MONTREAL - QUEBEC

On this route also BRC produces lowest cost/seat.km. It is 30% lower than LRC, 39% lower than SPV and 54% lower than the Conventional train. Figure 6.11 illustrates the details of all technologies on this route.

From the above analysis it can be concluded that on five routes at lower speed ranges SPV train produces lower cost/seat.km than LRC train, but at higher speed ranges LRC produces lower cost/seat.km than the SPV. On all the routes studied, the cost difference between the

FIGURE 6.10 TORONTO - NIAGARA FALLS

FIGURE 6.11 MONTREAL - QUEBEC

Conventional train and SPV is more at lower speed ranges and this difference reduces at a higher speed ranges. Finally, it has been observed that B1-level Rail Car is the most economical equipment option to run when compared with other technologies examined.

6.2 ANALYSIS OF THE BUS RESULTS

6.2.1 INCREMENTAL SUPPLY MODEL RESULTS

The output and the graphs of the Incremental Supply Model are presented in Appendix E.

The Double Deck or an Articulated bus data indicate that, although, the larger unit increases the servicing cost initially by 17%, as soon as the second conventional bus is needed, the new bus costs less by 43% than the standard bus. As the number of passengers increases there is an oscillation between regimes of higher cost and lower cost, with the magnitudes of the swings in the differences decreasing with the increasing passenger demand.

In all the figures it can be observed that the regimes of higher costs are less frequent with the larger capacity bus unit (80 seats) and the cost savings are always higher in terms of percentage. As the capital cost increases the initial differences will also increase. For example, if the capital cost of a larger bus is \$400,000 (1982

dollars), then the initial difference between standard bus and the test bus is 30%, but at a higher capital cost, it is always better to go for higher capacity buses. It can be noted also that, when the capital cost is \$400,000 the higher cost regimes occur three times in case of 61 seater bus and it occurs two times in the case of 70 and 80 seater buses. Therefore, it is always preferable to adopt higher capacity buses when the passenger demand is more than 61.

The most important cost comparison is for the Articulated Double Deck bus. In this case, the initial penalty is high (46%) but after the first 45 passengers, it is always cost advantageous to use the Jumbo bus. The cost savings for the 91 to 100 seat bus is 52%. Thus, this unit appears very attractive when there is a steady demand and it would be a good choice for heavy density corridor routes.

Finally, each of these candidate buses exhibits cost savings over the current operations at a number of specific passenger count regimes. There is no cost advantage of these larger buses at times of low passenger demand.

6.2.2 ROUTE SUPPLY MODEL RESULTS

The results of the Route Supply Model for six bus routes are presented in Appendix F. The standard bus produces higher cost per seat.km i.e. \$0.0268/seat.km, whereas the 61 seater Articulated or

Double Deck bus costs about \$0.0229/seat.km. The 70 seater new option bus costs about \$0.02/seat.km and the 80 seater bus costs about \$0.0175/seat.km.

The cost per seat.km of a 61 seat Articulated or Double Deck bus is 14.5% lower than the standard bus. The standard bus cost is 25% higher than 70 seater bus and 34.7% higher than the 80 seater bus. Therefore, on heavy demand routes it is always economical to run an 80 seat bus than 61 or 70 seat bus. However, all the three buses are more economical than the standard bus on all routes. If the capital cost of an Articulated or Double Deck bus is \$400,000 then the 80 seat bus is 27% lower than the standard bus. The cost per bus.km for a standard bus is \$1.21/bus.km, \$1.57/bus.km for a 80 seat candidate bus and \$1.76/bus.km for 100 seat Articulated Double Deck bus. Eventhough, the capital cost is high the driver productivity increases in the case of higher capacity buses.

Analysis indicated that the cost per seat.km of an Articulated Double Deck bus (Jumbo bus) is 34% lower than the standard bus. These buses are very sensitive to passenger demand and thus, they are cost-effective on fewer departures than the other alternative options. They are most cost effective on Montreaal - Ottawa and Montreal - Quebec City routes.

All the larger capacity buses assessed in this study indicate

significant potential to reduce the cost of servicing the existing passenger demand on all the routes.

By adopting high capacity buses, the frequency of buses per day will be reduced as compared to standard buses. By reducing the frequency of service the passenger demand will be affected. Therefore, these high capacity buses are best option only on high demand routes, where the number of passengers per departure is more than the standard bus.

CHAPTER 7

SUMMARY, CONCLUSIONS AND EXTENSIONS

7.1 SUMMARY

In recent years, there has been a growing concern about the future of transportation. Presently, attention is being focussed on the common transportation modes, especially rail and bus. In order to provide improved services, huge investments are necessary. It would, therefore, be necessary to plan and design an efficient transport system.

The rail service in North America faces a difficult future. In spite of spending billions of dollars on maintaining and re-equipping the intercity rail service, the usage of rail service is less than 2% of all journeys. The government and the operating agency are concerned about the fact that the level of demand is insufficient to make profits when compared with the expense of rail service. In spite of massive subsidies to Canada's passenger rail services, service quality has continued to deteriorate, and traffic volume continued to decline for many years.

Until the 1930's, the railroads dominated the transport market. The auto and bus, terminated the monopoly of railroad for short haul and air for long haul. The automobile dominated the market because of

its flexibility and perceived low operating costs. As there was no suitable technology available to reduce the cost of the locomotive hauled train, it could not compete with the automobile. When expansion of highway system became commercially viable, first the short haul and then the long haul passengers abandoned the train service. The public is concerned with the level of service (i.e., high speed and more frequency) and the quality of the equipment. Therefore, there is a need to find the new innovative technology which can attract more passengers and produce lower cost/seat.km.

The design and development of intercity buses in North America has been at a virtual standstill for many years. Bus development in other western countries has progressed at a much faster rate. Because of the government indifference to intercity bus operations, Canada is lagging in new bus designs. Most operators have realized that new bus designs must be brought into Canada.

The purpose of this thesis was to provide an assessment of the cost-efficiency in the use of the three new rail technologies along with the Conventional train and three bus technologies, along the Quebec - Windsor corridor.

Different cost variables (Table 4.1) were defined and quantified for the Conventional Locomotive Hauled train, Light, Rapid and Comfortable train, Self Propelled Vehicle (SPV-2000) and Bi-level

Rail Car. Eight important routes on Quebec - Windsor corridor were selected for the estimation of cost-efficiency of the above mentioned technologies. In order to do this, a Route Supply Model was developed. By using cost data of all technologies and passenger demand on all eight routes as an input to the model, a computerized program was developed to find out the required number of trains, total cost of operation, cost/train.km and cost/seat.km. Then graphs were plotted between speed in km/h.vs.cost/seat.km and conclusions were drawn.

Similarly, three new bus technologies such as Articulated bus, Double Deck bus and an Articulated Double Deck bus were considered. The bus operating cost and maintenance cost, driver cost and overhead costs were calculated for all the three new bus technologies including Standard bus. Then, six routes in the Quebec - Windsor corridor were selected to assess their cost-efficiency (in terms of cost of operation) of all the three larger buses along with the standard bus. In order to compare the cost of various units two methods were developed.

a) Incremental Supply Model - an analysis of the cost of servicing a range of passenger demands, and

b) Route Supply Model - an analysis of the number of buses required to satisfy the given demand on

all routes and their cost of operation.

By using the costs developed in chapter 4 as an input to the model a computer program was developed to calculate the percentage change of cost between the standard bus and the new options. In the case of Route Supply Model, it calculates the number of buses required on a given route, its total cost of operation, cost/bus.km, cost/seat.km for all the new bus options.

The conclusions drawn from the results are presented in next section.

7.2 CONCLUSIONS

7.2.1 RAIL TECHNOLOGY

The passenger rail as is now operated in Canada is unable to compete with the other modes of transportation and is facing heavy losses. This is mainly because of the usage of outdated technology and low service quality. The introduction of the modern high speed trains along the Quebec - Windsor would not only improve the service quality but also reduces the operating costs. Nevertheless, the development of a high speed rail service would require comprehensive and innovative transportation investigation.

From the analysis of various rail technology results, it can be concluded that the Bi-level Rail Car produces lower cost per seat.km than all other technological operations. It is capable of operating at speed ranges upto 170 km/h, over trackage which has been suitably upgraded, with much less damage to the infrastructure than would be caused by a Conventional train.

-- The BRC is the most productive equipment in terms of crew, fuel, maintenance and capital cost requirements. It reduces the trackway maintenance cost because of its lower weight than other technologies.

-- The BRC combines technology of the Self Propelled Rail Diesel Car and the Bi-level Rail passenger car. Developments in engine and transmission technology make the BRC a reliable vehicle.

-- The government subsidies can be reduced without having to discontinue the service.

-- The redirection of funds can be used to improve the rail line capacity, higher speeds etc,. These would upgrade the level of service and lead to increase in ridership.

-- Due to its high passenger carrying capacity and faster terminal turnaround times, fewer cars would be necessary to operate than would

be the case with the Conventional train and the SPV-2000.

-- The cost of BRC train increases incrementally with each additional car. Locomotive hauled train cost increase marginally with each additional coach as the cost of Locomotive can be spread out over more cars. It is uneconomical to run more than three Bi-level Rail Cars.

-- An additional advantage of the BRC is its Bi-directional operation. Thus it can spend more of its time in operation rather than being readied for service.

-- Maintenance facilities could be moved to small areas in or near the passenger terminals.

-- One BRC power car can haul non powered BRC cars. The use of non powered trailers will increase the train capacity and reduce the equipment purchase cost and maintenance cost due to the reduction in the number of engines. In an earlier study, it has been found that the cost saving of about 5% to 10% would be possible over the all powered BRC train of the same consist size (11).

-- The next train technology which produces low cost/seat.km is the LRC. Low costs occur on almost all routes.

-- On low density routes where demand seldom peaks over 88 passengers per trip, the SPV-2000 will be the best option. Example routes are Toronto - Kingston, Toronto - Niagara Falls and Montreal - Quebec City. On long distance routes, LRC is better in terms of unit costs.

-- The Conventional Locomotive train is not efficient and should be removed gradually from service.

By adopting new rail technologies, a significant improvement in the economics of passenger train service can occur. The government and the manufacturers should start working on these technologies for a new rail era.

7.2.2 BUS TECHNOLOGY

Most bus operators have realized that changes in bus design is necessary in order to reduce the cost of operation. The passenger today expects more in terms of a smooth riding, quiet, comfortable and vibration free mode of surface travel. Length restriction laws concerning buses should be relaxed in all provinces, and replaced by requirements of vehicle manoeuvrability.

Specific conclusions are given below:

-- An Articulated or Double Deck bus always produces lower cost

of operation/seat.km on the routes where the passenger demand is high.

-- The Articulated bus appears to present fewer operational restrictions as compared to Double Deck bus. One draw back will be the manoeuvrability of these buses at the terminals. However, this problem can likely be alleviated by small structural changes to allow for curb parking instead of the angle parking which is the current practice.

-- Based on the analysis presented in this thesis, it appears that the introduction of any one of the large buses would lower operating costs on all six routes analyzed. The greatest reductions are achieved with the use of Articulated Double Deck bus unit. However, because of operational constraints, it is doubtful whether this type of bus will be accepted by the carrier. The Articulated bus appears to be more favourably received by carriers.

In summary, the concept of introducing larger buses in to the intercity market appears to be economically and operationally feasible.

7.3 EXTENSIONS

In this thesis during the cost calculation process, the basic material was drawn from several sources and a number of assumptions were made. These values are based on the existing equipment. If the

data on the new equipment were available, it would improve the cost figures.

Future new technologies can be tested by using the Route Supply Model and Incremental Supply Model as outlined in this thesis for their cost-efficiency.

Data on travel volumes for bus routes is difficult to find and seems to vary from source to source. With the availability of reliable passenger data the cost efficiency estimates of the new bus technology can be improved.

The cost efficiency of the new bus technologies can be tested with the disaggregate passenger demand data i.e., daily passenger demand or hourly demand data. Study can also be done with the minimum number of departures and their effect on passenger demand. This illustrates how the operator can make decisions on the selection of technology and operating policies.

Finally, there is not much experience with larger buses in Canadian intercity market. The actual operation of these buses through demonstrations will result in additional information than obtained through this research.

REFERENCES

1. Bett, M. et. al., "VIA Rail/Bus competition",
Transport Management Training Centre,
Transport Canada, Oct. 1978, Ottawa.
2. Bombardier Ltd., "LRC train - Intercity Passenger
System", brochure, Boucherville, Quebec, 1981.
3. Canada Ministry of Transport, "Statement by
Transport Minister Otto Long on Rail
Passenger Services", supplemented with a
paper on "A Canadian Rail Passenger Program",
Ottawa, Jan. 1976.
4. Canadian Transport Commission, "Intercity Passenger
Transport Study", Information Canada,
Canada, 1971.
5. Canadian Transport Commission, "Intercity Passenger
Transport in Canada; A review of the existing
passenger transport systems, Report No. 252,
1975 and Analysis of the consequences of
alternative pricing and network strategies",
Report No. 254, 1976, Research Branch, Ottawa.
6. Canadian Transport Commission, "Transport Review,
Trends and Selection Issues", Research
Branch, Ottawa, March 1979, pp 78.

7. Canadian Transport Commission, "Truck and Rail Technological Developments to 1990", Research Branch, 10-78-19, Ottawa.
8. Canadian Transport Commission, "A comparison of AMTRAK and VIA costing approaches", March 31, 1982.
9. Canadian Transport Commission, "Intercity Passenger Transport Study", Research Branch, Sept. 1970.
10. De LewCather Canada Ltd., "The potential of high capacity buses in Canada", March, 1979.
11. Smith, Douglas N.W., "The Bi-level Self Propelled Rail Car : An Economic Analysis of the impact of Technological Innovation on the viability of Rail Passenger Service", June, 1982.
12. Hamzawi, S.G., "An optimization methodology for design and evaluation of intercity passenger transport system", Ph.D thesis, Carleton University, March, 1977.
13. Valentine, Harry., "Addendum to report on larger intercity buses", Carleton University, 1980.
14. Hiller, V.A.W, Pittack, F.W., "Fundamentals of motor vehicle technology", Hutchinson Educational, London, 1972.

15. Khan, A.M., "An analysis of VIA's potential in fulfilling rail passenger policy objectives", Carleton University, November, 1980.
16. Khan, A.M., "Intercity Passenger Transport Energy Efficiency, Data Base and Case Study", prepared for Strategic Studies Branch, Transport Canada, June, 1979.
17. Khan, A.M., "Planning and Evaluation of Alternative Routes of Regional Transport Systems", Department of Civil Engineering, University of Waterloo, January, 1968.
18. Lukasiewicz, J., "Modernization of Railways in Canada", Carleton University, 1973.
19. Lukasiewicz, J. "The Dilema of Passenger Rail in Canada, The Eighties: A new rail era", Canadian Institute of Guided Ground Transport, Queen's University at Kingston, Ontario, April, 1978.
20. Morlok, Edward. K., "Introduction to Transportation Engineering and Planning", McGraw Hill Publication, 1978.
21. Lea, N.D and Associates, "A feasibility of the introduction of larger capacity intercity buses", April, 1979.

22. Phillips, R.A.J., "Canada's Railways", McGraw Hill
Company of Canada Ltd., 1968.
23. Mittal, Ram. K., and Joseph Santamaria., "State of
the art in passenger rail rolling stock
equipment", prepared for U.S. Department of
Transportation, final report, September, 1977.
24. Resource Management Corporation, pp.6-39.
25. Reschenthaler, G., "Performance under regulation:
The Canadian Intercity Bus Industry",
Edmonton, 1980.
26. Orchin, Robert., "Development of cost estimation
methods for intercity passenger rail service",
senior project report, Carleton University,
March, 1981.
27. Science Council of Canada, "Opportunities in Canadian
Transportation: Rail and Bus as modes/industry",
Proceeding of a conference held in Montreal,
1979.
28. Science Council of Canada, "Line diagrams of Bi-level
Rail Car", opportunities in Canadian transporta-
tion, 1982.
29. Statistics Canada, "Railway Transport operating and
traffic statistics, Catalogue No. 52-210,
Ottawa, 1970-1980.

- 30. Statistics Canada, "Railway Transport part 1,
Comparative Summary of Statistics, 1971-75,
Catalogue No 52-207, Ottawa, December, 1976.
31. Statistics Canada, "Annual passenger bus and urban
statistics", Catalogue No 52-215, 1980.
32. Department of Transportation (U.S.A.), The Double
Deck bus demonstration project-executive
summary", UMTA-MA-06-0049-78-7.
33. ICC, The intercity bus industry", May, 1978, pp 21.
34. TOPS On-Line Services Inc., "Procedures for
analysing the economic costs of rail road
roadway for pricing purposes", Vol I & II,
prepared for U.S.D.O.T, Washington D.C,
January, 1976.
35. Transport Canada, "Study of competition and
regulation in the Canadian Intercity Bus
Industry, Study No. 2, "Market Characteristics
of the Canadian Intercity Bus Industry",
Ottawa, 1980.
36. Transport Canada - Strategic Planning, "Capital
stock and investment in the transport services
industry rail transport", T.P. 3087, 1980.
37. Transport Canada, "A study of competition and
regulation in the Canadian Intercity Bus

Industry", Report No. 2, T.P.3031 E, 1980.

38. Transport Canada, "Ownership patterns and foreign influence in the Canadian Intercity Bus Industry", T.P. 3031 E, 1980.
39. Transport Canada Development Centre, "Guided Ground Transportation Study", November, 1971.
40. Transport Canada, "Consumer Price Index Tables", 1982, Ottawa.
41. Transport Canada, "The potential for high capacity buses in Canada", March 1979.
42. Transport Canada, "Study of competition and regulation in the Canadian Intercity Bus Industry", Study No. 5, 1980.
43. Department of Transportation (U.S.A), "Northeast Corridor Transportation Project Report", P.B. 190-929, Washington D.C, 1970.
44. Department of Transportation (U.S.A.), "Survey to determine the potential for improved rail advanced vehicle service - rail cost analysis", December, 1972.
45. VIA Rail Canada, "Annual Report", 1979.
46. Yeates, M., "Main street: Windsor to Quebec City", Information Canada, Ottawa, 1978, pp 13 & 27.

APPENDIX A

RELATIONSHIP BETWEEN HORSEPOWER AND SPEED

Horsepower required .vs. speed

Inherent resistance

$$\text{--- locomotive } R = 1.3 T + 0.03 TV + CAV^2 + 29 N$$

$$\text{--- coaches } R = 1.3 T + 29 N + 0.03 TV + 0.041 V^2$$

Where,

T = weight in Tons

N = number of axles

V = speed in mph

A = cross sectional area ft^2

C = resistance parameter = 0.0017 for streamlined locomotives

$$\Sigma R \leq M = 375 p \eta / V$$

Where,

p = horse power

V = speed

η = transmission efficiency

M = provided tractive force

Since, we do not know the number of coaches or locomotives, let

loco = number of locomotives

coach = number of coaches

Now, $\Sigma R \leq M$

$$(1.3 T + 29 N + 0.003 TV^2 + CAV^2) \times \text{number of locomotives} \\ + (1.3 T + 29 N + 0.03 TV + 0.041 V^2) \times \text{number of coaches}$$

$$\leq 375 p \eta / V$$

substitute the technological values of each technology and find the speed V.

From the above equation we can get horse power (h.p) required,
for example for LRC train the following equation can be derived.

$$\begin{aligned} \text{h.p. required} = & (0.798 V + 0.0104 V^2 + 0.0006166 V^3) \times \text{number of} \\ & \text{locomotives} \\ & + (0.5153 V + 0.00397 V^2 + 0.0001215 V^3) \times \text{number} \\ & \text{of coaches} \end{aligned}$$

Each LRC locomotive can provide 2000 h.p at rail .

Therefore,

$$(\text{h.p. required}) \leq (\text{h.p. provided})$$

This relationship MUST hold .

Source : Ref 20 and 26

APPENDIX B
COST CALCULATIONS FOR VARIOUS RAIL TECHNOLOGIES

Cost of Conventional Train with Two coaches

Number of Seats ---- 144 (Cost in \$/veh-km of 1982 dollars)

SPEED (KM/H)

	70	90	105	120	135	150	170	185	200
Maintenance of loco	.216	0.283	0.349	0.416	0.482	0.548	0.615	0.681	0.750
Maintenance of coach	0.038	0.100	0.163	0.231	0.295	0.363	0.423	0.486	0.551
Fuel cost	0.61	0.631	0.688	0.769	0.869	0.994	1.120	1.263	1.431
Trackway maintenance	0.64	0.70	0.763	0.831	0.90	0.970	1.05	1.13	1.206
Crew cost	→	→	→	→	2.34	→	→	→	→
On board services	→	→	→	→	0.608	→	→	→	→
Station services	→	→	→	→	0.547	→	→	→	→
Marketing and Reservations	→	→	→	→	0.186	→	→	→	→
Taxes and Insurance	→	→	→	→	0.012	→	→	→	→
Depreciation	→	→	→	→	0.350	→	→	→	→
of loco and coaches	→	→	→	→	→	→	→	→	→
General Administration	→	→	→	→	0.522	→	→	→	→
Interest	→	→	→	→	0.037	→	→	→	→
Cleaning	→	→	→	→	0.180	→	→	→	→
Train Dispatching	→	→	→	→	0.180	→	→	→	→
Total Cost	6.46	6.68	6.93	7.21	7.51	7.84	8.17	8.52	8.90

Cost of Conventional Train with Three Coaches

Number of Seats ---- 216 (Cost in \$/veh-km of 1982 dollars)

SPEED (KM/H)

	70	90	105	120	135	150	170	185	200
Maintenance of loco	0.216	0.283	0.349	0.416	0.482	0.548	0.615	0.681	0.750
Maintenance of coach	0.056	0.150	0.244	0.347	0.443	0.544	0.634	0.729	0.769
Fuel cost	0.669	0.706	0.775	0.869	0.988	1.119	1.263	1.438	1.525
Trackway maintenance	0.719	0.781	0.856	0.931	1.006	1.094	1.181	1.269	1.500
Crew cost	→	→	→	→	2.813	→	→	→	→
On board services	→	→	→	→	0.912	→	→	→	→
Station services	→	→	→	→	0.819	→	→	→	→
Marketing and Reservations	→	→	→	→	0.279	→	→	→	→
Taxes and Insurance	→	→	→	→	0.019	→	→	→	→
Depreciation	→	→	→	→	→	→	→	→	→
of loco and coaches	→	→	→	→	0.530	→	→	→	→
General Administration	→	→	→	→	0.783	→	→	→	→
Interest	→	→	→	→	0.057	→	→	→	→
Cleaning	→	→	→	→	0.270	→	→	→	→
Train Dispatching	→	→	→	→	0.180	→	→	→	→
Total Cost	8.32	8.58	8.89	9.23	9.58	9.97	10.36	10.78	11.17

Cost of Conventional Train with Four Coaches

Number of Seats ---- 288 (Cost in \$/veh-km of 1982 dollars)

SPEED (KM/H)

	70	90	105	120	135	150	170	185	200
Maintenance of loco	0.216	0.283	0.349	0.409	0.482	0.548	0.615	0.681	
Maintenance of coach	0.075	0.200	0.325	0.463	0.590	0.725	0.845	1.025	
Fuel cost	0.73	0.781	0.863	0.975	1.101	1.25	1.419	1.606	
Trackway maintenance	0.794	0.863	0.950	1.031	1.113	1.206	1.306	1.406	
Crew cost	→	→	→	→	3.28	→	→	→	
On board services	→	→	→	→	1.22	→	→	→	
Station services	→	→	→	→	1.09	→	→	→	
Marketing and Reservations	→	→	→	→	0.372	→	→	→	
Taxes and Insurance	→	→	→	→	0.025	→	→	→	
Depreciation	→	→	→	→	→	→	→	→	
of loco and coaches	→	→	→	→	0.70	→	→	→	
General Administration	→	→	→	→	1.044	→	→	→	
Interest	→	→	→	→	0.076	→	→	→	
Cleaning	→	→	→	→	0.360	→	→	→	
Train Dispatching	→	→	→	→	0.180	→	→	→	
Total Cost	10.16	10.47	10.83	11.23	11.63	12.08	12.53	13.07	

Cost of Conventional Train with Five Coaches

Number of Seats ----- 360 (Cost in \$/veh-km of 1982 dollars)

-SPEED (KM/H)

	70	90	105	120	135	150	170	185	200
Maintenance of loco	0.216	0.283	0.349	0.409	0.482	0.548	0.615		
Maintenance of coach	0.094	0.250	0.406	0.581	0.738	0.906	1.056		
Fuel cost	0.80	0.863	0.956	1.075	1.219	1.380	1.569		
Trackway maintenance	0.863	0.944	1.031	1.12	1.213	1.313	1.425		
Grew cost	→	→	→	→	3.75	→	→		
On board services	→	→	→	→	1.52	→	→		
Station services	→	→	→	→	1.365	→	→		
Marketing and Reservations	→	→	→	→	0.465	→	→		
Taxes and Insurance	→	→	→	→	0.031	→	→		
Depreciation	→	→	→	→	→	→	→		
of loco and coaches	→	→	→	→	0.88	→	→		
General Administration	→	→	→	→	1.305	→	→		
Interest	→	→	→	→	0.95	→	→		
Cleaning	→	→	→	→	0.45	→	→		
Train Dispatching	→	→	→	→	0.18	→	→		
Total Cost	12.01	12.38	12.78	13.23	13.69	14.19	14.71		

Cost of IRC Train with Two Coaches

Number of Seats ---- 168 (Cost in \$/veh-km of 1982 dollars)

SPEED (KM/H)

	70	90	105	120	135	150	170	185	200
Maintenance of loco	0.216	0.283	0.349	0.416	0.482	0.548	0.615	0.681	0.750
Maintenance of coach	0.038	0.10	0.163	0.231	0.295	0.363	0.423	0.486	0.551
Fuel cost	0.525	0.531	0.563	0.613	0.681	0.763	0.850	0.944	0.956
Trackway maintenance	0.550	0.600	0.656	0.713	0.775	0.831	0.900	0.969	1.006
Crew cost	→	→	→	→	2.344	→	→	→	→
On board services	→	→	→	→	0.608	→	→	→	→
Station services	→	→	→	→	0.547	→	→	→	→
Marketing and Reservations	→	→	→	→	0.186	→	→	→	→
Taxes and Insurance	→	→	→	→	0.012	→	→	→	→
Depreciation	→	→	→	→	→	→	→	→	→
of loco and coaches	→	→	→	→	0.40	→	→	→	→
General Administration	→	→	→	→	0.522	→	→	→	→
Interest	→	→	→	→	0.037	→	→	→	→
Cleaning	→	→	→	→	0.18	→	→	→	→
Train Dispatching	→	→	→	→	0.18	→	→	→	→
Total Cost	6.35	6.53	6.75	6.99	7.25	7.52	7.80	7.90	8.28

Cost of LRC Train with Three Coaches

Number of Seats ---- 252 (Cost in \$/veh-km of 1982 dollars)

SPEED (KM/H)

	70	90	105	120	135	150	170	185	200
Maintenance of loco	0.216	0.283	0.349	0.416	0.482	0.548	0.615	0.681	
Maintenance of coach	0.056	0.150	0.244	0.347	0.440	0.544	0.631	0.731	
Fuel cost	0.581	0.594	0.634	0.700	0.775	0.869	0.975	1.10	
Trackway maintenance	0.613	0.669	0.731	0.794	0.863	0.931	1.006	1.08	
Crew cost	→				2.813			→	
On board services	→				0.912			→	
Station services	→				0.819			→	
Marketing and Reservations	→				0.279			→	
Taxes and Insurance	→				0.109			→	
Depreciation									
of loco and coaches	→				0.620			→	
General Administration	→				0.793			→	
Interest	→				0.057			→	
Cleaning	→				0.270			→	
Train Dispatching	→				0.180			→	
Total Cost	8.21	8.45	8.71	9.00	9.31	9.64	9.98	10.34	

Cost of LRC train with Four Coaches

Number of Seats ----- 336 (Cost in \$/veh-km of 1982 dollars)

SPEED (KM/H)

	70	90	105	120	135	150	170	185	200
Maintenance of loco	0.216	0.283	0.349	0.416	0.482	0.548	0.615	0.681	
Maintenance of coach	0.075	0.200	0.325	0.463	0.590	0.725	0.845	1.025	
Fuel cost	0.625	0.656	0.706	0.781	0.869	0.981	1.10	1.169	
Trackway maintenance	0.669	0.731	0.800	0.875	0.944	1.019	1.10	1.144	
Crew cost	→	→	→	→	3.280	→	→	→	
On board services	→	→	→	→	1.220	→	→	→	
Station services	→	→	→	→	1.090	→	→	→	
Marketing and Reservations	→	→	→	→	0.372	→	→	→	
Taxes and Insurance	→	→	→	→	0.025	→	→	→	
Depreciation	→	→	→	→	→	→	→	→	
of loco and coaches	→	→	→	→	0.830	→	→	→	
General Administration	→	→	→	→	1.044	→	→	→	
Interest	→	→	→	→	0.076	→	→	→	
Cleaning	→	→	→	→	0.360	→	→	→	
Train Dispatching	→	→	→	→	0.180	→	→	→	
Total Cost	10.062	10.35	10.65	11.01	11.36	11.75	12.14	12.50	

Cost of LRC Train with Five Coaches

Number of Seats ----- 420 (Cost in \$/veh-km of 1982 dollars)

SPEED (km/h)

	70	90	105	120	135	150	170	185	200
Maintenance of loco	0.216	0.283	0.349	0.416	0.482	0.548	0.615		
Maintenance of coach	0.094	0.250	0.406	0.581	0.738	0.906	1.056		
Fuel cost	0.681	0.713	0.775	0.863	0.969	1.088	1.231		
Trackway maintenance	0.725	0.794	0.869	0.944	1.019	1.10	1.194		
Crew cost	→	→	→	3.75	→	→	→		
On board services	→	→	→	1.52	→	→	→		
Station services	→	→	→	1.365	→	→	→		
Marketing and Reservations	→	→	→	0.465	→	→	→		
Taxes and Insurance	→	→	→	0.031	→	→	→		
Depreciation	→	→	→	→	→	→	→		
of loco and coaches	→	→	→	1.030	→	→	→		
General Administration	→	→	→	1.305	→	→	→		
Interest	→	→	→	0.095	→	→	→		
Cleaning	→	→	→	0.450	→	→	→		
Train Dispatching	→	→	→	0.180	→	→	→		
Total Cost	11.91	12.23	12.59	12.99	13.40	13.83	14.29		

Cost of One Self Propelled Vehicle - 2000
 Number of Seats ----- 88 (Cost in \$/veh.km of 1982 dollars)

SPEED (KM/H)

	80	95	110	130	145	160	175
Maintenance cost	0.284	0.388	0.481	0.581	0.675	0.775	0.875
Fuel cost	0.419	0.431	0.463	0.506	0.563	0.638	0.719
Trackway cost	0.563	0.613	0.663	0.719	0.775	0.838	0.894
Crew cost	→	→	→	0.938	→	→	→
On board services	→	→	→	0.304	→	→	→
Station services	→	→	→	0.273	→	→	→
Marketing and Reservations	→	→	→	0.093	→	→	→
Taxes and Insurance	→	→	→	0.006	→	→	→
Depreciation	→	→	→	0.250	→	→	→
General Administration	→	→	→	0.261	→	→	→
Interest	→	→	→	0.019	→	→	→
Cleaning	→	→	→	0.09	→	→	→
Train Dispatching	→	→	→	0.18	→	→	→
Total Cost	3.68	3.85	4.02	4.22	4.43	4.67	4.90

Cost of Two Self Propelled Vehicles - 2000
 Number of Seats ---- 176 (Cost in \$/veh.km of 1982 dollars)

SPEED (KM/H)

	80	95	110	130	145	160	175
Maintenance cost	0.560	0.775	0.963	1.163	1.350	1.550	1.75
Fuel cost	0.419	0.431	0.463	0.506	0.563	0.638	0.719
Trackway cost	0.806	0.880	0.963	1.044	1.125	1.219	1.306
Crew cost	→	→	→	1.406	→	→	→
On board services	→	→	→	0.608	→	→	→
Station services	→	→	→	0.546	→	→	→
Marketing and Reservations	→	→	→	0.186	→	→	→
Taxes and Insurance	→	→	→	0.012	→	→	→
Depreciation	→	→	→	0.500	→	→	→
General Administration	→	→	→	0.322	→	→	→
Interest	→	→	→	0.038	→	→	→
Cleaning	→	→	→	0.180	→	→	→
Train Dispatching	→	→	→	0.180	→	→	→
Total Cost	5.96	6.26	6.57	6.89	7.22	7.59	7.95

Cost of Three Self Propelled Vehicles - 2000
 Number of Seats 264 (Cost in \$/veh.km of 1982 dollars)

SPEED (KM/H)

	80	95	110	130	145	160	175
Maintenance cost	0.856	1.163	1.381	1.744	2.025	2.325	2.625
Fuel cost	0.419	0.431	0.463	0.506	0.563	0.638	0.719
Trackway cost	1.006	1.10	1.20	1.306	1.406	1.525	1.638
Crew cost	→	→	→	1.406	→	→	→
On board services	→	→	→	0.912	→	→	→
Station services	→	→	→	0.819	→	→	→
Marketing and Reservations	→	→	→	0.279	→	→	→
Taxes and Insurance	→	→	→	0.019	→	→	→
Depreciation	→	→	→	0.750	→	→	→
General Administration	→	→	→	0.783	→	→	→
Interest	→	→	→	0.057	→	→	→
Cleaning	→	→	→	0.270	→	→	→
Train Dispatching	→	→	→	0.180	→	→	→
Total Cost	7.76	8.17	8.52	9.03	9.47	9.96	10.46

Cost of One BI-level Rail Car
 Number of Seats ---- 132 (Cost in \$/veh.km of 1982 dollars)
 SPEED (KM/H)

	80	95	110	130	145	160	175
Maintenance cost	0.284	0.388	0.450	0.581	0.675	0.775	0.875
Fuel cost	0.456	0.469	0.506	0.556	0.625	0.706	0.800
Trackway cost	0.675	0.738	0.800	0.869	0.938	1.100	1.080
Crew cost	→	→	→	0.938	→	→	→
On board services	→	→	→	0.304	→	→	→
Station services	→	→	→	0.273	→	→	→
Marketing and Reservations	→	→	→	0.093	→	→	→
Taxes and Insurance	→	→	→	0.006	→	→	→
Depreciation	→	→	→	0.350	→	→	→
General Administration	→	→	→	0.261	→	→	→
Interest	→	→	→	0.019	→	→	→
Cleaning	→	→	→	0.090	→	→	→
Train Dispatching	→	→	→	0.180	→	→	→
Total Cost	3.93	4.11	4.27	4.52	4.75	5.00	5.27

Cost of Two M-level Rail Cars
 Number of Seats ---- 264 (Cost in \$/veh.km of 1982 dollars)

SPEED (KM/H)

	80	95	110	130	145	160	175
Maintenance cost	0.569	0.775	0.963	1.160	1.350	1.550	1.750
Fuel cost	0.450	0.469	0.506	0.556	0.625	0.813	0.82
Trackway cost	0.981	1.069	1.169	1.275	1.369	1.481	1.588
Crew cost	→	→	→	1.406	→	→	→
On board services	→	→	→	0.608	→	→	→
Station services	→	→	→	0.546	→	→	→
Marketing and Reservations	→	→	→	0.186	→	→	→
Taxes and Insurance	→	→	→	0.102	→	→	→
Depreciation	→	→	→	0.700	→	→	→
General Administration	→	→	→	0.522	→	→	→
Interest	→	→	→	0.038	→	→	→
Cleaning	→	→	→	0.180	→	→	→
Train Dispatching	→	→	→	0.180	→	→	→
Total Cost	6.38	6.69	7.02	7.37	7.72	8.22	8.52

Cost of Three Bi-level Rail Cars
 Number of Seats ----- 396 (Cost in \$/veh.km of 1982 dollars)
 SPEED (KM/H)

	80	95	110	130	145	160	175
Maintenance cost	0.856	1.163	1.381	1.744	2.025	2.325	2.625
Fuel cost	0.450	0.469	0.506	0.556	0.625	0.706	0.800
Trackway cost	1.225	1.338	1.463	1.594	1.713	1.863	1.994
Crew cost	→	→	→	1.406	→	→	→
On board services	→	→	→	0.912	→	→	→
Station services	→	→	→	0.819	→	→	→
Marketing and Reservations	→	→	→	0.279	→	→	→
Taxes and Insurance	→	→	→	0.019	→	→	→
Depreciation	→	→	→	1.05	→	→	→
General Administration	→	→	→	0.783	→	→	→
Interest	→	→	→	0.057	→	→	→
Cleaning	→	→	→	0.270	→	→	→
Train Dispatching	→	→	→	0.180	→	→	→
Total Cost	8.31	8.75	9.13	9.67	10.14	10.67	11.19

APPENDIX C

COMPUTER PROGRAMS FOR ROUTE SUPPLY MODEL AND INCREMENTAL SUPPLY MODEL

```

      IMPLICIT INTEGER (A-B,D-Z)
      REAL NUMR1,DENR1,NUMR2,DENR2,NUMR3,DENR3
      INTEGER CAP,MAXCOACH
      REAL LOADFCTR
      CHARACTER*40 CHAR
      DIMENSION PASS(8,12),ROUTE(8),COST(4,7),SPEED(7)
      READ(100,*)((PASS(I,J),J=1,12),I=1,8)
      READ(103,*)ROUTE
      READ(101,*)((COST(I,J),J=1,7),I=1,4))
      READ(102,*)CAP,MAXCOACH
      READ(106,*) SPEED
      LOADFCTR=0.6
      DO 10, I=1,8
      READ(104,60)CHAR
60  FORMAT(A40)
      WRITE(108,55)
55  FORMAT(1H1)
      WRITE (108,5)
5  FORMAT (10X,"SCENARIO: CONVENTIONAL LOCOMOTIVE TRAIN",52X,
1"LOAD FACTOR : 60%")
      WRITE (108,6)
6  FORMAT(10X,"PERIOD : JANUARY - DECEMBER 1981")
      WRITE(108,65)CHAR
65  FORMAT(10X,"ROUTE : ",A40)
      DO 20, J=1,7
      IF(J.EQ.4.OR.J.EQ.7)WRITE(108,55)
      WRITE(108,70)SPEED(J)
70  FORMAT(/10X,"SPEED:",I4,1X,"KMPE")
      WRITE(108,80)
80  FORMAT(10X,"MONTH",2X,"PASSENGER",4X,"DIST",1X,"PASSENGER",
11X,"ENGINES",1X,"COACHES",10X,"TOTAL",8X,"COSTPER",8X,
1"COSTPER",8X,"COSTPER")
      WRITE(108,90)
90  FORMAT(29X,"IN KM",7X,"-KM",27X,"COST",8X,
1"PASS.KM",7X,"TRAIN.KM",8X,"SEAT.KM")
      TOTP=0.0
      NUMR1=0.0
      DENR1=0.0
      NUMR2=0.0
      DENR2=0.0
      NUMR3=0.0
      DENR3=0.0
      DO 30, K=1,12
      PKM=PASS(I,K)*ROUTE(I)
      ENGINES=(PASS(I,K)+CAP)/(CAP*MAXCOACH)
      REMAIN=PASS(I,K)-ENGINES*CAP*MAXCOACH
      IF (REMAIN.LT.0) REMAIN=0
      ENGINES=(ENGINES/LOADFCTR)+0.5
      SERVICE=ENGINES
      COST1=0
      FLAG=0
      IF(REMAIN.EQ.0) GO TO 40
      FLAG=(REMAIN+CAP-1)/CAP
      IF(FLAG.EQ.1) FLAG=2

```



```

      COST1=COST(FLAG-1,J)
40  CONTINUE
      COACH=ENGINES*MAXCOACH+FLAG
      IF(ENGINES.EQ.0)ENGINES=1
      COST1=ENGINES*COST(4,J)+COST1
      COST1=COST1*ROUTE(I)
      COST3=COST1
      COSTPKM=COST3/PKM
      IF(FLAG.NE.0)ENGINES=ENGINES+1
      COSTPTKM=COST3/(SERVICE*ROUTE(I))
      COSTPSKM=COST3/(CAP*COACH*ROUTE(I))
      ICOACH=COACH
      WRITE(108,50)K,PASS(I,K),ROUTE(I),PKM,ENGINES,ICOACH,
1    COST3,COSTPKM,COSTPTKM,COSTPSKM
50  FORMAT(10X,I5,I11,I8,I10,I8,I8,F15.5,3F15.5)
      TOTP=TOTP+PASS(I,K)
      NUMR1=NUMR1+(COSTPKM*PKM)
      DENR1=DENR1+PKM
      NUMR2=NUMR2+(COSTPTKM*SERVICE*ROUTE(I))
      DENR2=DENR2+(SERVICE*ROUTE(I))
      NUMR3=NUMR3+(COSTPSKM*CAP*COACH*ROUTE(I))
      DENR3=DENR3+(CAP*COACH*ROUTE(I))
      CTOTCPKM=NUMR1/DENR1
      CTOTTKM=NUMR2/DENR2
      CTOTCSKM=NUMR3/DENR3
30  CONTINUE
      WRITE(108,95)TOTP,CTOTCPKM,CTOTTKM,CTOTCSKM
95  FORMAT(10X,"TOTAL",I11,49X,3F15.5)
      WRITE(108,75)
75  FORMAT(10X,I10("-"))
20  CONTINUE
10  CONTINUE
      STOP
      END

```

```

      INTEGER BBCAP,TBCAP
      DIMENSION DPKMBB(270),DPKMTB(270),DIFF(270)
      INTEGER ITBNAM(40),PERCNT(270)
      READ (100,*) BBCAP,BBCSKM,BDCSKM,BOVRKM
      READ (100,*) TBCAP,TBCSKM,TDCSKM,TOVRKM
      READ (100,5) ITBNAM
5     FORMAT(40A1)
      BTCOST = BBCSKM+BDCSKM+BOVRKM
      TTCOST = TBCSKM+TDCSKM+TOVRKM
      DO 10 I=1,270
        II=I-1
        DPKMBB(I)=((((II/BBCAP)+1)*BTCOST)/(I*1.0))
        DPKMTB(I)=((((II/TBCAP)+1)*TTCOST)/(I*1.0)
10    CONTINUE
      DO 20 I=1,270
        DPKMBB(I)=DPKMBB(I)+0.0005
        DPKMTB(I)=DPKMTB(I)+0.0005
        DIFF(I)=DPKMTB(I)-DPKMBB(I)
        RNDCOR=0.0005
        IF(DIFF(I).LT.0.0) RNDCOR=-RNDCOR
        DIFF(I)=DIFF(I)+RNDCOR
        PERCNT(I)=(DIFF(I)*100.0/DPKMBB(I))+1000*RNDCOR
20    CONTINUE
      PRINT(108,100)
100   FORMAT(1H1,/1X,"BUS COST MODEL")
      PRINT(108,110)
110   FORMAT(/,1X,"BASELINE BUS")
      PRINT(108,115)BBCAP,BBCSKM,BDCSKM,BOVRKM,BTCOST
115   FORMAT(/,1X,"SEATING CAPACITY :",I3,5X,"BUS COST $/KM
1: ",F4.2;/,1X,"DRIVER COST $/KM :",F3.2,5X,
2"OVERHEAD $/KM :",F4.2,5X,"TOTAL COST $/KM :",F5.3)
      PRINT(108,120)ITBNAM
120   FORMAT(/,1X,"SCENARIO :",40A1)
      PRINT(108,115) TBCAP,TBCSKM,TDCSKM,TOVRKM,TTCOST
      DO 40 ICOUNT=1,3
        PRINT(108,130)
130   FORMAT(/,1X,3("PASS",3X,"EASE",6X,"TEST",8X,"DIFF",
14X,"%",5X))
        PRINT(108,135)
135   FORMAT(1X,3(39(1H-),4X))
        ISTART=(ICOUNT-1)*90+1
        IEND=ISTART+29
        DO 50 I=ISTART,IEND
          J=I+30
          K=J+30
          PRINT(108,140)I,DPKMBB(I),DPKMTB(I),DIFF(I),PERCNT(I)
1         J,DPKMBB(J),DPKMTB(J),DIFF(J),PERCNT(J),K,DPKMBB(K),
2         DPKMTB(K),DIFF(K),PERCNT(K)
140   FORMAT(1X,3(I3,3X,F5.3,5X,F6.3,5X,F6.3,3X,I3,4X))
50    CONTINUE
      PRINT(108,135)
      PRINT(108,145)
145   FORMAT(1H1,/ )
40    CONTINUE
      STOP
      END

```

```

      IMPLICIT INTEGER (A-B,D-Z)
      INTEGER CAP
      REAL LOAD FCTR
      CHARACTER*25CHAR
      DIMENSION PASS(6),ROUTE(6),COST(3)
      READ (100,*) PASS
      READ (103,*) ROUTE
      READ (101,*) COST
      READ (102,*) CAP
      LOAD FCTR=0.7
      WRITE (108,5)
5     FORMAT(1X,"SCENARIO: ARTICULATED DOUBLE DECK BUS ( JUMBO JET )",
159X,"LOAD FACTOR = 70%")
      PRINT *, "PERIOD : PASSENGER DATA FOR THE YEAR 1976"
      WRITE (108,70)
      WRITE (108,80)
80    FORMAT(8X,"ROUTE",14X,"PASSENGER",2X,"DIST",1X,"PASSENGER",1X,
1"BUSES",5X,"BUS",6X,"DRIVER",2X,"OVERHEAD",5X,"TOTAL",
12X,"COST PER",2X,"COST PER",2X,"COST PER")
      WRITE (108,90)
90    FORMAT(37X,"IN KM",6X,"- KM",10X,"COST",8X,"COST",6X,"COST",6X,
1"COST",3X,"PASS.KM",4X,"BUS.KM",3X,"SEAT.KM")
      WRITE (108,95)
95    FORMAT(60X,"(0000°S)" 2X,"(0000°S)" 2X,"(0000°S)" 2X,
1"(0000°S)" )
      WRITE (108,70)
      DO 10 I=1,6
      READ (104,60) CHAR
60    FORMAT(A25)
      PKM=PASS(I)*ROUTE(I)
      BUSES=PASS(I)/(CAP*LOAD FCTR)
      REMAIN=PASS(I)-BUSES*CAP*LOAD FCTR
      IF (REMAIN.NE.O) BUSES=BUSES+1
      COST1=BUSES*COST(1)*ROUTE(I)/10000.
      COST2=BUSES*COST(2)*ROUTE(I)/10000.
      COST3=BUSES*COST(3)*ROUTE(I)/10000.
      COST4=(COST1+COST2+COST3)
      COSTPKM=(COST4*10000)/PKM
      COSTPBM=(COST4*10000)/(BUSES*ROUTE(I))
      COSTPSKM=(COST4*10000)/(BUSES*CAP*ROUTE(I))
      WRITE (108,50) CHAR,PASS(I),ROUTE(I),PKM,BUSES,COST1,COST2,COST3,
1COST4,COSTPKM,COSTPBM,COSTPSKM
50    FORMAT(1X,A25,I10,I6,I10,I6,7F10.5/)
      WRITE (108,70)
70    FORMAT(1X,128("-"))
10    CONTINUE
      WRITE (108,20)
20    FORMAT (1X,"NOTE : 100 SEAT BUS, CAPITAL COST 500K")
      STOP
      END

```

APPENDIX D
RESULTS OF FOUR RAIL TECHNOLOGIES ON MONTREAL - TORONTO ROUTE

LOAD FACTOR : 60%

SCENARIO: SELF PROPELLED 2000 (SPV - 2000)
 PERIOD : 1 JANUARY - DECEMBER 1981
 ROUTE : 1 MONTREAL - TORONTO

SPEED: 80 KMPH	PASSENGER	DIST IN KM	PASSENGER-KM	TRAINS	TOTAL COST	COST PER PASS-KM	COST PER TRAIN-KM	COST PER SEAT-KM
MONTH								
1	35754	536	19164144	226	939050.55500	.04900	7.75204	.02941
2	37200	536	19906360	236	979422.06200	.04900	7.74371	.02941
3	44618	536	23915248	203	1174911.07000	.04913	7.74550	.02941
4	30305	536	20531400	243	1000537.59000	.04912	7.74121	.02941
5	45987	536	24649032	291	1200186.75000	.04902	7.74328	.02941
6	46606	536	24780016	294	1221087.00000	.04891	7.75108	.02940
7	60014	536	32167504	379	1574210.50000	.04094	7.74923	.02940
8	67658	536	36264608	428	1778019.12000	.04093	7.75047	.02940
9	50376	536	27001536	318	1322676.37000	.04099	7.76000	.02939
10	40461	536	21687096	256	1062609.25000	.04910	7.74406	.02941
11	46935	536	25157160	297	1235129.67000	.04910	7.76000	.02939
12	40029	536	25743544	303	1230206.00000	.04876	7.76000	.02939
TOTAL	562031					.04901	7.75095	.02940

SPEED: 95 KMPH	PASSENGER	DIST IN KM	PASSENGER-KM	TRAINS	TOTAL COST	COST PER PASS-KM	COST PER TRAIN-KM	COST PER SEAT-KM
MONTH								
1	35754	536	19164144	226	900657.34400	.05159	8.16155	.03096
2	37200	536	19906360	236	1031156.79000	.05159	8.15169	.03097
3	44618	536	23915248	203	1236975.37000	.05172	8.15473	.03096
4	30305	536	20531400	243	1061010.50000	.05172	8.15222	.03096
5	45987	536	24649032	291	1272000.37000	.05160	8.15315	.03096
6	46606	536	24780016	294	1206437.50000	.05150	8.16150	.03096
7	60014	536	32167504	379	1657170.07000	.05152	8.15860	.03096
8	67658	536	36264608	428	1871947.75000	.05162	8.15791	.03096
9	50376	536	27001536	318	1392560.12000	.05157	8.17000	.03095
10	40461	536	21687096	256	110739.17000	.05159	8.15312	.03096
11	46935	536	25157160	297	1300520.50000	.05170	8.17000	.03095
12	40029	536	25743544	303	1326073.25000	.05154	8.17000	.03095
TOTAL	562031					.05160	8.16042	.03096

SPEED: 110 KMPH	PASSENGER	DIST IN KM	PASSENGER-KM	TRAINS	TOTAL COST	COST PER PASS-KM	COST PER TRAIN-KM	COST PER SEAT-KM
MONTH								
1	35754	536	19164144	226	1031033.50000	.05300	8.51137	.03229
2	37200	536	19906360	236	1075333.87000	.05300	8.50093	.03229
3	44618	536	23915248	203	1209989.62000	.05394	8.50410	.03229
4	30305	536	20531400	243	1107300.07000	.05393	8.50140	.03229
5	45987	536	24649032	291	1326503.50000	.05382	8.50154	.03229
6	46606	536	24780016	294	1341520.37000	.05370	8.51157	.03228
7	60014	536	32167504	379	1720374.75000	.05373	8.50013	.03228
8	67658	536	36264608	428	1952144.12000	.05383	8.50749	.03228
9	50376	536	27001536	318	1452216.07000	.05370	8.51000	.03227
10	40461	536	21687096	256	1146668.25000	.05300	8.50242	.03229
11	46935	536	25157160	297	1356315.75000	.05391	8.52000	.03227
12	40029	536	25743544	303	1303716.12000	.05375	8.52000	.03227
TOTAL	562031					.05381	8.51004	.03228

SPEED: 130 KMPH	PASSENGER	DIST IN KM	PASSENGER-KM	TRAINS	TOTAL COST	COST PER PASS. KM	COST PER TRAIN KM	COST PER SEAT KM
1	35754	536	19164144	226	1092711.00000	.05702	9.02053	.03422
2	37200	536	19906360	236	1139600.62000	.05702	9.00942	.03422
3	44610	536	23915240	203	1367144.37000	.05717	8.81309	.03422
4	30305	536	20531400	243	1173581.25000	.05716	9.01071	.03422
5	45987	536	24649032	291	1405805.00000	.05704	9.01347	.03422
6	46606	536	24900016	294	1421036.37000	.05692	9.02272	.03422
7	60014	536	32167504	379	1811812.12000	.05693	9.01731	.03422
8	67650	536	36264600	420	2068976.00000	.05705	9.01076	.03422
9	50376	536	27001536	310	1539145.37000	.05700	9.03000	.03422
10	40461	536	21687096	256	1236402.25000	.05701	9.01121	.03422
11	46935	536	25157160	297	1417501.62000	.05714	9.03000	.03420
12	48029	536	25743544	303	1466544.12000	.05697	9.03000	.03420
TOTAL	562031					.05703	9.01932	.03422

SPEED: 145 KMPH	PASSENGER	DIST IN KM	PASSENGER-KM	TRAINS	TOTAL COST	COST PER PASS. KM	COST PER TRAIN KM	COST PER SEAT KM
1	35754	536	19164144	226	1145951.07000	.05900	9.44004	.03509
2	37200	536	19906360	236	1195315.63000	.05900	9.44084	.03509
3	44610	536	23915240	203	1413703.07000	.05993	9.45219	.03509
4	30305	536	20531400	243	1230747.00000	.05994	9.44926	.03509
5	45987	536	24649032	291	1474391.25000	.05982	9.45260	.03509
6	46606	536	24900016	294	1491114.37000	.05969	9.46235	.03500
7	60014	536	32167504	379	1921032.12000	.05972	9.45670	.03500
8	67650	536	36264600	420	2169792.25000	.05983	9.45072	.03500
9	50376	536	27001536	310	1614142.50000	.05970	9.47000	.03507
10	40461	536	21687096	256	1296734.00000	.05979	9.45031	.03589
11	46935	536	25157160	297	1507548.12000	.05993	9.47000	.03507
12	48029	536	25743544	303	1538003.75000	.05974	9.47000	.03507
TOTAL	562031					.05981	9.45001	.03508

SPEED: 160 KMPH	PASSENGER	DIST IN KM	PASSENGER-KM	TRAINS	TOTAL COST	COST PER PASS. KM	COST PER TRAIN KM	COST PER SEAT KM
1	35754	536	19164144	226	1205244.12000	.06289	9.94951	.03774
2	37200	536	19906360	236	1257064.67000	.06290	9.93750	.03775
3	44610	536	23915240	203	1507977.00000	.06306	9.94131	.03775
4	30305	536	20531400	243	1294434.67000	.06305	9.93023	.03775
5	45987	536	24649032	291	1550405.50000	.06291	9.94102	.03774
6	46606	536	24900016	294	1568266.25000	.06270	9.95194	.03774
7	60014	536	32167504	379	2020470.75000	.06281	9.91604	.03774
8	67650	536	36264600	420	2202060.12000	.06293	9.94764	.03774
9	50376	536	27001536	310	1697662.00000	.06287	9.96000	.03773
10	40461	536	21687096	256	1363035.07000	.06209	9.93934	.03775
11	46935	536	25157160	297	1505552.25000	.06303	9.96000	.03773
12	48029	536	25743544	303	1617583.62000	.06291	9.96000	.03773
TOTAL	562031						9.94074	.03774

SPEED: 175 KMPH	PASSENGER	DIST IN KM	PASSENGER-KM	TRAINS	TOTAL COST	COST PER PASS-KM	COST PER TRAIN-KM	COST PER BEAT-KM
1	35254	536	19164144	226	1265737.12000	.06605	10.44089	.03964
2	37288	536	19986368	236	1320168.00000	.06605	10.44644	.03964
3	44610	536	23915248	203	1503676.75000	.06622	10.44035	.03964
4	30305	536	20531400	243	1359415.07000	.06621	10.43712	.03964
5	45987	536	24649032	291	1620528.75000	.06607	10.44009	.03964
6	46606	536	24900816	294	1646903.25000	.06593	10.45146	.03963
7	60014	536	32167504	379	2121966.00000	.06596	10.44533	.03964
8	67650	536	36264880	428	2396627.37000	.06609	10.44701	.03963
9	50376	536	27001536	310	1702086.00000	.06603	10.46000	.03962
10	40461	536	21887096	256	1432299.12000	.06604	10.43020	.03964
11	46935	536	25157140	297	1665140.25000	.06619	10.46000	.03962
12	40029	536	21574344	303	1698787.62000	.06607	10.44763	.03963
TOTAL	562031							

SCENARIO: CONVENTIONAL LOCOMOTIVE TRAIN
 PERIOD : JANUARY - DECEMBER 1981
 ROUTE : MONTREAL - TORONTO

LOAD FACTOR : 40%

SPEED: 70 KMPH	MONTH	PASSENGER	DIST. PASSENGER IN KM	ENGINES	COACHES	TOTAL COST	COST/FASS. KM	COST/TRAIN KM	COST/SEAT KM
1	35754	536	19164144	166	827	1065626.87000	.05561	12.04915	.03339
2	37200	536	19906360	173	863	1111885.37000	.05562	12.05037	.03330
3	44618	536	23915240	207	1035	1332533.50000	.05572	12.01000	.03336
4	30305	536	20531480	170	800	1143072.12000	.05571	12.01700	.03330
5	45987	536	24642032	213	1064	1370166.00000	.05559	12.05792	.03337
6	46606	536	24900016	216	1070	1380491.87000	.05559	12.04870	.03330
7	60014	536	32167504	278	1309	1780594.37000	.05560	12.04660	.03337
8	67658	536	36264608	313	1565	2014093.62000	.05556	12.01000	.03336
9	50376	536	27001536	233	1165	1499904.75000	.05555	12.01000	.03336
10	40461	536	21687096	188	937	1207240.75000	.05567	12.04454	.03337
11	46935	536	25157160	210	1007	1400369.62000	.05566	12.03977	.03330
12	48029	536	25743544	223	1113	1435553.37000	.05569	12.04740	.03338
TOTAL	562031	536	25743544	223	1113	1435553.37000	.05562	12.03810	.03337

SPEED: 90 KMPH	MONTH	PASSENGER	DIST. PASSENGER IN KM	ENGINES	COACHES	TOTAL COST	COST/FASS. KM	COST/TRAIN KM	COST/SEAT KM
1	35754	536	19164144	166	827	1090467.62000	.05732	12.42048	.03442
2	37200	536	19906360	173	863	1145935.75000	.05734	12.42980	.03441
3	44618	536	23915240	207	1035	1373585.62000	.05744	12.38000	.03439
4	30305	536	20531480	170	800	1179114.12000	.05743	12.42847	.03441
5	45987	536	24642032	213	1064	1412376.00000	.05730	12.42939	.03440
6	46606	536	24900016	216	1070	1431270.00000	.05729	12.41991	.03440
7	60014	536	32167504	278	1309	1843695.25000	.05732	12.41780	.03439
8	67658	536	36264608	313	1565	2076967.75000	.05727	12.38000	.03439
9	50376	536	27001536	233	1165	1546113.37000	.05726	12.38000	.03439
10	40461	536	21687096	188	937	1244432.62000	.05738	12.41572	.03441
11	46935	536	25157160	210	1007	1443523.00000	.05730	12.41070	.03441
12	48029	536	25743544	223	1113	1477719.75000	.05740	12.41065	.03440
TOTAL	562031	536	25743544	223	1113	1477719.75000	.05734	12.40899	.03440

SPEED: 105 KMPH	MONTH	PASSENGER	DIST. PASSENGER IN KM	ENGINES	COACHES	TOTAL COST	COST/FASS. KM	COST/TRAIN KM	COST/SEAT KM
1	35754	536	19164144	166	827	1133977.62000	.05917	12.07900	.03553
2	37200	536	19906360	173	863	1182928.75000	.05919	12.01169	.03552
3	44618	536	23915240	207	1035	1417868.50000	.05926	12.20000	.03550
4	30305	536	20531480	170	800	1171229.12000	.05926	12.03023	.03552
5	45987	536	24642032	213	1064	1438021.75000	.05915	12.01100	.03551
6	46606	536	24900016	216	1070	1477532.12000	.05915	12.02135	.03552
7	60014	536	32167504	278	1309	1903227.00000	.05917	12.01910	.03551
8	67658	536	36264608	313	1565	2144075.00000	.05912	12.20000	.03550
9	50376	536	27001536	233	1165	1576060.62000	.05911	12.20000	.03550
10	40461	536	21687096	188	937	1284679.37000	.05924	12.01706	.03553
11	46935	536	25157160	210	1007	1490101.75000	.05923	12.01193	.03552
12	48029	536	25743544	223	1113	1525402.75000	.05926	12.02004	.03552
TOTAL	562031	536	25743544	223	1113	1525402.75000	.05919	12.01004	.03551

SPEED 170 KMPH	PASSENGER	DIST IN KM	PASSENGER -KH	ENGINES	COACHES	TOTAL COST	COST/PER PASS-KM	COST/PER TRAIN-KM	COST/PER SEAT-KM
1	35754	536	19164144	166	827	1305331.50000	.04811	14.75951	.04090
2	37208	536	19986360	173	863	1361697.25000	.06813	14.77023	.04009
3	44618	536	21915248	207	1035	1632103.87000	.06825	14.71000	.04006
4	30305	536	20531180	170	800	1401120.00000	.06824	14.76853	.04089
5	45907	536	24649032	213	1064	1670242.75000	.06807	14.76910	.04087
6	46606	536	24980816	216	1070	1700233.25000	.06808	14.75019	.04088
7	60014	536	32167504	278	1309	2190239.12000	.06810	14.75523	.04087
8	67658	536	36264600	313	1565	2467087.25000	.06805	14.71000	.04006
9	50376	536	27001536	233	1165	1837102.37000	.06804	14.75369	.04019
10	40461	536	21687096	180	937	1470791.25000	.06819	14.74765	.04009
11	46935	536	25157160	210	1007	1715328.62000	.06818	14.75667	.04000
12	48039	536	25743544	223	1113	1755925.25000	.06831	14.74504	.04000
TOTAL	562031						.06813		

SCENARIO: LIGHT, RAPID AND COMFORTABLE TRAIN
 PERIOD : JANUARY - DECEMBER 1981
 ROUTE : MONTREAL - TORONTO

LOAD FACTOR 1.402

SPEED: 70 KMPH		DIST PASSENGER ENGINES COACHES				TOTAL		COST/PER	
MONTH	PASSENGER	IN KM	-KM	IN KM	COACHES	COST	PASS. KM	TRAIN. KM	SEAT. KM
1	35754	536	19164144	143	712	909097.50000	.04748	11.93472	.02638
2	37208	536	19906368	148	739	943005.93000	.04722	11.97045	.02037
3	44610	536	23915240	170	007	1133339.00000	.04739	11.94587	.02830
4	30305	536	20531400	153	762	973715.10900	.04743	11.95178	.02830
5	45907	536	24649032	183	913	1166244.75000	.04711	11.95511	.02037
6	46606	536	24980016	105	975	1180995.50000	.04720	11.91000	.02036
7	60014	536	32167504	230	1190	1519334.75000	.04723	11.91000	.02036
8	67650	536	36264600	269	1342	1714251.25000	.04727	11.93369	.02037
9	50376	536	27001536	200	1000	1276251.07000	.04720	11.91000	.02036
10	40461	536	21607096	161	802	1024805.19000	.04725	11.94989	.02030
11	46935	536	25157160	106	929	1106300.75000	.04716	11.96439	.02036
12	40029	536	25157160	191	952	1216317.07000	.04725	11.94342	.02030
TOTAL	562031	536	25743544	191	952	1216317.07000	.04729	11.93904	.02037

SPEED: 90 KMPH		DIST PASSENGER ENGINES COACHES				TOTAL		COST/PER	
MONTH	PASSENGER	IN KM	-KM	IN KM	COACHES	COST	PASS. KM	TRAIN. KM	SEAT. KM
1	35754	536	19164144	143	712	934349.03600	.04076	12.22599	.02915
2	37208	536	19906368	148	739	969173.74700	.04049	12.30041	.02913
3	44610	536	23915240	170	007	1163784.67000	.04066	12.26609	.02914
4	30305	536	20531400	153	762	999902.63300	.04070	12.27296	.02914
5	45907	536	24649032	183	913	1197590.12000	.04059	12.26443	.02913
6	46606	536	24980016	105	975	1212726.75000	.04055	12.23000	.02912
7	60014	536	32167504	230	1190	1560156.67000	.04050	12.23000	.02912
8	67650	536	36264600	269	1342	1760315.00000	.04054	12.25436	.02913
9	50376	536	27001536	200	1000	1311056.00000	.04055	12.23000	.02912
10	40461	536	21607096	161	802	1052344.75000	.04052	12.27081	.02914
11	46935	536	25157160	106	929	1218274.37000	.04043	12.20595	.02913
12	40029	536	25157160	191	952	1249003.25000	.04052	12.26437	.02914
TOTAL	562031	536	25743544	191	952	1249003.25000	.04056	12.26069	.02913

SPEED: 105 KMPH		DIST PASSENGER ENGINES COACHES				TOTAL		COST/PER	
MONTH	PASSENGER	IN KM	-KM	IN KM	COACHES	COST	PASS. KM	TRAIN. KM	SEAT. KM
1	35754	536	19164144	143	712	961060.07000	.05019	12.63754	.03000
2	37208	536	19906368	148	739	997697.68000	.04992	12.68245	.02977
3	44610	536	23915240	170	007	1190056.37000	.05010	12.63013	.03000
4	30305	536	20531400	153	762	1039350.47000	.05014	12.63441	.03000
5	45907	536	24649032	183	913	1232040.12000	.05002	12.63706	.02999
6	46606	536	24980016	105	975	1248424.37000	.04990	12.59000	.02990
7	60014	536	32167504	230	1190	1606001.00000	.04991	12.59000	.02990
8	67650	536	36264600	269	1342	1817146.25000	.04977	12.61519	.02999
9	50376	536	27001536	200	1000	1349640.00000	.04970	12.59000	.02990
10	40461	536	21607096	161	802	1081316.37000	.04975	12.63219	.03000
11	46935	536	25157160	106	929	1254132.75000	.04985	12.64257	.02990
12	40029	536	25157160	191	952	1285703.50000	.04995	12.62553	.03000
TOTAL	562031	536	25743544	191	952	1285703.50000	.04999	12.62167	.02999

SPEED 120 KMPH	PASSENGER	DIST IN KM	PASSENGER IN KM	ENGINES	COACHES	TOTAL COST	COSTPER PASS.KM	COSTPER TRAIN.KM	COSTPER SEAT.KM
1	35754	536	19164144	143	712	992441.50000	.05179	13.03923	.03096
2	37208	536	19986368	140	739	1029409.42000	.05151	13.06490	.03094
3	44618	536	23915248	178	807	1236133.87000	.05167	13.07949	.03095
4	30305	536	20531400	153	762	1067067.07000	.05173	13.03599	.03096
5	45987	536	24649032	183	913	1272024.37000	.05161	13.03945	.03094
6	46606	536	24980816	185	925	1280080.37000	.05156	12.97000	.03093
7	60014	536	32167504	230	1190	1657100.25000	.05151	12.99000	.03093
8	67658	536	36264608	269	1342	1869734.12000	.05156	13.01608	.03094
9	50376	536	27001536	200	1000	1392528.00000	.05152	12.99000	.03093
10	40461	536	21687096	161	802	1117769.00000	.05154	13.03369	.03096
11	46935	536	25157160	186	929	1293909.62000	.05144	13.04931	.03094
12	48029	536	25743544	191	952	1326648.12000	.05153	13.02679	.03095
TOTAL	562031						.05150	13.02377	.03094

SPEED 135 KMPH	PASSENGER	DIST IN KM	PASSENGER IN KM	ENGINES	COACHES	TOTAL COST	COSTPER PASS.KM	COSTPER TRAIN.KM	COSTPER SEAT.KM
1	35754	536	19164144	143	712	1023786.79000	.05142	13.45106	.03194
2	37208	536	19986368	140	739	1061901.62000	.05313	13.47220	.03192
3	44618	536	23915248	170	807	1275170.75000	.05332	13.44096	.03193
4	30305	536	20531400	153	762	1095610.75000	.05336	13.44770	.03193
5	45987	536	24649032	183	913	1312106.07000	.05323	13.45115	.03192
6	46606	536	24980816	185	925	1320743.07000	.05317	13.40000	.03190
7	60014	536	32167504	230	1190	1709411.12000	.05314	13.40000	.03190
8	67658	536	36264608	269	1342	1920769.12000	.05319	13.42705	.03192
9	50376	536	27001536	200	1000	1436479.07000	.05320	13.40000	.03190
10	40461	536	21687096	161	802	1133049.07000	.05317	13.44531	.03181
11	46935	536	25157160	186	929	1334832.07000	.05308	13.46140	.03191
12	48029	536	25743544	191	952	1368541.07000	.05316	13.43816	.03193
TOTAL	562031						.05321	13.43393	.03192

SPEED 150 KMPH	PASSENGER	DIST IN KM	PASSENGER IN KM	ENGINES	COACHES	TOTAL COST	COSTPER PASS.KM	COSTPER TRAIN.KM	COSTPER SEAT.KM
1	35754	536	19164144	143	712	1056659.62000	.05514	13.80796	.03296
2	37208	536	19986368	140	739	1095991.25000	.05504	13.70993	.03294
3	44618	536	23915248	170	807	1316110.37000	.05503	13.87240	.03296
4	30305	536	20531400	153	762	1130708.37000	.05500	13.87947	.03296
5	45987	536	24649032	183	913	1354311.12000	.05494	13.80297	.03295
6	46606	536	24980816	185	925	1371302.25000	.05490	13.81000	.03293
7	60014	536	32167504	230	1190	1764285.37000	.05485	13.83000	.03293
8	67658	536	36264608	269	1342	1990682.50000	.05489	13.85806	.03295
9	50376	536	27001536	200	1000	1407576.00000	.05471	13.83000	.03293
10	40461	536	21687096	161	802	1190091.50000	.05480	13.82200	.03296
11	46935	536	25157160	186	929	1377600.75000	.05476	13.87551	.03294
12	48029	536	25743544	191	952	1412477.07000	.05487	13.83950	.03295
TOTAL	562031						.05491	13.86516	.03294

SCENARIO: B1 - LEVEL RAIL CAR (DRC)
 PERIOD : JANUARY - DECEMBER 1981
 ROUTE : MONTREAL - TORONTO

LOAD FACTOR : 1.50X

SPEED: 80 KMPH	MONTH	PASSENGER	DIST IN KM	PASSENGER-KM	TRAINS	TOTAL COST	COST PER PASS. KM	COST PER TRAIN, KM	COST PER SEAT, KM
1	1	35754	536	19164144	151	670230.45300	.01497	0.20099	.02100
2	2	37200	536	19906360	158	701409.58600	.01509	0.20220	.02100
3	3	44618	536	23915248	108	037382.04200	.01501	0.31000	.02098
4	4	30305	536	20531400	162	721573.89800	.01514	0.31000	.02098
5	5	45907	536	24649032	194	061759.34400	.01496	0.20742	.02100
6	6	46606	536	24980016	197	077469.50000	.01511	0.31000	.02098
7	7	60014	536	32167504	253	1125067.07000	.01500	0.30237	.02099
8	8	67650	536	36264600	205	1269435.50000	.01500	0.31000	.02090
9	9	50376	536	27001536	213	946380.37500	.01505	0.20944	.02100
10	10	40461	536	21607096	171	759313.64400	.01501	0.20439	.02100
11	11	46935	536	25157160	190	000009.10700	.01502	0.30025	.02100
12	12	40029	536	25743544	203	901046.70900	.01503	0.28042	.02100
TOTAL		562031					.01503	0.29730	.02099

SPEED: 95 KMPH	MONTH	PASSENGER	DIST IN KM	PASSENGER-KM	TRAINS	TOTAL COST	COST PER PASS. KM	COST PER TRAIN, KM	COST PER SEAT, KM
1	1	35754	536	19164144	151	705702.94500	.01602	0.71927	.02212
2	2	37200	536	19906360	158	730532.94500	.01695	0.72063	.02212
3	3	44618	536	23915248	100	001720.00000	.01607	0.75000	.02210
4	4	30305	536	20531400	162	759780.00000	.01701	0.75000	.02210
5	5	45987	536	24649032	194	907372.94500	.01601	0.72600	.02211
6	6	46606	536	24980016	197	923930.00000	.01699	0.75000	.02210
7	7	60014	536	32167504	253	1105465.75000	.01605	0.74108	.02210
8	8	67650	536	36264600	205	1336650.00000	.01606	0.75000	.02210
9	9	50376	536	27001536	213	996402.94500	.01690	0.72022	.02211
10	10	40461	536	21607096	171	799502.94500	.01607	0.72207	.02211
11	11	46935	536	25157160	190	927315.02000	.01607	0.73960	.02211
12	12	40029	536	25743544	203	949502.94500	.01609	0.72714	.02211
TOTAL		562031					.01609	0.73653	.02211

SPEED: 110 KMPH	MONTH	PASSENGER	DIST IN KM	PASSENGER-KM	TRAINS	TOTAL COST	COST PER PASS. KM	COST PER TRAIN, KM	COST PER SEAT, KM
1	1	35754	536	19164144	151	736140.71100	.01042	9.02701	.02300
2	2	37200	536	19906360	158	720596.44900	.01056	9.09924	.02300
3	3	44618	536	23915248	108	920011.02000	.01047	9.13000	.02306
4	4	30305	536	20531400	162	792776.15600	.01061	9.13000	.02306
5	5	45907	536	24649032	194	946760.94500	.01041	9.10495	.02307
6	6	46606	536	24980016	197	94054.94500	.01059	9.13000	.02306
7	7	60014	536	32167504	253	1236970.00000	.01045	9.12166	.02306
8	8	67650	536	36264600	205	1394890.75000	.01046	9.13000	.02306
9	9	50376	536	27001536	213	1039740.07000	.01051	9.10710	.02307
10	10	40461	536	21607096	171	034214.31200	.01047	9.10150	.02307
11	11	46935	536	25157160	190	967017.66400	.01047	9.11934	.02307
12	12	40029	536	25743544	203	990012.07800	.01049	9.10606	.02307
TOTAL		562031					.01049	9.11593	.02307

SPEED: 130 KMPH	MONTH	PASSENGER	DIST IN KM	PASSENGER-KM	TRAINS	TOTAL COST	COST PER PASS-KM	COST PER TRAIN-KM	COST PER SEAT-KM
1	35754	536	19164144	151	779090.71100	.04070	9.63509	.02444	
2	37288	536	19906368	158	816172.55500	.04084	9.63740	.02444	
3	44610	536	23915248	180	974426.55500	.04074	9.67000	.02442	
4	30305	536	20531400	162	839665.42200	.04090	9.67000	.02442	
5	45907	536	24649032	194	1002764.07000	.04068	9.64145	.02444	
6	46606	536	24980816	197	1021074.63000	.04077	9.67000	.02442	
7	60014	536	32167504	253	1310096.50000	.04073	9.66091	.02443	
8	67658	536	36264608	285	1477109.12000	.04071	9.67000	.02442	
9	50376	536	27001516	213	1101244.12000	.04078	9.64502	.02443	
10	40461	536	21607076	171	803553.10900	.04074	9.63780	.02444	
11	46935	536	25167160	198	1025024.95000	.04074	9.65818	.02443	
12	48029	536	25743544	203	1049412.87000	.04076	9.64463	.02444	
TOTAL	562031						9.65504	.02443	

SPEED: 145 KMPH	MONTH	PASSENGER	DIST IN KM	PASSENGER-KM	TRAINS	TOTAL COST	COST PER PASS-KM	COST PER TRAIN-KM	COST PER SEAT PER
	1	35754	536	19164144	151	817801.97700	.04267	10.10430	.02563
	2	37288	536	19906368	150	855847.26600	.04282	10.10309	.02563
	3	44618	536	23915248	180	101707.50000	.04273	10.14000	.02561
	4	30305	536	20531400	162	800476.46900	.04280	10.14000	.02561
	5	45907	536	24649032	194	1031500.62000	.04266	10.11232	.02562
	6	46606	536	24980816	197	1020702.75000	.04284	10.14000	.02561
	7	60014	536	32167504	253	1373767.07000	.04271	10.13043	.02562
	8	67658	536	36264608	285	1548796.37000	.04271	10.14000	.02561
	9	50376	536	27001536	213	1154774.37000	.04277	10.11469	.02562
	10	40461	536	21607096	171	924502.70900	.04272	10.10848	.02563
	11	46935	536	25167160	198	1074840.75000	.04273	10.12770	.02562
	12	48029	536	25743544	203	1100424.00000	.04275	10.11345	.02562
	TOTAL	562031					.04275	10.12433	.02562

SPEED: 160 KMPH	MONTH	PASSENGER	DIST IN KM	PASSENGER-KM	TRAINS	TOTAL COST	COST PER PASSENGER	COST PER TRAIN-KM	COST PER SEAT PER
	1	35754	536	19164144	151	860547.97700	.04490	10.61745	.02697
	2	37288	536	19906368	158	900581.62000	.04506	10.63411	.02697
	3	44618	536	23915248	180	1075184.50000	.04496	10.67000	.02694
	4	30305	536	20531400	162	928497.22800	.04513	10.62000	.02694
	5	45907	536	24649032	194	1106476.12000	.04490	10.44072	.02696
	6	46606	536	24980816	197	1128466.62000	.04510	10.67000	.02694
	7	60014	536	32167504	253	1445624.12000	.04494	10.66032	.02696
	8	67658	536	36264608	285	1629949.12000	.04495	10.67000	.02694
	9	50376	536	27001516	213	1215133.37000	.04500	10.61338	.02696
	10	40461	536	21607076	171	974930.37500	.04495	10.63004	.02697
	11	46935	536	25167160	190	1131072.50000	.04496	10.65763	.02696
	12	48029	536	25743544	203	1157942.12000	.04498	10.64207	.02696
	TOTAL	562031					.04490	10.65360	.02696

SPEED 175 KMPH	MONTH	PASSENGER	DIST IN KM	PASSENGER-KM	TRAINS	TOTAL COST	COST PER PASS.KM	COST PER TRAIN.KM	COST PER SEAT.KM
1	35754	536	19164144	151	902500.71100	.04709	11.15079	.02028	
2	37200	536	1998368	158	944485.60200	.04726	11.13253	.02028	
3	44618	536	23915248	100	1127593.07000	.04715	11.17000	.02026	
4	38305	536	20531400	162	971650.07000	.04732	11.19000	.02026	
5	45907	536	24649032	194	1160407.25000	.04700	11.15848	.02028	
6	46606	536	24980816	197	1181524.37000	.04730	11.19000	.02026	
7	60014	536	32167504	253	1516022.32000	.04713	11.17945	.02027	
8	67558	536	36264500	205	1709304.37000	.04714	11.19000	.02026	
9	50376	536	27001536	213	1274366.75000	.04720	11.16221	.02028	
10	40461	536	21687096	171	1022452.52000	.04715	11.15538	.02028	
11	46935	536	25157160	198	1106141.12000	.04715	11.17651	.02027	
12	48029	536	25743544	203	1214300.37000	.04717	11.16084	.02028	
TOTAL	562031					.04717	11.17270	.02027	

APPENDIX E
RESULTS OF INCREMENTAL SUPPLY MODEL FOR ALL BUS TECHNOLOGIES

BUS COST MODEL

BASELINE BUS

SEATING CAPACITY : 45 BUS COST 1/KM : .50 TOTAL COST 1/KM : 1.210
 DRIVER COST 1/KM : .55 OVERHEAD 1/KM : .16

SCENARIO : ARTICULATED DOUBLE DECK BUS

SEATING CAPACITY : 61 BUS COST 1/KM : .62 TOTAL COST 1/KM : 1.400
 DRIVER COST 1/KM : .55 OVERHEAD 1/KM : .16

PASS	RASE	TEST	DIFF	Z	PASS	RASE	TEST	DIFF	Z	PASS	RASE	TEST	DIFF	Z
1	1.210	1.401	.191	16	31	.040	.046	.007	17	61	.040	.023	-.017	-43
2	.606	.701	.096	16	32	.030	.044	.006	17	62	.040	.046	.007	17
3	.404	.467	.064	16	33	.037	.043	.006	17	63	.039	.043	.007	17
4	.303	.351	.048	16	34	.036	.042	.006	17	64	.038	.044	.006	17
5	.243	.281	.039	16	35	.035	.041	.006	17	65	.030	.044	.006	17
6	.202	.234	.032	16	36	.034	.039	.006	17	66	.037	.043	.006	17
7	.173	.201	.028	16	37	.033	.038	.006	17	67	.037	.042	.006	17
8	.152	.176	.024	16	38	.032	.037	.006	17	68	.036	.042	.006	17
9	.135	.154	.022	16	39	.032	.036	.005	17	69	.036	.041	.006	17
10	.122	.141	.020	16	40	.031	.036	.005	17	70	.035	.041	.006	17
11	.111	.129	.018	16	41	.030	.035	.005	17	71	.035	.040	.006	17
12	.101	.117	.016	16	42	.029	.034	.005	17	72	.034	.039	.006	17
13	.094	.108	.015	16	43	.029	.033	.005	17	73	.034	.039	.006	17
14	.087	.101	.014	16	44	.028	.032	.005	17	74	.033	.038	.006	17
15	.081	.094	.013	16	45	.027	.031	.005	17	75	.033	.038	.006	17
16	.076	.088	.012	16	46	.027	.031	.005	17	76	.032	.037	.006	17
17	.072	.083	.012	16	47	.027	.030	.005	17	77	.032	.037	.005	17
18	.068	.078	.011	16	48	.026	.030	.005	17	78	.032	.036	.005	17
19	.064	.074	.011	16	49	.026	.029	.005	17	79	.031	.036	.005	17
20	.061	.071	.010	16	50	.025	.029	.005	17	80	.031	.036	.005	17
21	.058	.067	.009	16	51	.025	.028	.005	17	81	.030	.035	.005	17
22	.054	.064	.009	16	52	.024	.027	.005	17	82	.030	.035	.005	17
23	.051	.061	.009	16	53	.024	.027	.005	17	83	.030	.034	.005	17
24	.049	.059	.008	16	54	.024	.026	.005	17	84	.029	.034	.005	17
25	.047	.057	.008	17	55	.023	.026	.005	17	85	.029	.033	.005	17
26	.045	.054	.008	17	56	.023	.026	.005	17	86	.029	.033	.005	17
27	.043	.052	.007	17	57	.022	.025	.005	17	87	.028	.033	.005	17
28	.042	.051	.007	17	58	.022	.025	.005	17	88	.028	.032	.005	17
29	.041	.050	.007	17	59	.021	.024	.005	17	89	.028	.032	.005	17
30	.041	.049	.007	17	60	.021	.024	.005	17	90	.027	.032	.005	17

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
91	.040	.031	-.010	-24	121	.031	.024	-.007	-24	131	.033	.020	-.005	-13
92	.040	.031	-.010	-24	122	.030	.023	-.007	-24	132	.032	.020	-.005	-13
93	.040	.031	-.009	-24	123	.030	.023	-.005	-17	133	.032	.020	-.005	-13
94	.039	.030	-.009	-24	124	.030	.024	-.003	17	134	.032	.020	-.005	-13
95	.039	.030	-.009	-24	125	.030	.024	-.003	17	135	.032	.020	-.005	-13
96	.038	.030	-.008	-24	126	.029	.024	-.003	17	136	.032	.020	-.005	-13
97	.038	.030	-.008	-24	127	.029	.024	-.003	17	137	.031	.027	-.005	-13
98	.038	.029	-.007	-24	128	.029	.023	-.005	17	138	.031	.027	-.005	-13
99	.037	.029	-.009	-24	129	.029	.023	-.005	17	139	.031	.027	-.005	-13
100	.037	.029	-.009	-24	130	.029	.023	-.005	17	140	.031	.027	-.005	-13
101	.036	.028	-.009	-24	131	.029	.023	-.005	17	141	.031	.027	-.004	-13
102	.036	.028	-.009	-24	132	.029	.023	-.005	17	142	.030	.026	-.004	-13
103	.036	.028	-.009	-24	133	.028	.023	-.005	17	143	.030	.026	-.004	-13
104	.035	.027	-.008	-24	134	.028	.023	-.005	17	144	.030	.026	-.004	-13
105	.035	.027	-.008	-24	135	.027	.023	-.005	17	145	.030	.026	-.004	-13
106	.035	.027	-.008	-24	136	.036	.031	-.003	-14	146	.029	.026	-.004	-13
107	.034	.027	-.008	-24	137	.036	.031	-.003	-14	147	.029	.026	-.004	-13
108	.034	.026	-.008	-24	138	.036	.031	-.003	-14	148	.029	.026	-.004	-13
109	.034	.026	-.008	-24	139	.035	.031	-.003	-14	149	.029	.025	-.004	-13
110	.034	.026	-.008	-24	140	.035	.031	-.003	-14	150	.029	.025	-.004	-13
111	.033	.026	-.008	-24	141	.035	.030	-.003	-14					
112	.033	.025	-.008	-24	142	.034	.030	-.003	-14					
113	.033	.025	-.008	-24	143	.034	.030	-.003	-14					
114	.032	.025	-.008	-24	144	.034	.030	-.003	-14					
115	.032	.025	-.008	-24	145	.034	.029	-.003	-15					
116	.032	.025	-.008	-24	146	.034	.029	-.003	-15					
117	.032	.024	-.008	-24	147	.033	.029	-.003	-15					
118	.031	.024	-.007	-24	148	.033	.029	-.003	-15					
119	.031	.024	-.007	-24	149	.033	.029	-.003	-15					
120	.031	.024	-.007	-24	150	.033	.029	-.003	-15					

PASS	BASE	TEST	DIFF	X	PASS	BASE	TEST	DIFF	X	PASS	BASE	TEST	DIFF	X
181	.014	.024	-.011	-32	211	.029	.027	-.003	-9	241	.031	.024	-.007	-24
182	.014	.024	-.011	-32	212	.029	.027	-.003	-9	242	.031	.024	-.007	-24
183	.034	.023	-.011	-32	213	.029	.027	-.003	-9	243	.010	.024	-.007	-24
184	.033	.031	-.003	-9	214	.029	.027	-.003	-9	244	.010	.023	-.007	-24
185	.033	.031	-.003	-9	215	.029	.027	-.003	-9	245	.010	.029	-.002	-5
186	.033	.031	-.003	-9	216	.029	.026	-.003	-9	246	.010	.029	-.002	-5
187	.033	.030	-.003	-9	217	.028	.026	-.003	-9	247	.010	.029	-.002	-5
188	.033	.030	-.003	-9	218	.028	.026	-.003	-9	248	.010	.029	-.002	-5
189	.033	.030	-.003	-9	219	.028	.026	-.003	-9	249	.010	.029	-.002	-5
190	.032	.030	-.003	-9	220	.028	.026	-.003	-9	250	.010	.029	-.002	-5
191	.032	.030	-.003	-9	221	.028	.026	-.003	-9	251	.029	.028	-.002	-5
192	.032	.030	-.003	-9	222	.028	.026	-.003	-9	252	.029	.028	-.002	-5
193	.032	.030	-.003	-9	223	.028	.026	-.003	-9	253	.029	.028	-.002	-5
194	.032	.029	-.003	-9	224	.028	.026	-.003	-9	254	.029	.028	-.002	-5
195	.032	.029	-.003	-9	225	.027	.025	-.003	-9	255	.029	.028	-.002	-5
196	.031	.029	-.003	-9	226	.033	.025	-.008	-24	256	.029	.028	-.002	-5
197	.031	.029	-.003	-9	227	.032	.025	-.008	-24	257	.029	.028	-.002	-5
198	.031	.029	-.003	-9	228	.032	.025	-.008	-24	258	.029	.028	-.002	-5
199	.031	.029	-.003	-9	229	.032	.025	-.008	-24	259	.029	.028	-.002	-5
200	.031	.029	-.003	-9	230	.031	.025	-.008	-24	260	.028	.027	-.001	-5
201	.031	.028	-.003	-9	231	.032	.025	-.008	-24	261	.028	.027	-.001	-5
202	.030	.028	-.003	-9	232	.032	.025	-.008	-24	262	.028	.027	-.001	-5
203	.030	.028	-.003	-9	233	.032	.025	-.008	-24	263	.028	.027	-.001	-5
204	.030	.028	-.003	-9	234	.032	.024	-.008	-24	264	.028	.027	-.001	-5
205	.030	.028	-.003	-9	235	.031	.024	-.008	-24	265	.028	.027	-.001	-5
206	.030	.028	-.003	-9	236	.031	.024	-.008	-24	266	.028	.027	-.001	-5
207	.030	.028	-.003	-9	237	.031	.024	-.008	-24	267	.028	.027	-.001	-5
208	.030	.027	-.003	-9	238	.031	.024	-.007	-24	268	.028	.027	-.001	-5
209	.029	.027	-.003	-9	239	.031	.024	-.007	-24	269	.027	.027	-.001	-5
210	.029	.027	-.003	-9	240	.031	.024	-.007	-24	270	.027	.026	-.001	-5

BUS COST MODEL

BASELINE BUS

SEATING CAPACITY 1.45 BUS COST 1/KM 1.50 TOTAL COST 1/KM 11.210
 DRIVER COST 1/KM 1.55 OVERHEAD 1/KM .13

SCENARIO PARTICIPATION OR DOUBLE DECK BUS

SEATING CAPACITY 1.70 BUS COST 1/KM 1.69 TOTAL COST 1/KM 11.400
 DRIVER COST 1/KM 1.55 OVERHEAD 1/KM .16

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
1	1.210	1.401	.191	16	31	.040	.046	.007	17	61	.040	.023	-.017	-43
2	.606	.701	.095	16	32	.030	.044	.014	17	62	.040	.023	-.017	-43
3	.404	.467	.064	16	33	.037	.043	.006	17	63	.039	.023	-.017	-43
4	.303	.351	.040	16	34	.036	.042	.006	17	64	.030	.022	-.016	-43
5	.243	.281	.039	16	35	.035	.041	.006	17	65	.030	.022	-.016	-43
6	.202	.234	.032	16	36	.034	.039	.005	17	66	.037	.022	-.016	-43
7	.173	.201	.028	16	37	.033	.038	.005	17	67	.037	.021	-.018	-43
8	.152	.176	.024	16	38	.032	.037	.005	17	68	.036	.021	-.016	-43
9	.135	.158	.023	16	39	.031	.036	.005	17	69	.036	.021	-.015	-43
10	.122	.141	.020	16	40	.031	.036	.005	17	70	.035	.021	-.015	-43
11	.111	.129	.018	16	41	.030	.035	.005	17	71	.035	.020	-.015	-43
12	.101	.117	.016	16	42	.029	.034	.005	17	72	.034	.039	.006	17
13	.094	.108	.015	16	43	.029	.033	.005	17	73	.034	.039	.006	17
14	.087	.101	.014	16	44	.028	.032	.005	17	74	.033	.030	.006	17
15	.081	.094	.013	16	45	.027	.031	.005	17	75	.033	.030	.006	17
16	.076	.088	.012	16	46	.026	.031	.005	17	76	.032	.027	.006	17
17	.072	.083	.011	16	47	.025	.030	.005	17	77	.032	.027	.006	17
18	.068	.079	.011	16	48	.024	.029	.005	17	78	.031	.026	.005	17
19	.064	.074	.011	16	49	.023	.028	.005	17	79	.031	.026	.005	17
20	.061	.071	.010	16	50	.022	.027	.005	17	80	.031	.026	.005	17
21	.058	.067	.010	16	51	.021	.026	.005	17	81	.030	.025	.005	17
22	.056	.064	.009	16	52	.020	.025	.005	17	82	.030	.025	.005	17
23	.053	.061	.009	16	53	.019	.024	.005	17	83	.030	.024	.005	17
24	.051	.059	.008	17	54	.018	.023	.005	17	84	.029	.024	.005	17
25	.049	.057	.008	17	55	.018	.023	.005	17	85	.029	.023	.005	17
26	.047	.054	.007	17	56	.017	.022	.005	17	86	.028	.023	.005	17
27	.045	.052	.007	17	57	.016	.021	.005	17	87	.028	.023	.005	17
28	.044	.051	.007	17	58	.015	.020	.005	17	88	.028	.022	.005	17
29	.042	.049	.007	17	59	.014	.019	.005	17	89	.028	.022	.005	17
30	.041	.047	.007	17	60	.013	.018	.005	17	90	.027	.022	.005	17

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
91	.040	.031	-.010	-24	121	.011	.024	-.007	-24	151	.033	.020	-.005	-15
92	.040	.031	-.010	-24	122	.010	.023	-.007	-24	152	.032	.020	-.005	-15
93	.040	.031	-.009	-24	123	.030	.024	-.007	-24	153	.012	.020	-.005	-15
94	.019	.010	-.009	-24	124	.010	.021	-.007	-24	154	.012	.020	-.005	-15
95	.039	.030	-.009	-24	125	.010	.021	-.007	-24	155	.032	.020	-.005	-15
96	.018	.010	-.009	-24	126	.029	.023	-.007	-24	156	.032	.020	-.005	-15
97	.030	.029	-.009	-24	127	.029	.022	-.007	-24	157	.031	.027	-.005	-15
98	.030	.029	-.009	-24	128	.029	.022	-.007	-24	158	.031	.027	-.005	-15
99	.037	.028	-.009	-24	129	.029	.022	-.007	-24	159	.011	.027	-.005	-15
100	.037	.029	-.008	-24	130	.020	.022	-.007	-24	160	.011	.027	-.005	-15
101	.036	.020	-.009	-24	131	.020	.022	-.007	-24	161	.011	.027	-.004	-15
102	.016	.020	-.009	-24	132	.020	.022	-.007	-24	162	.030	.026	-.004	-15
103	.036	.020	-.009	-24	133	.020	.022	-.007	-24	163	.030	.026	-.004	-15
104	.035	.027	-.008	-24	134	.028	.021	-.007	-24	164	.030	.026	-.004	-15
105	.035	.027	-.008	-24	135	.027	.021	-.007	-24	165	.030	.026	-.004	-15
106	.015	.027	-.008	-24	136	.016	.021	-.016	-43	166	.010	.026	-.004	-15
107	.034	.027	-.008	-24	137	.036	.021	-.015	-43	167	.029	.026	-.004	-15
108	.034	.026	-.008	-24	138	.018	.021	-.015	-43	168	.029	.026	-.004	-15
109	.034	.026	-.008	-24	139	.035	.021	-.015	-43	169	.028	.025	-.004	-15
110	.014	.025	-.008	-24	140	.015	.021	-.015	-43	170	.029	.025	-.004	-15
111	.033	.026	-.008	-24	141	.035	.030	-.005	-14	171	.029	.025	-.004	-15
112	.033	.026	-.008	-24	142	.015	.030	-.005	-14	172	.029	.025	-.004	-15
113	.033	.025	-.008	-24	143	.034	.030	-.005	-14	173	.020	.025	-.004	-15
114	.032	.025	-.008	-24	144	.014	.030	-.005	-14	174	.020	.025	-.004	-15
115	.032	.025	-.008	-24	145	.034	.029	-.005	-15	175	.020	.025	-.004	-15
116	.032	.025	-.008	-24	146	.034	.029	-.005	-15	176	.020	.024	-.004	-15
117	.032	.024	-.008	-24	147	.033	.029	-.005	-15	177	.020	.024	-.004	-15
118	.011	.024	-.007	-24	148	.013	.029	-.005	-15	178	.020	.024	-.004	-15
119	.031	.024	-.007	-24	149	.013	.029	-.005	-15	179	.020	.024	-.004	-15
120	.031	.024	-.007	-24	150	.013	.029	-.005	-15	180	.027	.024	-.004	-15

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
191	.014	.024	-.011	-32	211	.028	.027	-.003	-9	241	.031	.024	-.007	-24
192	.034	.024	-.011	-32	212	.029	.027	-.003	-9	242	.031	.024	-.007	-24
193	.034	.023	-.011	-32	213	.029	.027	-.003	-9	243	.030	.023	-.007	-24
194	.033	.023	-.011	-32	214	.029	.027	-.003	-9	244	.030	.023	-.007	-24
195	.033	.023	-.011	-32	215	.029	.027	-.003	-9	245	.030	.023	-.007	-24
196	.033	.023	-.010	-32	216	.029	.026	-.003	-9	246	.030	.023	-.007	-24
197	.033	.023	-.010	-32	217	.028	.026	-.003	-9	247	.030	.023	-.007	-24
198	.033	.023	-.010	-32	218	.028	.026	-.003	-9	248	.030	.023	-.007	-24
199	.033	.023	-.010	-32	219	.028	.026	-.003	-9	249	.030	.023	-.007	-24
200	.032	.023	-.010	-32	220	.028	.026	-.003	-9	250	.030	.023	-.007	-24
201	.032	.022	-.010	-32	221	.028	.026	-.003	-9	251	.029	.023	-.007	-24
202	.032	.022	-.010	-32	222	.028	.026	-.003	-9	252	.029	.023	-.007	-24
203	.032	.022	-.010	-32	223	.028	.026	-.003	-9	253	.029	.023	-.007	-24
204	.032	.022	-.010	-32	224	.028	.026	-.003	-9	254	.029	.023	-.007	-24
205	.031	.022	-.010	-32	225	.027	.025	-.003	-9	255	.029	.022	-.007	-24
206	.031	.022	-.010	-32	226	.027	.025	-.003	-9	256	.029	.022	-.007	-24
207	.031	.022	-.010	-32	227	.027	.025	-.003	-9	257	.029	.022	-.007	-24
208	.031	.022	-.010	-32	228	.027	.025	-.003	-9	258	.029	.022	-.007	-24
209	.031	.022	-.010	-32	229	.027	.025	-.003	-9	259	.029	.022	-.007	-24
210	.031	.022	-.010	-32	230	.027	.025	-.003	-9	260	.029	.022	-.007	-24
211	.031	.021	-.010	-32	231	.027	.025	-.003	-9	261	.029	.022	-.007	-24
212	.030	.021	-.010	-32	232	.027	.025	-.003	-9	262	.028	.022	-.007	-24
213	.030	.021	-.010	-32	233	.027	.025	-.003	-9	263	.028	.022	-.007	-24
214	.030	.021	-.010	-32	234	.027	.024	-.003	-9	264	.028	.022	-.007	-24
215	.030	.021	-.009	-32	235	.027	.024	-.003	-9	265	.028	.022	-.007	-24
216	.030	.021	-.009	-32	236	.027	.024	-.003	-9	266	.028	.022	-.007	-24
217	.030	.021	-.009	-32	237	.027	.024	-.003	-9	267	.028	.022	-.007	-24
218	.030	.021	-.009	-32	238	.027	.024	-.003	-9	268	.028	.022	-.007	-24
219	.029	.021	-.009	-32	239	.027	.024	-.003	-9	269	.027	.021	-.007	-24
220	.029	.021	-.009	-32	240	.027	.024	-.003	-9	270	.027	.021	-.007	-24

BUS COST MODEL

BASELINE BUS

SEATING CAPACITY : 45 BUS COST 1/KM : .50
 DRIVER COST 1/KM : .55 OVERHEAD 1/KM : .16 TOTAL COST 1/KM : 1.210

SCENARIO : ARTICULATED DOUBLE DECK BUS

SEATING CAPACITY : 80 BUS COST 1/KM : .69
 DRIVER COST 1/KM : .55 OVERHEAD 1/KM : .16 TOTAL COST 1/KM : 1.400

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
1	1.210	1.401	.191	16	31	.040	.046	.007	17	41	.040	.023	-.017	-43
2	.606	.701	.094	16	32	.030	.044	.006	17	42	.040	.023	-.017	-43
3	.404	.467	.064	16	33	.037	.043	.006	17	43	.039	.023	-.017	-43
4	.503	.551	.048	16	34	.036	.042	.006	17	44	.038	.022	-.016	-43
5	.243	.281	.039	16	35	.035	.041	.006	17	45	.038	.022	-.016	-43
6	.202	.234	.032	16	36	.034	.039	.006	17	46	.037	.022	-.016	-43
7	.173	.201	.028	16	37	.033	.038	.006	17	47	.037	.021	-.016	-43
8	.152	.176	.024	16	38	.032	.037	.006	17	48	.036	.021	-.016	-43
9	.135	.156	.022	16	39	.032	.036	.005	17	49	.036	.021	-.015	-43
10	.122	.141	.020	16	40	.031	.036	.005	17	50	.035	.021	-.015	-43
11	.111	.129	.018	16	41	.030	.035	.005	17	51	.035	.020	-.013	-43
12	.094	.108	.015	16	42	.029	.034	.005	17	52	.034	.020	-.014	-43
13	.087	.101	.014	16	43	.028	.033	.005	17	53	.033	.019	-.014	-43
14	.081	.094	.013	16	44	.027	.032	.005	17	54	.033	.019	-.014	-43
15	.076	.088	.012	16	45	.027	.032	.005	17	55	.032	.019	-.014	-43
16	.072	.083	.012	16	46	.026	.031	.005	17	56	.032	.019	-.014	-43
17	.068	.078	.011	16	47	.026	.030	.005	17	57	.032	.019	-.014	-43
18	.064	.074	.011	16	48	.025	.030	.005	17	58	.032	.018	-.014	-43
19	.061	.071	.010	16	49	.025	.029	.005	17	59	.031	.018	-.013	-43
20	.058	.067	.010	16	50	.024	.029	.005	17	60	.031	.018	-.013	-43
21	.056	.064	.009	16	51	.024	.028	.005	17	61	.030	.035	.005	17
22	.053	.061	.009	16	52	.024	.027	.005	17	62	.030	.035	.005	17
23	.051	.059	.008	16	53	.024	.026	.005	17	63	.030	.034	.005	17
24	.049	.057	.008	16	54	.024	.026	.005	17	64	.029	.034	.005	17
25	.047	.054	.008	16	55	.024	.026	.005	17	65	.029	.033	.005	17
26	.045	.052	.008	16	56	.024	.026	.005	17	66	.029	.033	.005	17
27	.043	.050	.007	16	57	.024	.025	.005	17	67	.028	.033	.005	17
28	.042	.049	.007	16	58	.024	.024	.005	17	68	.028	.032	.005	17
29	.041	.047	.007	16	59	.024	.024	.005	17	69	.027	.032	.005	17
30			.007	17	60	.041	.024	-.018	-43	90	.027	.032	.005	17

PASS	BASE	TEST	DIFF	X	PASS	BASE	TEST	DIFF	X	PASS	BASE	TEST	DIFF	X
91	.040	.031	-.010	-24	121	.031	.024	-.007	-24	151	.033	.019	-.014	-43
92	.040	.031	-.010	-24	122	.030	.023	-.007	-24	152	.032	.019	-.014	-43
93	.040	.031	-.009	-24	123	.030	.023	-.007	-24	153	.032	.019	-.014	-43
94	.039	.030	-.009	-24	124	.030	.023	-.007	-24	154	.032	.019	-.014	-43
95	.039	.030	-.009	-24	125	.030	.023	-.007	-24	155	.032	.019	-.014	-43
96	.038	.029	-.008	-24	126	.029	.022	-.007	-24	156	.031	.018	-.013	-43
97	.038	.029	-.009	-24	127	.029	.022	-.007	-24	157	.031	.018	-.013	-43
98	.037	.028	-.009	-24	128	.028	.022	-.007	-24	158	.031	.018	-.013	-43
99	.037	.028	-.008	-24	129	.028	.022	-.007	-24	159	.031	.018	-.013	-43
100	.036	.028	-.009	-24	130	.028	.022	-.007	-24	160	.030	.026	-.004	-43
101	.036	.028	-.009	-24	131	.028	.022	-.007	-24	161	.030	.026	-.004	-43
102	.036	.028	-.009	-24	132	.028	.022	-.007	-24	162	.030	.026	-.004	-43
103	.035	.027	-.008	-24	133	.028	.022	-.007	-24	163	.030	.026	-.004	-43
104	.035	.027	-.008	-24	134	.028	.022	-.007	-24	164	.030	.026	-.004	-43
105	.035	.027	-.008	-24	135	.027	.021	-.007	-24	165	.030	.026	-.004	-43
106	.035	.027	-.008	-24	136	.036	.021	-.016	-43	166	.030	.026	-.004	-43
107	.034	.026	-.008	-24	137	.036	.021	-.015	-43	167	.029	.026	-.004	-43
108	.034	.026	-.008	-24	138	.036	.021	-.015	-43	168	.029	.026	-.004	-43
109	.034	.026	-.008	-24	139	.035	.021	-.015	-43	169	.029	.025	-.004	-43
110	.034	.026	-.008	-24	140	.035	.021	-.015	-43	170	.029	.025	-.004	-43
111	.033	.026	-.008	-24	141	.035	.020	-.015	-43	171	.029	.025	-.004	-43
112	.033	.026	-.008	-24	142	.035	.020	-.015	-43	172	.029	.025	-.004	-43
113	.033	.025	-.008	-24	143	.034	.020	-.015	-43	173	.028	.025	-.004	-43
114	.032	.025	-.008	-24	144	.034	.020	-.015	-43	174	.028	.025	-.004	-43
115	.032	.025	-.008	-24	145	.034	.020	-.015	-43	175	.028	.025	-.004	-43
116	.032	.025	-.008	-24	146	.034	.020	-.014	-43	176	.028	.024	-.004	-43
117	.032	.024	-.008	-24	147	.033	.020	-.014	-43	177	.028	.024	-.004	-43
118	.031	.024	-.008	-24	148	.033	.019	-.014	-43	178	.028	.024	-.004	-43
119	.031	.024	-.007	-24	149	.033	.019	-.014	-43	179	.028	.024	-.004	-43
120	.031	.024	-.007	-24	150	.033	.019	-.014	-43	180	.027	.024	-.004	-43

PASS	BASE	TEST	DIFF	X	PASS	BASE	TEST	DIFF	X	PASS	BASE	TEST	DIFF	X
181	.034	.024	-.011	-32	211	.029	.020	-.009	-32	241	.031	.024	-.007	-34
182	.034	.023	-.011	-32	212	.029	.020	-.009	-32	242	.031	.024	-.007	-34
183	.033	.023	-.011	-32	213	.029	.020	-.009	-32	243	.031	.024	-.007	-34
184	.033	.023	-.010	-32	214	.029	.020	-.009	-32	244	.031	.024	-.007	-34
185	.033	.023	-.010	-32	215	.029	.020	-.009	-32	245	.031	.024	-.007	-34
186	.033	.023	-.010	-32	216	.029	.020	-.009	-32	246	.031	.024	-.007	-34
187	.033	.023	-.010	-32	217	.029	.020	-.009	-32	247	.031	.024	-.007	-34
188	.033	.023	-.010	-32	218	.029	.020	-.009	-32	248	.031	.024	-.007	-34
189	.033	.023	-.010	-32	219	.029	.020	-.009	-32	249	.031	.024	-.007	-34
190	.032	.022	-.010	-32	220	.028	.020	-.009	-32	250	.030	.023	-.007	-34
191	.032	.022	-.010	-32	221	.028	.020	-.009	-32	251	.029	.023	-.007	-34
192	.032	.022	-.010	-32	222	.028	.020	-.009	-32	252	.029	.023	-.007	-34
193	.032	.022	-.010	-32	223	.028	.020	-.009	-32	253	.029	.023	-.007	-34
194	.032	.022	-.010	-32	224	.028	.020	-.009	-32	254	.029	.023	-.007	-34
195	.032	.022	-.010	-32	225	.027	.020	-.009	-32	255	.029	.022	-.007	-34
196	.031	.022	-.010	-32	226	.031	.020	-.014	-43	256	.029	.022	-.007	-34
197	.031	.022	-.010	-32	227	.032	.020	-.014	-43	257	.029	.022	-.007	-34
198	.031	.022	-.010	-32	228	.032	.020	-.014	-43	258	.029	.022	-.007	-34
199	.031	.022	-.010	-32	229	.032	.020	-.014	-43	259	.029	.022	-.007	-34
200	.031	.022	-.010	-32	230	.032	.020	-.014	-43	260	.029	.022	-.007	-34
201	.031	.021	-.010	-32	231	.032	.020	-.014	-43	261	.029	.022	-.007	-34
202	.030	.021	-.010	-32	232	.032	.020	-.014	-43	262	.029	.022	-.007	-34
203	.030	.021	-.010	-32	233	.032	.020	-.014	-43	263	.029	.022	-.007	-34
204	.030	.021	-.010	-32	234	.032	.020	-.014	-43	264	.029	.022	-.007	-34
205	.030	.021	-.010	-32	235	.031	.020	-.014	-43	265	.029	.022	-.007	-34
206	.030	.021	-.009	-32	236	.031	.020	-.013	-43	266	.029	.022	-.007	-34
207	.030	.021	-.009	-32	237	.031	.020	-.013	-43	267	.029	.021	-.007	-34
208	.030	.021	-.009	-32	238	.031	.020	-.013	-43	268	.029	.021	-.007	-34
209	.029	.021	-.009	-32	239	.031	.020	-.013	-43	269	.027	.021	-.007	-34
210	.029	.021	-.009	-32	240	.031	.020	-.013	-43	270	.027	.021	-.007	-34

BUS COST MODEL

BASELINE BUS

SEATING CAPACITY 1.45 BUS COST \$/KM 1.50
 DRIVER COST \$/KM 1.55 OVERHEAD \$/KM 1.16 TOTAL COST \$/KM 11.210

SCENARIO PARTICULATED OR DOUBLE DECK BUS

SEATING CAPACITY 1.61 BUS COST \$/KM 1.77
 DRIVER COST \$/KM 1.55 OVERHEAD \$/KM 1.16 TOTAL COST \$/KM 11.400

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
1	1.210	1.401	.271	22	31	.040	.048	.009	23
2	.606	.741	.136	22	32	.030	.047	.009	23
3	.464	.494	.091	22	33	.037	.045	.009	23
4	.303	.371	.060	22	34	.036	.044	.008	23
5	.243	.297	.055	22	35	.035	.043	.008	23
6	.202	.247	.046	23	36	.034	.042	.008	23
7	.173	.212	.039	23	37	.033	.041	.008	23
8	.152	.184	.034	23	38	.032	.039	.008	23
9	.135	.145	.031	23	39	.032	.030	.007	24
10	.122	.145	.020	23	40	.031	.030	.007	24
11	.111	.135	.025	23	41	.030	.037	.007	24
12	.101	.124	.023	23	42	.029	.036	.007	24
13	.094	.114	.021	23	43	.029	.035	.007	24
14	.087	.104	.020	23	44	.020	.034	.007	24
15	.081	.099	.019	23	45	.027	.033	.007	24
16	.076	.093	.017	23	46	.033	.031	.007	24
17	.072	.088	.016	23	47	.032	.032	.007	24
18	.068	.083	.016	23	48	.031	.031	.007	24
19	.064	.070	.015	23	49	.031	.031	.007	24
20	.061	.075	.014	23	50	.030	.030	.007	24
21	.058	.071	.013	23	51	.030	.030	.007	24
22	.054	.068	.013	23	52	.047	.029	.007	24
23	.053	.065	.012	23	53	.046	.028	.007	24
24	.051	.062	.012	23	54	.045	.020	.007	24
25	.049	.060	.011	23	55	.045	.027	.007	24
26	.047	.057	.011	23	56	.044	.027	.007	24
27	.045	.055	.011	23	57	.043	.026	.007	24
28	.044	.053	.010	23	58	.042	.026	.007	24
29	.042	.052	.010	23	59	.042	.026	.007	24
30	.041	.050	.010	23	60	.041	.025	.007	24
31	.040	.049	.009	23	61	.040	.025	.007	24
32	.039	.047	.009	23	62	.040	.025	.007	24
33	.038	.046	.009	23	63	.039	.025	.007	24
34	.037	.045	.009	23	64	.038	.025	.007	24
35	.036	.044	.009	23	65	.037	.025	.007	24
36	.035	.043	.009	23	66	.036	.025	.007	24
37	.034	.042	.009	23	67	.035	.025	.007	24
38	.033	.041	.009	23	68	.034	.025	.007	24
39	.032	.040	.009	23	69	.033	.025	.007	24
40	.031	.039	.009	23	70	.032	.025	.007	24
41	.030	.038	.009	23	71	.031	.025	.007	24
42	.029	.037	.009	23	72	.030	.025	.007	24
43	.028	.036	.009	23	73	.029	.025	.007	24
44	.027	.035	.009	23	74	.028	.025	.007	24
45	.026	.034	.009	23	75	.027	.025	.007	24
46	.025	.033	.009	23	76	.026	.025	.007	24
47	.024	.032	.009	23	77	.025	.025	.007	24
48	.023	.031	.009	23	78	.024	.025	.007	24
49	.022	.030	.009	23	79	.023	.025	.007	24
50	.021	.029	.009	23	80	.022	.025	.007	24
51	.020	.028	.009	23	81	.021	.025	.007	24
52	.019	.027	.009	23	82	.020	.025	.007	24
53	.018	.026	.009	23	83	.019	.025	.007	24
54	.017	.025	.009	23	84	.018	.025	.007	24
55	.016	.024	.009	23	85	.017	.025	.007	24
56	.015	.023	.009	23	86	.016	.025	.007	24
57	.014	.022	.009	23	87	.015	.025	.007	24
58	.013	.021	.009	23	88	.014	.025	.007	24
59	.012	.020	.009	23	89	.013	.025	.007	24
60	.011	.019	.009	23	90	.012	.025	.007	24
61	.010	.018	.009	23	91	.011	.025	.007	24
62	.009	.017	.009	23	92	.010	.025	.007	24
63	.008	.016	.009	23	93	.009	.025	.007	24
64	.007	.015	.009	23	94	.008	.025	.007	24
65	.006	.014	.009	23	95	.007	.025	.007	24
66	.005	.013	.009	23	96	.006	.025	.007	24
67	.004	.012	.009	23	97	.005	.025	.007	24
68	.003	.011	.009	23	98	.004	.025	.007	24
69	.002	.010	.009	23	99	.003	.025	.007	24
70	.001	.009	.009	23	100	.002	.025	.007	24

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
91	.040	.033	-.007	-19	121	.031	.025	-.006	-20	151	.013	.010	-.003	-18
92	.040	.033	-.007	-19	122	.030	.025	-.006	-20	152	.012	.010	-.002	-18
93	.040	.032	-.008	-19	123	.030	.027	.007	24	153	.012	.010	-.002	-18
94	.039	.032	-.007	-19	124	.030	.036	.007	24	154	.012	.029	-.003	-10
95	.039	.032	-.007	-20	125	.030	.036	.007	24	155	.012	.029	-.003	-10
96	.038	.031	-.007	-20	126	.029	.036	.007	24	156	.012	.029	-.003	-10
97	.038	.031	-.007	-20	127	.029	.035	.007	24	157	.011	.029	-.003	-10
98	.038	.031	-.007	-20	128	.029	.035	.007	24	158	.011	.029	-.003	-10
99	.037	.030	-.007	-20	129	.028	.035	.007	24	159	.011	.020	-.003	-10
100	.037	.030	-.007	-20	130	.028	.035	.007	24	160	.011	.020	-.003	-10
101	.036	.030	-.006	-20	131	.028	.034	.007	24	161	.011	.020	-.003	-10
102	.036	.030	-.006	-20	132	.028	.034	.007	24	162	.010	.028	-.003	-10
103	.036	.029	-.007	-20	133	.028	.034	.007	24	163	.010	.020	-.003	-10
104	.035	.029	-.006	-20	134	.028	.034	.007	24	164	.010	.020	-.003	-10
105	.035	.029	-.006	-20	135	.027	.033	.007	24	165	.010	.027	-.003	-10
106	.035	.028	-.007	-20	136	.027	.033	-.003	-10	166	.010	.027	-.003	-10
107	.034	.028	-.006	-20	137	.026	.033	-.003	-10	167	.009	.027	-.003	-10
108	.034	.028	-.006	-20	138	.026	.033	-.003	-10	168	.009	.027	-.003	-10
109	.034	.028	-.006	-20	139	.025	.032	-.003	-10	169	.009	.027	-.003	-10
110	.034	.027	-.007	-20	140	.025	.032	-.003	-10	170	.009	.027	-.003	-10
111	.033	.027	-.006	-20	141	.025	.032	-.003	-10	171	.009	.026	-.003	-10
112	.033	.027	-.006	-20	142	.025	.032	-.003	-10	172	.009	.026	-.003	-10
113	.033	.027	-.006	-20	143	.024	.032	-.003	-10	173	.009	.026	-.003	-10
114	.032	.026	-.006	-20	144	.024	.031	-.003	-10	174	.008	.026	-.003	-10
115	.032	.026	-.006	-20	145	.024	.031	-.003	-10	175	.008	.026	-.003	-10
116	.032	.026	-.006	-20	146	.024	.031	-.003	-10	176	.008	.026	-.003	-10
117	.032	.026	-.006	-20	147	.023	.031	-.003	-10	177	.008	.026	-.003	-10
118	.031	.026	-.006	-20	148	.023	.031	-.003	-10	178	.008	.025	-.003	-10
119	.031	.025	-.006	-20	149	.023	.030	-.003	-10	179	.008	.025	-.003	-10
120	.031	.025	-.006	-20	150	.023	.030	-.003	-10	180	.007	.025	-.003	-10

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PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
101	.034	.025	-.009	-20	211	.029	.029	-.001	-4	241	.031	.025	-.006	-20
102	.034	.025	-.009	-20	212	.029	.029	-.001	-4	242	.031	.025	-.006	-20
103	.034	.025	-.009	-20	213	.029	.029	-.001	-4	243	.031	.025	-.006	-20
104	.033	.033	-.001	-4	214	.029	.029	-.001	-4	244	.030	.025	-.004	-20
105	.033	.033	-.001	-4	215	.029	.030	-.001	-4	245	.030	.031	-.001	-4
106	.033	.032	-.001	-4	216	.029	.030	-.001	-4	246	.030	.031	.001	4
107	.033	.032	-.001	-4	217	.029	.030	-.001	-4	247	.030	.030	.001	4
108	.033	.032	-.001	-4	218	.029	.030	-.001	-4	248	.030	.030	.001	4
109	.033	.032	-.001	-4	219	.029	.030	-.001	-4	249	.030	.030	.001	4
110	.032	.032	-.001	-4	220	.029	.027	-.002	-4	250	.030	.030	.001	4
111	.032	.031	-.001	-4	221	.029	.027	-.002	-4	251	.029	.030	.001	4
112	.032	.031	-.001	-4	222	.029	.027	-.002	-4	252	.029	.030	.001	4
113	.032	.031	-.001	-4	223	.029	.027	-.002	-4	253	.029	.030	.001	4
114	.032	.031	-.001	-4	224	.029	.027	-.002	-4	254	.029	.030	.001	4
115	.032	.031	-.001	-4	225	.029	.027	-.002	-4	255	.029	.030	.001	4
116	.031	.031	-.001	-4	226	.029	.027	-.002	-4	256	.029	.029	.001	4
117	.031	.031	-.001	-4	227	.029	.027	-.002	-4	257	.029	.029	.001	4
118	.031	.031	-.001	-4	228	.029	.027	-.002	-4	258	.029	.029	.001	4
119	.031	.030	-.001	-4	229	.029	.026	-.003	-20	259	.029	.029	.001	4
120	.031	.030	-.001	-4	230	.029	.026	-.003	-20	260	.029	.029	.001	4
121	.031	.030	-.001	-4	231	.029	.026	-.003	-20	261	.029	.029	.001	4
122	.030	.030	-.001	-4	232	.029	.026	-.003	-20	262	.029	.029	.001	4
123	.030	.030	-.001	-4	233	.029	.026	-.003	-20	263	.029	.029	.001	4
124	.030	.030	-.001	-4	234	.029	.026	-.003	-20	264	.029	.029	.001	4
125	.030	.030	-.001	-4	235	.029	.026	-.003	-20	265	.029	.029	.001	4
126	.030	.030	-.001	-4	236	.029	.026	-.003	-20	266	.029	.029	.001	4
127	.030	.030	-.001	-4	237	.029	.026	-.003	-20	267	.029	.029	.001	4
128	.030	.030	-.001	-4	238	.029	.026	-.003	-20	268	.029	.029	.001	4
129	.029	.029	-.001	-4	239	.029	.026	-.003	-20	269	.029	.029	.001	4
130	.029	.029	-.001	-4	240	.029	.026	-.003	-20	270	.029	.029	.001	4

BUS COST MODEL

BASELINE BUS

SEATING CAPACITY : 45 BUS COST 1/KM : .50
DRIVER COST 1/KM : .55 OVERHEAD 1/KM : .16 TOTAL COST 1/KM : 1.210

SCENARIO : ARTICULATED OR DOUBLE DECK BUS

SEATING CAPACITY : 70 BUS COST 1/KM : .77
DRIVER COST 1/KM : .55 OVERHEAD 1/KM : .16 TOTAL COST 1/KM : 1.400

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
1	1.210	1.401	.271	22	31	.040	.048	.009	23	61	.040	.025	-.016	-40
2	.606	.741	.136	22	32	.030	.047	.009	23	62	.040	.024	-.016	-40
3	.404	.494	.091	23	33	.037	.045	.008	21	63	.039	.024	-.015	-40
4	.303	.371	.068	22	34	.036	.044	.008	23	64	.038	.024	-.015	-40
5	.243	.297	.055	22	35	.035	.043	.008	23	65	.030	.023	-.015	-40
6	.202	.247	.046	23	36	.034	.042	.008	23	66	.037	.023	-.015	-40
7	.173	.212	.039	21	37	.033	.041	.008	23	67	.037	.023	-.015	-40
8	.152	.186	.034	23	38	.032	.039	.008	24	68	.036	.022	-.014	-40
9	.135	.165	.031	23	39	.032	.030	.007	24	69	.036	.022	-.014	-40
10	.122	.149	.028	23	40	.031	.030	.007	24	70	.035	.022	-.014	-40
11	.111	.135	.025	23	41	.030	.037	.007	24	71	.035	.042	.008	23
12	.101	.124	.023	23	42	.029	.036	.007	24	72	.034	.042	.008	23
13	.094	.114	.021	23	43	.029	.035	.007	24	73	.034	.041	.008	23
14	.087	.106	.020	23	44	.028	.034	.007	24	74	.033	.041	.008	23
15	.081	.099	.019	23	45	.027	.033	.007	24	75	.033	.040	.008	23
16	.076	.093	.017	23	46	.026	.031	.021	-39	76	.032	.039	.008	24
17	.072	.088	.016	23	47	.025	.032	-.021	-39	77	.032	.039	.008	24
18	.068	.083	.016	23	48	.024	.031	-.020	-39	78	.032	.030	.007	24
19	.064	.078	.015	23	49	.023	.031	-.020	-39	79	.031	.030	.007	24
20	.061	.075	.014	23	50	.022	.030	-.019	-39	80	.031	.030	.007	24
21	.058	.071	.013	23	51	.021	.030	-.019	-39	81	.030	.037	.007	24
22	.056	.068	.013	23	52	.020	.029	-.019	-39	82	.030	.037	.007	24
23	.053	.065	.012	23	53	.019	.028	-.018	-40	83	.030	.036	.007	24
24	.051	.062	.012	23	54	.018	.028	-.018	-40	84	.029	.036	.007	24
25	.049	.060	.011	23	55	.017	.027	-.017	-40	85	.029	.035	.007	24
26	.047	.057	.011	23	56	.016	.026	-.017	-40	86	.028	.035	.007	24
27	.045	.055	.011	23	57	.015	.026	-.017	-40	87	.028	.034	.007	24
28	.044	.053	.010	23	58	.014	.026	-.016	-40	88	.028	.034	.007	24
29	.042	.052	.010	23	59	.013	.026	-.016	-40	89	.028	.034	.007	24
30	.041	.050	.010	23	60	.012	.025	-.016	-40	90	.027	.033	.007	24

PASS	BASE	TEST	DIFF	X	PASS	BASE	TEST	DIFF	X	PASS	BASE	TEST	DIFF	Z
91	.040	.033	-.008	-19	121	.031	.025	-.006	-20	151	.033	.030	-.003	-10
92	.040	.033	-.008	-19	122	.030	.025	-.006	-20	152	.032	.030	-.003	-10
93	.040	.032	-.008	-19	123	.030	.025	-.006	-20	153	.032	.030	-.003	-10
94	.039	.032	-.008	-19	124	.030	.024	-.006	-20	154	.032	.029	-.003	-10
95	.039	.032	-.008	-20	125	.030	.024	-.006	-20	155	.032	.029	-.003	-10
96	.038	.031	-.007	-20	126	.029	.024	-.006	-20	156	.032	.029	-.003	-10
97	.038	.031	-.007	-20	127	.029	.024	-.006	-20	157	.031	.029	-.003	-10
98	.038	.031	-.007	-20	128	.029	.024	-.006	-20	158	.031	.029	-.003	-10
99	.037	.030	-.007	-20	129	.029	.023	-.006	-20	159	.031	.028	-.003	-10
100	.037	.030	-.007	-20	130	.028	.023	-.006	-20	160	.031	.028	-.003	-10
101	.036	.030	-.007	-20	131	.028	.023	-.006	-20	161	.031	.028	-.003	-10
102	.036	.030	-.007	-20	132	.028	.023	-.006	-20	162	.030	.028	-.003	-10
103	.035	.029	-.007	-20	133	.028	.023	-.006	-20	163	.030	.028	-.003	-10
104	.035	.029	-.007	-20	134	.028	.023	-.006	-20	164	.030	.028	-.003	-10
105	.035	.029	-.007	-20	135	.027	.022	-.005	-20	165	.030	.027	-.003	-10
106	.035	.028	-.007	-20	136	.026	.022	-.014	-40	166	.030	.027	-.003	-10
107	.034	.028	-.007	-20	137	.026	.022	-.014	-40	167	.029	.027	-.003	-10
108	.034	.028	-.007	-20	138	.026	.022	-.014	-40	168	.029	.027	-.003	-10
109	.034	.028	-.007	-20	139	.025	.022	-.014	-40	169	.029	.027	-.003	-10
110	.034	.027	-.007	-20	140	.025	.022	-.014	-40	170	.029	.027	-.003	-10
111	.033	.027	-.007	-20	141	.025	.022	-.003	-10	171	.029	.026	-.003	-10
112	.033	.027	-.006	-20	142	.025	.022	-.003	-10	172	.029	.026	-.003	-10
113	.033	.027	-.006	-20	143	.024	.022	-.003	-10	173	.028	.026	-.003	-10
114	.032	.026	-.006	-20	144	.024	.021	-.003	-10	174	.028	.026	-.003	-10
115	.032	.026	-.006	-20	145	.024	.021	-.003	-10	175	.028	.026	-.003	-10
116	.032	.026	-.006	-20	146	.024	.021	-.003	-10	176	.028	.026	-.003	-10
117	.032	.026	-.006	-20	147	.023	.021	-.003	-10	177	.028	.026	-.003	-10
118	.031	.026	-.006	-20	148	.023	.021	-.003	-10	178	.028	.025	-.003	-10
119	.031	.025	-.006	-20	149	.023	.021	-.003	-10	179	.028	.025	-.003	-10
120	.031	.025	-.006	-20	150	.023	.020	-.003	-10	180	.027	.025	-.003	-10

PASS	BASE	TEST	DIFF	X	PASS	BASE	TEST	DIFF	X	PASS	BASE	TEST	DIFF	X
181	.034	.025	-.009	-20	211	.029	.029	-.001	-4	241	.031	.025	-.004	-20
182	.034	.025	-.008	-28	212	.029	.028	-.001	-4	242	.030	.025	-.004	-20
183	.033	.025	-.008	-20	213	.028	.028	-.001	-4	243	.030	.025	-.004	-20
184	.033	.024	-.009	-20	214	.027	.028	-.001	-4	244	.030	.025	-.004	-20
185	.033	.024	-.009	-20	215	.027	.028	-.001	-4	245	.030	.025	-.004	-20
186	.033	.024	-.009	-20	216	.027	.028	-.001	-4	246	.030	.025	-.004	-20
187	.033	.024	-.009	-20	217	.027	.028	-.001	-4	247	.030	.025	-.004	-20
188	.033	.024	-.009	-20	218	.027	.028	-.001	-4	248	.030	.025	-.004	-20
189	.032	.024	-.009	-20	219	.027	.027	-.001	-4	249	.030	.024	-.004	-20
190	.032	.024	-.009	-20	220	.027	.027	-.001	-4	250	.029	.024	-.004	-20
191	.032	.024	-.009	-20	221	.027	.027	-.001	-4	251	.029	.024	-.004	-20
192	.032	.024	-.009	-20	222	.027	.027	-.001	-4	252	.029	.024	-.004	-20
193	.032	.024	-.009	-20	223	.027	.027	-.001	-4	253	.029	.024	-.004	-20
194	.032	.023	-.009	-20	224	.027	.027	-.001	-4	254	.029	.024	-.004	-20
195	.032	.023	-.009	-20	225	.027	.027	-.001	-4	255	.029	.024	-.004	-20
196	.031	.023	-.009	-20	226	.027	.027	-.001	-4	256	.029	.024	-.004	-20
197	.031	.023	-.009	-20	227	.027	.027	-.001	-4	257	.029	.024	-.004	-20
198	.031	.023	-.009	-20	228	.027	.026	-.001	-4	258	.029	.023	-.004	-20
199	.031	.023	-.009	-20	229	.027	.026	-.001	-4	259	.029	.023	-.004	-20
200	.031	.023	-.009	-20	230	.027	.026	-.001	-4	260	.029	.023	-.004	-20
201	.030	.022	-.008	-20	231	.027	.026	-.001	-4	261	.028	.023	-.004	-20
202	.030	.022	-.008	-20	232	.027	.026	-.001	-4	262	.028	.023	-.004	-20
203	.030	.022	-.008	-20	233	.027	.026	-.001	-4	263	.028	.023	-.004	-20
204	.030	.022	-.008	-20	234	.027	.026	-.001	-4	264	.028	.023	-.004	-20
205	.030	.022	-.008	-20	235	.027	.026	-.001	-4	265	.028	.023	-.004	-20
206	.030	.022	-.008	-20	236	.027	.026	-.001	-4	266	.028	.023	-.004	-20
207	.030	.022	-.008	-20	237	.027	.025	-.002	-20	267	.028	.023	-.004	-20
208	.029	.022	-.008	-20	238	.027	.025	-.002	-20	268	.027	.023	-.004	-20
209	.029	.022	-.008	-20	239	.027	.025	-.002	-20	269	.027	.023	-.004	-20
210	.029	.022	-.008	-20	240	.027	.025	-.002	-20	270	.027	.022	-.005	-20

BUS COST MODEL

BASELINE BUS

SEATING CAPACITY 1.45 BUS COST \$/KH 1.16 TOTAL COST \$/KH 11.210

DRIVER COST \$/KH 1.55 OVERHEAD \$/KH 1.16

SLEMANIO ARTICULATED OR PEOPLE DECK BUS

SEATING CAPACITY 1.40 BUS COST \$/KH 1.16 TOTAL COST \$/KH 11.400

DRIVER COST \$/KH 1.55 OVERHEAD \$/KH 1.16

PASS	BASE	TEST	UNIT	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
1	1.210	1.401	.271	22	31	.040	.040	.000	23	61	.040	.025	-.016	-40
2	.606	.741	.136	22	32	.030	.047	.017	23	62	.040	.024	-.016	-40
3	.404	.494	.091	22	33	.017	.045	.028	23	63	.019	.034	-.015	-40
4	.303	.371	.060	22	34	.016	.044	.028	23	64	.030	.024	-.015	-40
5	.243	.297	.055	22	35	.015	.043	.028	23	65	.030	.023	-.015	-40
6	.202	.247	.046	23	36	.014	.042	.028	23	66	.037	.023	-.015	-40
7	.173	.212	.039	23	37	.013	.041	.028	23	67	.037	.023	-.015	-40
8	.152	.186	.034	23	38	.012	.039	.027	24	68	.036	.022	-.014	-40
9	.135	.165	.031	23	39	.012	.030	.018	24	69	.036	.022	-.014	-40
10	.122	.149	.020	23	40	.011	.030	.017	24	70	.035	.022	-.014	-40
11	.111	.135	.015	23	41	.010	.017	.007	24	71	.035	.021	-.014	-40
12	.101	.124	.023	23	42	.009	.036	.027	24	72	.034	.021	-.013	-40
13	.094	.114	.021	23	43	.009	.035	.027	24	73	.034	.021	-.013	-40
14	.087	.106	.020	23	44	.007	.034	.027	24	74	.033	.021	-.013	-40
15	.081	.099	.019	23	45	.007	.033	.027	24	75	.033	.020	-.013	-40
16	.076	.093	.017	23	46	.005	.031	.026	24	76	.032	.020	-.013	-40
17	.072	.088	.016	23	47	.005	.032	.026	24	77	.032	.020	-.013	-40
18	.060	.083	.016	23	48	.005	.031	.026	24	78	.032	.019	-.013	-40
19	.064	.078	.015	23	49	.005	.031	.026	24	79	.031	.019	-.012	-40
20	.061	.075	.014	23	50	.004	.030	.026	24	80	.031	.019	-.012	-40
21	.058	.071	.014	23	51	.004	.030	.026	24	81	.030	.017	-.012	-40
22	.056	.068	.013	23	52	.004	.029	.026	24	82	.030	.017	-.012	-40
23	.053	.065	.013	23	53	.004	.028	.026	24	83	.030	.016	-.012	-40
24	.051	.062	.012	23	54	.004	.028	.026	24	84	.030	.016	-.012	-40
25	.049	.060	.011	23	55	.004	.027	.026	24	85	.030	.015	-.012	-40
26	.042	.052	.011	23	56	.004	.027	.026	24	86	.029	.015	-.012	-40
27	.045	.055	.011	23	57	.004	.026	.026	24	87	.028	.015	-.012	-40
28	.044	.053	.010	23	58	.004	.026	.026	24	88	.028	.014	-.012	-40
29	.042	.052	.010	23	59	.004	.026	.026	24	89	.028	.014	-.012	-40
30	.041	.050	.010	23	60	.004	.025	-.016	24	90	.027	.013	-.012	-40

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
91	.040	.013	-.000	-19	121	.031	.025	-.006	-20	151	.041	.030	-.013	-40
92	.040	.033	-.000	-19	122	.030	.025	-.006	-20	152	.012	.020	-.013	-40
93	.040	.032	-.000	-19	123	.030	.023	-.006	-20	153	.032	.020	-.013	-40
94	.039	.032	-.000	-19	124	.030	.024	-.006	-20	154	.032	.020	-.013	-40
95	.038	.022	-.000	-20	125	.030	.024	-.006	-20	155	.032	.020	-.013	-40
96	.038	.022	-.000	-20	126	.030	.024	-.006	-20	156	.032	.020	-.013	-40
97	.038	.031	-.000	-20	127	.029	.024	-.006	-20	157	.031	.019	-.012	-40
98	.038	.031	-.000	-20	128	.029	.024	-.006	-20	158	.031	.019	-.012	-40
99	.037	.010	-.000	-20	129	.029	.023	-.006	-20	159	.031	.019	-.012	-40
100	.037	.010	-.000	-20	130	.029	.023	-.006	-20	160	.031	.019	-.012	-40
101	.036	.010	-.000	-20	131	.029	.023	-.006	-20	161	.031	.020	-.003	-10
102	.036	.030	-.000	-20	132	.028	.023	-.006	-20	162	.030	.020	-.003	-10
103	.036	.029	-.000	-20	133	.028	.023	-.006	-20	163	.030	.020	-.003	-10
104	.035	.029	-.000	-20	134	.028	.023	-.006	-20	164	.030	.020	-.003	-10
105	.035	.029	-.000	-20	135	.027	.022	-.006	-20	165	.030	.027	-.003	-10
106	.035	.028	-.000	-20	136	.027	.022	-.006	-20	166	.030	.027	-.003	-10
107	.034	.020	-.000	-20	137	.026	.022	-.006	-20	167	.029	.027	-.003	-10
108	.034	.020	-.000	-20	138	.026	.022	-.006	-20	168	.029	.027	-.003	-10
109	.034	.020	-.000	-20	139	.025	.022	-.006	-20	169	.029	.027	-.003	-10
110	.034	.027	-.000	-20	140	.025	.022	-.006	-20	170	.029	.027	-.003	-10
111	.033	.027	-.000	-20	141	.025	.021	-.006	-20	171	.029	.026	-.003	-10
112	.033	.027	-.000	-20	142	.025	.021	-.006	-20	172	.029	.026	-.003	-10
113	.033	.027	-.000	-20	143	.024	.021	-.006	-20	173	.029	.026	-.003	-10
114	.032	.026	-.000	-20	144	.024	.021	-.006	-20	174	.029	.026	-.003	-10
115	.032	.026	-.000	-20	145	.024	.021	-.006	-20	175	.029	.026	-.003	-10
116	.032	.026	-.000	-20	146	.024	.021	-.006	-20	176	.029	.026	-.003	-10
117	.032	.026	-.000	-20	147	.023	.021	-.006	-20	177	.029	.026	-.003	-10
118	.031	.026	-.000	-20	148	.023	.021	-.006	-20	178	.029	.026	-.003	-10
119	.031	.025	-.000	-20	149	.023	.020	-.006	-20	179	.029	.025	-.003	-10
120	.031	.025	-.000	-20	150	.023	.020	-.006	-20	180	.029	.025	-.003	-10

PASS	RASE	TEST	DIFF	Z	PASS	RASE	TEST	DIFF	Z	PASS	RASE	TEST	DIFF	Z
101	.014	.025	-.009	-20	211	.029	.022	-.000	-20	241	.031	.025	-.006	-20
102	.014	.025	-.009	-20	212	.029	.021	-.000	-20	242	.031	.025	-.006	-20
103	.034	.025	-.009	-20	213	.029	.021	-.000	-20	243	.030	.025	-.006	-20
104	.033	.025	-.009	-20	214	.029	.021	-.000	-20	244	.030	.025	-.006	-20
105	.033	.025	-.009	-20	215	.029	.021	-.000	-20	245	.030	.025	-.006	-20
106	.033	.024	-.009	-20	216	.028	.021	-.000	-20	246	.030	.024	-.006	-20
107	.033	.024	-.009	-20	217	.028	.021	-.000	-20	247	.030	.024	-.006	-20
108	.033	.024	-.009	-20	218	.028	.021	-.000	-20	248	.030	.024	-.006	-20
109	.033	.024	-.009	-20	219	.028	.021	-.000	-20	249	.030	.024	-.006	-20
110	.032	.024	-.009	-20	220	.028	.021	-.000	-20	250	.030	.024	-.006	-20
111	.032	.024	-.009	-20	221	.028	.021	-.000	-20	251	.029	.024	-.006	-20
112	.032	.024	-.009	-20	222	.028	.021	-.000	-20	252	.029	.024	-.006	-20
113	.032	.023	-.009	-20	223	.028	.020	-.000	-20	253	.029	.024	-.006	-20
114	.032	.023	-.009	-20	224	.028	.020	-.000	-20	254	.029	.024	-.006	-20
115	.032	.023	-.009	-20	225	.027	.020	-.000	-20	255	.029	.024	-.006	-20
116	.031	.023	-.009	-20	226	.027	.020	-.000	-20	256	.029	.024	-.006	-20
117	.031	.023	-.009	-20	227	.027	.020	-.000	-20	257	.029	.024	-.006	-20
118	.031	.023	-.009	-20	228	.027	.020	-.000	-20	258	.029	.023	-.006	-20
119	.031	.023	-.009	-20	229	.027	.020	-.000	-20	259	.029	.023	-.006	-20
120	.031	.023	-.009	-20	230	.027	.020	-.000	-20	260	.029	.023	-.006	-20
121	.031	.023	-.009	-20	231	.027	.020	-.000	-20	261	.028	.023	-.006	-20
122	.030	.022	-.009	-20	232	.027	.020	-.000	-20	262	.028	.023	-.006	-20
123	.030	.022	-.009	-20	233	.027	.020	-.000	-20	263	.028	.023	-.006	-20
124	.030	.022	-.009	-20	234	.027	.020	-.000	-20	264	.028	.023	-.006	-20
125	.030	.022	-.009	-20	235	.027	.020	-.000	-20	265	.028	.023	-.006	-20
126	.030	.022	-.009	-20	236	.027	.020	-.000	-20	266	.028	.023	-.006	-20
127	.030	.022	-.009	-20	237	.027	.020	-.000	-20	267	.028	.023	-.006	-20
128	.030	.022	-.009	-20	238	.027	.020	-.000	-20	268	.028	.023	-.006	-20
129	.029	.022	-.009	-20	239	.027	.020	-.000	-20	269	.027	.023	-.005	-20
130	.029	.022	-.009	-20	240	.027	.020	-.000	-20	270	.027	.022	-.005	-20

RUS COST MODEL

BASLINE BUS

SEATING CAPACITY : 45 BUS COST : /KM : .50
DRIVER COST : /KM : .55 OVERHEAD : /KM : .16 TOTAL COST : /KM : 1.210

SCENARIO : ARTICULATED OR DOUBLE DECK BUS

SEATING CAPACITY : 61 BUS COST : /KM : .86
DRIVER COST : /KM : .55 OVERHEAD : /KM : .16 TOTAL COST : /KM : 1.570

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
1	1.210	1.571	.361	30	14	.040	.051	.012	31	61	.040	.026	-.014	-36
2	.604	.704	.101	30	37	.030	.050	.012	31	62	.040	.051	.012	31
3	.404	.524	.121	30	33	.037	.048	.011	31	63	.039	.050	.012	31
4	.303	.393	.091	30	34	.036	.047	.011	31	64	.038	.050	.012	31
5	.243	.315	.073	30	35	.035	.045	.011	31	65	.030	.049	.012	31
6	.203	.263	.061	30	36	.034	.044	.010	31	66	.035	.049	.011	31
7	.173	.223	.052	30	39	.033	.043	.010	31	67	.036	.047	.011	31
8	.152	.197	.046	30	38	.032	.042	.010	31	68	.036	.047	.011	31
9	.135	.175	.041	30	39	.032	.041	.010	31	69	.036	.046	.011	31
10	.122	.150	.037	30	40	.031	.040	.010	31	70	.035	.045	.011	31
11	.111	.143	.033	30	41	.030	.039	.009	31	71	.035	.045	.011	31
12	.101	.131	.031	30	42	.029	.038	.009	31	72	.034	.044	.011	31
13	.094	.121	.028	30	43	.029	.037	.009	31	73	.034	.044	.010	31
14	.087	.113	.026	30	44	.028	.036	.009	31	74	.033	.043	.010	31
15	.081	.105	.025	30	45	.027	.035	.009	31	75	.033	.042	.010	31
16	.076	.099	.023	30	46	.027	.035	.009	31	76	.032	.042	.010	31
17	.072	.093	.022	30	47	.026	.034	.009	31	77	.032	.041	.010	31
18	.068	.088	.021	30	48	.026	.033	.009	31	78	.032	.041	.010	31
19	.064	.083	.020	30	49	.025	.033	.009	31	79	.031	.040	.010	31
20	.061	.079	.019	30	50	.024	.032	.009	31	80	.031	.040	.010	31
21	.058	.075	.018	30	51	.023	.031	.009	31	81	.030	.039	.009	31
22	.056	.072	.017	30	52	.022	.031	.009	31	82	.030	.039	.009	31
23	.053	.069	.016	30	53	.021	.030	.009	31	83	.030	.039	.009	31
24	.051	.066	.016	30	54	.020	.030	.009	31	84	.029	.038	.009	31
25	.049	.063	.015	30	55	.019	.029	.009	31	85	.029	.037	.009	31
26	.047	.061	.014	30	56	.018	.028	.009	31	86	.029	.037	.009	31
27	.045	.059	.014	31	57	.017	.028	.009	31	87	.028	.036	.009	31
28	.044	.057	.013	31	58	.016	.027	.009	31	88	.028	.036	.009	31
29	.042	.055	.013	31	59	.015	.027	.009	31	89	.028	.036	.009	31
30	.041	.053	.013	31	60	.014	.027	.009	31	90	.027	.035	.009	31

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
91	.040	.035	-.006	-15	121	.031	.026	-.005	-15	151	.033	.032	-.001	-4
92	.040	.037	-.003	-15	122	.030	.028	-.002	-15	152	.032	.031	-.001	-4
93	.039	.034	-.005	-15	123	.030	.028	-.002	-15	153	.032	.031	-.001	-4
94	.039	.034	-.005	-15	124	.030	.028	-.002	-15	154	.032	.031	-.001	-4
95	.038	.033	-.005	-15	125	.029	.027	-.002	-15	155	.032	.031	-.001	-4
96	.038	.033	-.005	-15	126	.029	.027	-.002	-15	156	.032	.031	-.001	-4
97	.038	.033	-.005	-15	127	.029	.027	-.002	-15	157	.031	.030	-.001	-4
98	.037	.032	-.005	-15	128	.029	.027	-.002	-15	158	.031	.030	-.001	-4
99	.037	.032	-.005	-15	129	.028	.027	-.001	-15	159	.031	.030	-.001	-4
100	.036	.031	-.005	-15	130	.028	.027	-.001	-15	160	.031	.030	-.001	-4
101	.036	.031	-.005	-15	131	.028	.027	-.001	-15	161	.031	.030	-.001	-4
102	.036	.031	-.005	-15	132	.028	.027	-.001	-15	162	.030	.029	-.001	-4
103	.035	.030	-.005	-15	133	.028	.027	-.001	-15	163	.030	.029	-.001	-4
104	.035	.030	-.005	-15	134	.028	.027	-.001	-15	164	.030	.029	-.001	-4
105	.035	.030	-.005	-15	135	.027	.026	-.001	-15	165	.030	.029	-.001	-4
106	.035	.030	-.005	-15	136	.027	.026	-.001	-15	166	.030	.029	-.001	-4
107	.034	.029	-.005	-15	137	.026	.025	-.001	-15	167	.029	.028	-.001	-4
108	.034	.029	-.005	-15	138	.026	.025	-.001	-15	168	.029	.028	-.001	-4
109	.034	.029	-.005	-15	139	.025	.024	-.001	-15	169	.029	.028	-.001	-4
110	.034	.029	-.005	-15	140	.025	.024	-.001	-15	170	.029	.028	-.001	-4
111	.033	.028	-.005	-15	141	.025	.024	-.001	-15	171	.029	.028	-.001	-4
112	.033	.028	-.005	-15	142	.025	.024	-.001	-15	172	.029	.028	-.001	-4
113	.033	.028	-.005	-15	143	.024	.023	-.001	-15	173	.028	.027	-.001	-4
114	.032	.027	-.005	-15	144	.024	.023	-.001	-15	174	.028	.027	-.001	-4
115	.032	.027	-.005	-15	145	.024	.023	-.001	-15	175	.028	.027	-.001	-4
116	.032	.027	-.005	-15	146	.024	.023	-.001	-15	176	.028	.027	-.001	-4
117	.032	.027	-.005	-15	147	.023	.022	-.001	-15	177	.028	.027	-.001	-4
118	.031	.026	-.005	-15	148	.023	.022	-.001	-15	178	.028	.027	-.001	-4
119	.031	.026	-.005	-15	149	.023	.022	-.001	-15	179	.028	.027	-.001	-4
120	.031	.026	-.005	-15	150	.023	.022	-.001	-15	180	.027	.026	-.001	-4

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
181	.034	.027	-.008	-23	241	.031	.027	-.005	-15	241	.031	.027	-.005	-15
182	.034	.028	-.008	-23	242	.031	.028	-.003	-13	242	.031	.028	-.003	-13
183	.033	.035	.002	3	243	.030	.030	.000	0	243	.030	.030	.000	0
184	.033	.034	.002	3	244	.030	.030	.000	0	244	.030	.030	.000	0
185	.033	.034	.002	3	245	.030	.030	.000	0	245	.030	.030	.000	0
186	.033	.034	.002	3	246	.030	.030	.000	0	246	.030	.030	.000	0
187	.033	.034	.002	3	247	.030	.030	.000	0	247	.030	.030	.000	0
188	.033	.034	.002	3	248	.030	.030	.000	0	248	.030	.030	.000	0
189	.032	.034	.002	3	249	.030	.030	.000	0	249	.030	.030	.000	0
190	.032	.033	.002	3	250	.030	.030	.000	0	250	.030	.030	.000	0
191	.032	.033	.002	3	251	.029	.029	.000	0	251	.029	.029	.000	0
192	.032	.033	.002	3	252	.029	.029	.000	0	252	.029	.029	.000	0
193	.032	.033	.002	3	253	.029	.029	.000	0	253	.029	.029	.000	0
194	.032	.033	.002	3	254	.029	.029	.000	0	254	.029	.029	.000	0
195	.032	.033	.002	3	255	.029	.029	.000	0	255	.029	.029	.000	0
196	.031	.033	.002	3	256	.029	.029	.000	0	256	.029	.029	.000	0
197	.031	.032	.002	3	257	.029	.029	.000	0	257	.029	.029	.000	0
198	.031	.032	.002	3	258	.029	.029	.000	0	258	.029	.029	.000	0
199	.031	.032	.002	3	259	.029	.029	.000	0	259	.029	.029	.000	0
200	.031	.032	.002	3	260	.029	.029	.000	0	260	.029	.029	.000	0
201	.030	.031	.002	3	261	.028	.028	.000	0	261	.028	.028	.000	0
202	.030	.031	.002	3	262	.028	.028	.000	0	262	.028	.028	.000	0
203	.030	.031	.002	3	263	.028	.028	.000	0	263	.028	.028	.000	0
204	.030	.031	.002	3	264	.028	.028	.000	0	264	.028	.028	.000	0
205	.030	.031	.002	3	265	.028	.028	.000	0	265	.028	.028	.000	0
206	.030	.031	.002	3	266	.028	.028	.000	0	266	.028	.028	.000	0
207	.030	.031	.002	3	267	.028	.028	.000	0	267	.028	.028	.000	0
208	.030	.031	.002	3	268	.028	.028	.000	0	268	.028	.028	.000	0
209	.029	.031	.002	3	269	.027	.027	.000	0	269	.027	.027	.000	0
210	.029	.030	.002	3	270	.027	.027	.000	0	270	.027	.027	.000	0

RUS COST MODEL

BASELINE RUS

SEATING CAPACITY 1.45 RUS COST 1/KM 1.50 TOTAL COST 1/KM 11.210
DRIVER COST 1/KM 1.55 OVERHEAD 1/KM 1.16

SCENARIO (ARTICULATED OR DOUBLE DECK BUS)

SLATTING CAPACITY 1.70 RUS COST 1/KM 1.86 TOTAL COST 1/KM 11.570
DRIVER COST 1/KM 1.55 OVERHEAD 1/KM 1.16

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
1	1.210	1.871	.161	30	31	.040	.051	.017	31	61	.040	.026	-.014	36
2	.206	.786	.101	30	32	.030	.050	.012	31	62	.040	.026	-.014	36
3	.404	.524	.171	30	33	.037	.040	.011	31	63	.019	.025	-.014	36
4	.303	.393	.091	30	34	.016	.047	.011	31	64	.030	.025	-.014	36
5	.243	.315	.071	30	35	.015	.045	.011	31	65	.018	.025	-.014	36
6	.202	.262	.061	30	36	.034	.044	.011	31	66	.017	.024	-.013	36
7	.173	.225	.052	30	37	.013	.043	.010	31	67	.037	.024	-.013	36
8	.152	.197	.046	30	38	.032	.042	.010	31	68	.036	.024	-.013	36
9	.135	.175	.041	30	39	.012	.041	.010	31	69	.016	.023	-.013	36
10	.122	.150	.037	30	40	.031	.040	.010	31	70	.015	.023	-.013	36
11	.111	.143	.031	30	41	.030	.039	.009	31	71	.035	.043	.011	31
12	.101	.131	.031	30	42	.029	.030	.009	31	72	.034	.041	.011	31
13	.094	.121	.028	30	43	.029	.037	.009	31	73	.034	.041	.010	31
14	.087	.113	.026	30	44	.028	.036	.009	31	74	.033	.042	.010	31
15	.081	.105	.025	30	45	.027	.035	.009	31	75	.033	.042	.010	31
16	.076	.099	.023	30	46	.053	.035	.017	36	76	.032	.042	.010	31
17	.072	.093	.021	30	47	.052	.034	.019	36	77	.032	.041	.010	31
18	.068	.091	.021	30	48	.051	.033	.018	36	78	.032	.041	.010	31
19	.064	.089	.019	30	49	.050	.033	.018	36	79	.031	.040	.010	31
20	.061	.087	.019	30	50	.049	.032	.018	36	80	.031	.040	.010	31
21	.058	.085	.018	30	51	.048	.031	.017	36	81	.030	.039	.009	31
22	.056	.082	.017	30	52	.047	.031	.017	36	82	.030	.039	.009	31
23	.053	.080	.016	30	53	.046	.030	.017	36	83	.030	.038	.009	31
24	.051	.078	.016	30	54	.045	.030	.016	36	84	.029	.038	.009	31
25	.049	.076	.015	30	55	.045	.029	.016	36	85	.029	.037	.009	31
26	.047	.074	.014	30	56	.044	.029	.016	36	86	.029	.037	.009	31
27	.045	.072	.014	31	57	.043	.028	.015	36	87	.028	.036	.009	31
28	.044	.071	.013	31	58	.042	.027	.015	36	88	.028	.036	.009	31
29	.042	.069	.013	31	59	.042	.027	.015	36	89	.027	.035	.009	31
30	.041	.068	.013	31	60	.041	.027	.015	36	90	.027	.035	.009	31

PASS	RAGE	TEST	DIFF	Z	PASS	RAGE	TEST	DIFF	Z	PASS	RAGE	TEST	DIFF	Z
91	.040	.035	-.006	-15	121	.031	.026	-.005	-15	151	.033	.032	-.001	-4
92	.040	.035	-.006	-15	122	.030	.026	-.005	-15	152	.032	.032	-.001	-4
93	.040	.034	-.006	-15	123	.030	.026	-.006	-15	153	.032	.031	-.001	-4
94	.039	.034	-.006	-15	124	.030	.026	-.006	-15	154	.032	.031	-.001	-4
95	.039	.034	-.006	-15	125	.030	.026	-.006	-15	155	.032	.031	-.001	-4
96	.038	.033	-.006	-15	126	.029	.025	-.004	-15	156	.032	.031	-.001	-4
97	.038	.033	-.006	-15	127	.029	.025	-.004	-15	157	.031	.031	-.001	-4
98	.038	.033	-.006	-15	128	.029	.025	-.004	-15	158	.031	.030	-.001	-4
99	.037	.032	-.005	-15	129	.029	.025	-.004	-15	159	.031	.030	-.001	-4
100	.037	.032	-.005	-15	130	.029	.025	-.004	-15	160	.031	.030	-.001	-4
101	.036	.032	-.005	-15	131	.028	.024	-.004	-15	161	.031	.030	-.001	-4
102	.036	.031	-.005	-15	132	.028	.024	-.004	-15	162	.030	.030	-.001	-4
103	.036	.031	-.005	-15	133	.028	.024	-.004	-15	163	.030	.029	-.001	-4
104	.035	.031	-.005	-15	134	.028	.024	-.004	-15	164	.030	.029	-.001	-4
105	.035	.030	-.005	-15	135	.027	.024	-.004	-15	165	.030	.029	-.001	-4
106	.035	.030	-.005	-15	136	.027	.024	-.004	-15	166	.030	.029	-.001	-4
107	.034	.030	-.005	-15	137	.026	.023	-.004	-15	167	.029	.029	-.001	-4
108	.034	.030	-.005	-15	138	.026	.023	-.004	-15	168	.029	.029	-.001	-4
109	.034	.029	-.005	-15	139	.025	.023	-.004	-15	169	.029	.029	-.001	-4
110	.034	.029	-.005	-15	140	.025	.023	-.004	-15	170	.029	.029	-.001	-4
111	.033	.029	-.005	-15	141	.025	.024	-.001	-4	171	.029	.028	-.001	-4
112	.033	.029	-.005	-15	142	.025	.024	-.001	-4	172	.029	.028	-.001	-4
113	.033	.028	-.005	-15	143	.024	.023	-.001	-4	173	.029	.028	-.001	-4
114	.032	.028	-.005	-15	144	.024	.023	-.001	-4	174	.028	.028	-.001	-4
115	.032	.028	-.005	-15	145	.024	.023	-.001	-4	175	.028	.027	-.001	-4
116	.032	.027	-.005	-15	146	.024	.023	-.001	-4	176	.028	.027	-.001	-4
117	.032	.027	-.005	-15	147	.023	.023	-.001	-4	177	.028	.027	-.001	-4
118	.031	.027	-.005	-15	148	.023	.023	-.001	-4	178	.028	.027	-.001	-4
119	.031	.027	-.005	-15	149	.023	.023	-.001	-4	179	.028	.027	-.001	-4
120	.031	.027	-.005	-15	150	.023	.023	-.001	-4	180	.027	.027	-.001	-4

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
181	.034	.027	-.008	-23	211	.029	.030	.002	5	241	.031	.027	-.005	-15
182	.034	.026	-.008	-23	212	.029	.030	.002	5	242	.031	.026	-.005	-15
183	.034	.026	-.008	-23	213	.029	.030	.002	5	243	.030	.026	-.005	-15
184	.033	.026	-.008	-23	214	.025	.030	.002	5	244	.030	.026	-.005	-15
185	.033	.026	-.008	-23	215	.029	.030	.002	5	245	.030	.026	-.005	-15
186	.033	.026	-.008	-23	216	.029	.030	.002	5	246	.030	.026	-.004	-15
187	.033	.026	-.008	-23	217	.020	.029	.002	5	247	.030	.026	-.004	-15
188	.033	.026	-.008	-23	218	.020	.029	.002	4	248	.030	.026	-.004	-15
189	.033	.025	-.008	-23	219	.020	.029	.002	4	249	.030	.026	-.004	-15
190	.032	.025	-.006	-23	220	.020	.029	.002	4	250	.030	.026	-.004	-15
191	.032	.025	-.006	-23	221	.020	.029	.002	4	251	.029	.026	-.004	-15
192	.032	.025	-.006	-23	222	.020	.029	.002	4	252	.029	.025	-.004	-15
193	.032	.025	-.006	-23	223	.020	.029	.002	4	253	.029	.025	-.004	-15
194	.032	.025	-.006	-23	224	.020	.029	.002	4	254	.029	.025	-.004	-15
195	.032	.025	-.006	-23	225	.027	.020	.002	4	255	.029	.025	-.004	-15
196	.031	.024	-.007	-23	226	.032	.030	-.005	-15	256	.029	.025	-.004	-15
197	.031	.024	-.007	-23	227	.032	.030	-.005	-15	257	.029	.025	-.004	-15
198	.031	.024	-.007	-23	228	.032	.030	-.005	-15	258	.029	.025	-.004	-15
199	.031	.024	-.007	-23	229	.032	.030	-.005	-15	259	.029	.025	-.004	-15
200	.031	.024	-.007	-23	230	.032	.030	-.005	-15	260	.029	.025	-.004	-15
201	.031	.024	-.007	-23	231	.032	.030	-.005	-15	261	.029	.025	-.004	-15
202	.030	.024	-.007	-23	232	.032	.030	-.005	-15	262	.029	.024	-.004	-15
203	.030	.024	-.007	-23	233	.032	.030	-.005	-15	263	.028	.024	-.004	-15
204	.030	.024	-.007	-23	234	.032	.030	-.005	-15	264	.028	.024	-.004	-15
205	.030	.023	-.007	-23	235	.031	.027	-.005	-15	265	.028	.024	-.004	-15
206	.030	.023	-.007	-23	236	.031	.027	-.005	-15	266	.028	.024	-.004	-15
207	.030	.023	-.007	-23	237	.031	.027	-.005	-15	267	.028	.024	-.004	-15
208	.029	.023	-.007	-23	238	.031	.027	-.005	-15	268	.028	.024	-.004	-15
209	.029	.023	-.007	-23	239	.031	.027	-.005	-15	269	.027	.024	-.004	-15
210	.029	.023	-.007	-23	240	.031	.027	-.005	-15	270	.027	.024	-.004	-15

BUS COST MODEL

BASELINE BUS

SEATING CAPACITY : 45 BUS COST 1/KM : .50 TOTAL COST 1/KM : 1.210
 DRIVER COST 1/KM : .55 OVERHEAD 1/KM : .16

SCENARIO : ARTICULATED OR DOUBLE DECK BUS

SEATING CAPACITY : 80 BUS COST 1/KM : .86 TOTAL COST 1/KM : 1.570
 DRIVER COST 1/KM : .55 OVERHEAD 1/KM : .16

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
1	1.210	1.571	.361	30	31	.040	.051	.012	31	61	.040	.026	-.014	-36
2	.606	.786	.181	30	32	.038	.050	.012	31	62	.040	.026	-.014	-36
3	.404	.524	.121	30	33	.037	.048	.011	31	63	.039	.025	-.014	-36
4	.303	.393	.091	30	34	.036	.047	.011	31	64	.038	.025	-.014	-36
5	.243	.315	.073	30	35	.035	.045	.011	31	65	.038	.025	-.014	-36
6	.202	.262	.061	30	36	.034	.044	.011	31	66	.037	.024	-.013	-36
7	.173	.225	.052	30	37	.033	.043	.010	31	67	.037	.024	-.013	-36
8	.152	.197	.046	30	38	.032	.042	.010	31	68	.036	.024	-.013	-36
9	.135	.175	.041	30	39	.032	.041	.010	31	69	.036	.023	-.013	-36
10	.122	.158	.037	30	40	.031	.040	.010	31	70	.035	.023	-.013	-36
11	.111	.143	.033	30	41	.030	.039	.009	31	71	.034	.022	-.012	-36
12	.101	.131	.031	30	42	.029	.038	.009	31	72	.034	.022	-.012	-36
13	.094	.121	.028	30	43	.029	.037	.009	31	73	.034	.022	-.012	-36
14	.087	.113	.026	30	44	.028	.036	.009	31	74	.033	.022	-.012	-36
15	.081	.105	.025	30	45	.027	.035	.009	31	75	.033	.021	-.012	-36
16	.076	.099	.023	30	46	.027	.035	-.019	-36	76	.032	.021	-.012	-36
17	.072	.093	.022	30	47	.027	.034	-.019	-36	77	.032	.021	-.012	-36
18	.068	.088	.021	30	48	.026	.033	-.018	-36	78	.032	.021	-.011	-36
19	.064	.083	.019	30	49	.026	.033	-.018	-36	79	.031	.020	-.011	-36
20	.061	.079	.019	30	50	.025	.032	-.018	-36	80	.031	.020	-.011	-36
21	.058	.075	.018	30	51	.024	.031	-.017	-36	81	.030	.019	-.009	31
22	.056	.072	.017	30	52	.024	.031	-.017	-36	82	.030	.019	-.009	31
23	.053	.069	.016	30	53	.023	.030	-.017	-36	83	.030	.019	-.009	31
24	.051	.066	.016	30	54	.023	.030	-.016	-36	84	.029	.018	-.009	31
25	.049	.063	.015	30	55	.023	.029	-.016	-36	85	.029	.017	-.009	31
26	.047	.061	.014	30	56	.022	.029	-.016	-36	86	.029	.017	-.009	31
27	.045	.059	.014	31	57	.022	.028	-.015	-36	87	.028	.016	-.009	31
28	.044	.057	.013	31	58	.022	.028	-.015	-36	88	.028	.016	-.009	31
29	.042	.055	.013	31	59	.021	.027	-.015	-36	89	.027	.015	-.009	31
30	.041	.053	.013	31	60	.021	.027	-.015	-36	90	.027	.015	-.009	31

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
91	.040	.035	-.006	-15	121	.031	.026	-.005	-15	151	.033	.021	-.012	-36
92	.040	.034	-.006	-15	122	.030	.028	-.002	-15	152	.032	.021	-.011	-36
93	.039	.034	-.005	-15	123	.030	.026	-.004	-15	153	.032	.021	-.011	-36
94	.039	.034	-.005	-15	124	.030	.026	-.004	-15	154	.032	.021	-.011	-36
95	.038	.033	-.005	-15	125	.029	.025	-.004	-15	155	.032	.021	-.011	-36
96	.038	.033	-.005	-15	126	.029	.025	-.004	-15	156	.031	.020	-.011	-36
97	.038	.033	-.005	-15	127	.029	.025	-.004	-15	157	.031	.020	-.011	-36
98	.037	.032	-.005	-15	128	.028	.024	-.004	-15	158	.031	.020	-.011	-36
99	.037	.032	-.005	-15	129	.028	.024	-.004	-15	159	.031	.020	-.011	-36
100	.036	.032	-.004	-15	130	.028	.024	-.004	-15	160	.031	.020	-.011	-36
101	.036	.031	-.005	-15	131	.028	.024	-.004	-15	161	.030	.020	-.011	-36
102	.036	.031	-.005	-15	132	.028	.024	-.004	-15	162	.030	.020	-.011	-36
103	.035	.030	-.005	-15	133	.028	.024	-.004	-15	163	.030	.020	-.011	-36
104	.035	.030	-.005	-15	134	.027	.024	-.004	-15	164	.030	.020	-.011	-36
105	.035	.030	-.005	-15	135	.027	.024	-.004	-15	165	.030	.020	-.011	-36
106	.034	.030	-.004	-15	136	.027	.024	-.004	-15	166	.029	.020	-.011	-36
107	.034	.030	-.004	-15	137	.027	.024	-.004	-15	167	.029	.020	-.011	-36
108	.034	.030	-.004	-15	138	.027	.024	-.004	-15	168	.029	.020	-.011	-36
109	.034	.030	-.004	-15	139	.027	.024	-.004	-15	169	.029	.020	-.011	-36
110	.033	.029	-.004	-15	140	.027	.024	-.004	-15	170	.029	.020	-.011	-36
111	.033	.029	-.004	-15	141	.027	.024	-.004	-15	171	.029	.020	-.011	-36
112	.033	.029	-.004	-15	142	.027	.024	-.004	-15	172	.029	.020	-.011	-36
113	.032	.028	-.004	-15	143	.027	.024	-.004	-15	173	.029	.020	-.011	-36
114	.032	.028	-.004	-15	144	.027	.024	-.004	-15	174	.029	.020	-.011	-36
115	.032	.028	-.004	-15	145	.027	.024	-.004	-15	175	.029	.020	-.011	-36
116	.032	.028	-.004	-15	146	.027	.024	-.004	-15	176	.029	.020	-.011	-36
117	.031	.027	-.004	-15	147	.027	.024	-.004	-15	177	.029	.020	-.011	-36
118	.031	.027	-.004	-15	148	.027	.024	-.004	-15	178	.029	.020	-.011	-36
119	.031	.027	-.004	-15	149	.027	.024	-.004	-15	179	.029	.020	-.011	-36
120	.031	.027	-.004	-15	150	.027	.024	-.004	-15	180	.029	.020	-.011	-36

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
181	.034	.027	-.008	-23	211	.029	.023	-.007	-23	241	.031	.027	-.005	-15
182	.034	.026	-.008	-23	212	.029	.023	-.007	-23	242	.031	.026	-.005	-15
183	.033	.026	-.008	-23	213	.029	.023	-.007	-23	243	.030	.026	-.005	-15
184	.033	.026	-.008	-23	214	.028	.023	-.007	-23	244	.030	.026	-.005	-15
185	.033	.026	-.008	-23	215	.028	.023	-.007	-23	245	.030	.026	-.005	-15
186	.033	.026	-.008	-23	216	.028	.023	-.007	-23	246	.030	.026	-.005	-15
187	.032	.025	-.008	-23	217	.028	.022	-.007	-23	247	.030	.026	-.005	-15
188	.032	.025	-.008	-23	218	.028	.022	-.007	-23	248	.030	.026	-.005	-15
189	.032	.025	-.008	-23	219	.028	.022	-.007	-23	249	.030	.026	-.005	-15
190	.032	.025	-.008	-23	220	.028	.022	-.007	-23	250	.030	.026	-.005	-15
191	.032	.025	-.008	-23	221	.028	.022	-.007	-23	251	.029	.025	-.004	-15
192	.032	.025	-.008	-23	222	.028	.022	-.007	-23	252	.029	.025	-.004	-15
193	.032	.025	-.008	-23	223	.028	.022	-.007	-23	253	.029	.025	-.004	-15
194	.032	.025	-.008	-23	224	.028	.022	-.007	-23	254	.029	.025	-.004	-15
195	.032	.025	-.008	-23	225	.028	.022	-.007	-23	255	.029	.025	-.004	-15
196	.031	.024	-.007	-23	226	.027	.021	-.006	-23	256	.029	.025	-.004	-15
197	.031	.024	-.007	-23	227	.027	.021	-.006	-23	257	.029	.025	-.004	-15
198	.031	.024	-.007	-23	228	.027	.021	-.006	-23	258	.029	.025	-.004	-15
199	.031	.024	-.007	-23	229	.027	.021	-.006	-23	259	.029	.025	-.004	-15
200	.031	.024	-.007	-23	230	.027	.021	-.006	-23	260	.029	.025	-.004	-15
201	.031	.024	-.007	-23	231	.027	.021	-.006	-23	261	.029	.025	-.004	-15
202	.030	.024	-.007	-23	232	.027	.021	-.006	-23	262	.028	.024	-.004	-15
203	.030	.024	-.007	-23	233	.027	.021	-.006	-23	263	.028	.024	-.004	-15
204	.030	.024	-.007	-23	234	.027	.021	-.006	-23	264	.028	.024	-.004	-15
205	.030	.024	-.007	-23	235	.027	.021	-.006	-23	265	.028	.024	-.004	-15
206	.030	.023	-.007	-23	236	.027	.020	-.006	-23	266	.028	.024	-.004	-15
207	.030	.023	-.007	-23	237	.027	.020	-.006	-23	267	.028	.024	-.004	-15
208	.029	.023	-.007	-23	238	.027	.020	-.006	-23	268	.027	.024	-.004	-15
209	.029	.023	-.007	-23	239	.027	.020	-.006	-23	269	.027	.024	-.004	-15
210	.029	.023	-.007	-23	240	.027	.020	-.006	-23	270	.027	.024	-.004	-15

RUS COST MODEL

BASLINE BUS

SEATING CAPACITY : 45 BUS COST 1/KM 1.50
DRIVER COST 1/KM 1.55 OVERHEAD 1/KM 1.16 TOTAL COST 1/KM 11.210

SCENARIO ARTICULATED DOUBLE DECK BUS (JUNRO JET)

SEATING CAPACITY : 100 BUS COST 1/KM 11.05
DRIVER COST 1/KM 1.55 OVERHEAD 1/KM 1.16 TOTAL COST 1/KM 11.760

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
1	1.710	1.761	.551	45	31	.040	.057	.018	46	61	.040	.029	-.011	-28
2	.606	.001	.276	45	32	.030	.056	.018	46	62	.040	.029	-.011	-28
3	.404	.507	.104	46	33	.017	.054	.017	46	63	.039	.028	-.011	-28
4	.303	.441	.130	46	34	.036	.052	.017	46	64	.030	.020	-.011	-28
5	.243	.353	.111	46	35	.045	.051	.016	46	65	.030	.020	-.011	-28
6	.202	.294	.092	46	36	.054	.049	.016	46	66	.037	.027	-.011	-28
7	.173	.252	.079	46	37	.033	.040	.015	46	67	.017	.027	-.010	-28
8	.152	.221	.069	46	38	.032	.047	.015	46	68	.036	.026	-.010	-28
9	.135	.196	.062	46	39	.012	.046	.015	46	69	.036	.026	-.010	-28
10	.122	.177	.056	46	40	.011	.045	.014	46	70	.015	.025	-.010	-28
11	.111	.161	.051	46	41	.010	.043	.014	46	71	.015	.025	-.010	-28
12	.101	.147	.046	46	42	.029	.042	.014	46	72	.034	.025	-.010	-28
13	.094	.136	.043	46	43	.029	.041	.013	46	73	.034	.025	-.010	-28
14	.087	.126	.040	46	44	.020	.041	.013	46	74	.035	.024	-.009	-28
15	.081	.118	.037	46	45	.027	.040	.013	46	75	.033	.024	-.009	-28
16	.076	.111	.035	46	46	.053	.039	-.015	-28	76	.032	.024	-.009	-28
17	.072	.104	.033	46	47	.052	.038	-.015	-28	77	.032	.023	-.009	-28
18	.068	.090	.031	46	48	.031	.037	-.014	-28	78	.032	.023	-.009	-28
19	.064	.093	.029	46	49	.030	.036	-.014	-28	79	.031	.023	-.009	-28
20	.061	.089	.026	46	50	.046	.036	-.014	-28	80	.031	.023	-.009	-28
21	.058	.084	.027	46	51	.040	.035	-.013	-28	81	.030	.022	-.009	-28
22	.056	.081	.026	46	52	.047	.034	-.013	-28	82	.030	.022	-.009	-28
23	.053	.077	.024	46	53	.046	.034	-.013	-28	83	.030	.022	-.009	-28
24	.051	.074	.023	46	54	.045	.033	-.013	-28	84	.029	.021	-.008	-29
25	.049	.071	.021	46	55	.045	.033	-.013	-28	85	.029	.021	-.008	-29
26	.047	.068	.022	46	56	.044	.032	-.012	-28	86	.029	.021	-.008	-29
27	.045	.066	.021	46	57	.043	.031	-.012	-28	87	.020	.021	-.008	-29
28	.044	.063	.020	46	58	.042	.031	-.012	-28	88	.020	.021	-.008	-29
29	.042	.061	.019	46	59	.042	.030	-.012	-28	89	.020	.020	-.008	-29
30	.041	.059	.019	46	60	.041	.030	-.012	-28	90	.027	.020	-.008	-29

PASS	DATE	TEST	DIFF	Z	PASS	DATE	TEST	DIFF	Z	PASS	DATE	TEST	DIFF	Z
91	.040	.020	-.021	-52	121	.041	.030	-.001	-5	151	.033	.024	-.009	-28
92	.040	.010	-.021	-52	122	.030	.029	-.001	-5	152	.032	.024	-.009	-28
93	.040	.019	-.021	-52	123	.030	.029	-.001	-5	153	.032	.024	-.009	-28
94	.039	.019	-.020	-52	124	.030	.029	-.001	-5	154	.032	.024	-.009	-28
95	.039	.019	-.020	-52	125	.030	.029	-.001	-5	155	.032	.024	-.009	-28
96	.038	.019	-.020	-52	126	.029	.028	-.001	-5	156	.032	.024	-.009	-28
97	.038	.019	-.020	-52	127	.029	.028	-.001	-5	157	.031	.023	-.009	-28
98	.037	.018	-.019	-52	128	.029	.028	-.001	-5	158	.031	.023	-.009	-28
99	.037	.018	-.019	-52	129	.028	.027	-.001	-5	159	.031	.023	-.009	-28
100	.037	.018	-.019	-52	130	.028	.027	-.001	-5	160	.031	.023	-.009	-28
101	.036	.015	-.002	-4	131	.028	.027	-.001	-5	161	.031	.023	-.009	-28
102	.036	.015	-.002	-4	132	.028	.027	-.001	-5	162	.030	.022	-.009	-28
103	.036	.015	-.002	-4	133	.028	.027	-.001	-5	163	.030	.022	-.009	-28
104	.035	.014	-.002	-4	134	.028	.027	-.001	-5	164	.030	.022	-.009	-28
105	.035	.014	-.002	-4	135	.027	.027	-.001	-5	165	.030	.022	-.009	-28
106	.035	.014	-.002	-4	136	.027	.026	-.001	-5	166	.030	.022	-.009	-28
107	.034	.013	-.002	-4	137	.026	.026	-.001	-5	167	.029	.022	-.009	-28
108	.034	.013	-.002	-4	138	.026	.026	-.001	-5	168	.029	.022	-.009	-28
109	.034	.013	-.002	-4	139	.026	.026	-.001	-5	169	.029	.022	-.009	-28
110	.034	.013	-.002	-4	140	.025	.026	-.001	-5	170	.029	.022	-.009	-28
111	.033	.012	-.001	-5	141	.025	.025	-.001	-5	171	.029	.022	-.009	-28
112	.033	.012	-.001	-5	142	.025	.025	-.001	-5	172	.029	.022	-.009	-28
113	.033	.012	-.001	-5	143	.024	.025	-.001	-5	173	.028	.021	-.009	-28
114	.032	.011	-.001	-5	144	.024	.025	-.001	-5	174	.028	.021	-.009	-28
115	.032	.011	-.001	-5	145	.024	.025	-.001	-5	175	.028	.021	-.009	-28
116	.032	.011	-.001	-5	146	.024	.025	-.001	-5	176	.028	.021	-.009	-28
117	.032	.011	-.001	-5	147	.023	.024	-.001	-5	177	.028	.020	-.009	-28
118	.031	.010	-.001	-5	148	.023	.024	-.001	-5	178	.028	.020	-.009	-28
119	.031	.010	-.001	-5	149	.023	.024	-.001	-5	179	.028	.020	-.009	-28
120	.031	.010	-.001	-5	150	.023	.024	-.001	-5	180	.027	.020	-.009	-28

PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z	PASS	BASE	TEST	DIFF	Z
181	.034	.020	-.014	-43	211	.029	.026	-.004	-14	241	.031	.022	-.009	-20
182	.034	.020	-.014	-43	212	.028	.025	-.004	-14	242	.030	.022	-.008	-20
183	.034	.020	-.014	-43	213	.029	.025	-.004	-14	243	.030	.022	-.008	-20
184	.033	.020	-.014	-43	214	.029	.025	-.004	-14	244	.030	.022	-.008	-20
185	.033	.020	-.014	-43	215	.029	.025	-.004	-14	245	.030	.022	-.008	-20
186	.033	.019	-.014	-43	216	.028	.025	-.004	-14	246	.030	.022	-.008	-20
187	.033	.019	-.014	-43	217	.028	.025	-.004	-14	247	.030	.022	-.008	-20
188	.033	.019	-.014	-43	218	.028	.025	-.004	-14	248	.030	.022	-.008	-20
189	.033	.019	-.014	-43	219	.028	.025	-.004	-14	249	.030	.022	-.008	-20
190	.032	.019	-.014	-43	220	.028	.024	-.004	-14	250	.030	.022	-.008	-20
191	.032	.019	-.014	-43	221	.028	.024	-.004	-14	251	.030	.022	-.008	-20
192	.032	.019	-.014	-43	222	.028	.024	-.004	-14	252	.030	.022	-.008	-20
193	.032	.019	-.014	-43	223	.028	.024	-.004	-14	253	.030	.022	-.008	-20
194	.032	.019	-.014	-43	224	.028	.024	-.004	-14	254	.030	.022	-.008	-20
195	.032	.019	-.014	-43	225	.027	.024	-.004	-14	255	.030	.022	-.008	-20
196	.031	.018	-.013	-43	226	.027	.024	-.004	-14	256	.030	.022	-.008	-20
197	.031	.018	-.013	-43	227	.027	.024	-.004	-14	257	.030	.022	-.008	-20
198	.031	.018	-.013	-43	228	.027	.024	-.004	-14	258	.030	.022	-.008	-20
199	.031	.018	-.013	-43	229	.027	.024	-.004	-14	259	.030	.022	-.008	-20
200	.031	.018	-.013	-43	230	.027	.024	-.004	-14	260	.030	.022	-.008	-20
201	.031	.017	-.013	-43	231	.027	.023	-.004	-14	261	.030	.022	-.008	-20
202	.030	.017	-.013	-43	232	.027	.023	-.004	-14	262	.030	.022	-.008	-20
203	.030	.017	-.013	-43	233	.027	.023	-.004	-14	263	.030	.022	-.008	-20
204	.030	.017	-.013	-43	234	.027	.023	-.004	-14	264	.030	.022	-.008	-20
205	.030	.017	-.013	-43	235	.027	.023	-.004	-14	265	.030	.022	-.008	-20
206	.030	.017	-.013	-43	236	.027	.023	-.004	-14	266	.030	.022	-.008	-20
207	.030	.017	-.013	-43	237	.027	.023	-.004	-14	267	.030	.022	-.008	-20
208	.030	.017	-.013	-43	238	.027	.023	-.004	-14	268	.030	.022	-.008	-20
209	.029	.016	-.013	-43	239	.027	.023	-.004	-14	269	.027	.020	-.008	-20
210	.029	.016	-.013	-43	240	.027	.023	-.004	-14	270	.027	.020	-.008	-20

81 SEATS ARTICULATED OR DOUBLE DECKER BUS. (CAPITAL COST \$300,000)

PASSENGER COUNT

CHANGE IN SERVICING COSTS FROM BASELINE

70 SEATS ARTICULATED OR DOUBLE DECKER BUS (CAPITAL COST \$300,000)

CHANGE IN SERVICING COSTS FROM BASELINE

PASSENGER COUNT

80 SEATS ARTICULATED OR DOUBLE DECKER BUS (CAPITAL COST \$300,000)

PASSENGER COUNT

% CHANGE IN SERVICING COSTS FROM BASELINE

200

81 SEATS ARTICULATED OR DOUBLE DECKER BUS (CAPITAL COST \$350,000)

CHANGE IN SERVICING COSTS FROM BASELINE

PASSENGER COUNT

201

70 SEATS ARTICULATED OR DOUBLE DECKER BUS (CAPITAL COST \$350,000)

CHANGE IN SERVICING COSTS FROM BASELINE

PASSENGER COUNT

80 SEATS ARTICULATED OR DOUBLE DECKER BUS (CAPITAL COST \$350,000)

CHANGE IN SERVICING COSTS FROM BASELINE

PASSENGER COUNT

61 SEATS ARTICULATED OR DOUBLE DECKER BUS (CAPITAL COST \$400,000)

CHANGE IN SERVICING COSTS FROM BASELINE

PASSENGER COUNT

70 SEATS ARTICULATED OR DOUBLE DECKER BUS (CAPITAL COST \$400,000)

CHANGE IN SERVICING COSTS FROM BASELINE

PASSENGER COUNT

205

80 SEATS ARTICULATED OR DOUBLE DECKER BUS (CAPITAL COST \$400,000)

CHANGE IN SERVICING COSTS FROM BASELINE

PASSENGER COUNT

7 CHANGE IN SERVICING COSTS FROM BASELINE

00	
50	
40	
30	
20	
10	
-10	10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240
-20	
-30	
-40	
-50	
-60	

PASSENGER COUNT

APPENDIX F
RESULTS OF ROUTE SUPPLY MODEL FOR ALL BUS TECHNOLOGIES

SCENARIO: STANDARD BUS

PERIOD : PASSENGER DATA FOR THE YEAR 1976

LOAD FACTOR = 70%

ROUTE	PASSENGER IN KM	DIST PASSENGER IN KM	RUSES - KM	RUS COST (0000'S)	DRIVER COST (0000'S)	OVERHEAD COST (0000'S)	TOTAL COST (0000'S)	COST PER PASS.KM	COST PER RUS.KM	COST PER SEAT.KM
MONTREAL - TORONTO	207000	540	111700000	6572	177.44400	195.10340	56.78200	429.41446	.03042	1.21000
MONTREAL - OTTAWA	675000	175	131625000	21429	208.91275	229.82602	66.85048	505.61725	.03041	1.21000
MONTREAL - QUEREZ CITY	702000	253	177606000	22206	201.91700	310.10968	90.21372	602.24127	.03041	1.21000
TORONTO - OTTAWA	283000	395	111785000	8905	177.45375	195.19912	56.70520	429.43005	.03042	1.21000
TORONTO - WINNOSOR	45000	380	17100000	1429	27.15100	29.86610	0.58032	65.70542	.03042	1.21000
TORONTO - LONDON	135000	190	25650000	4286	40.71700	44.70070	13.02944	90.53514	.03042	1.21000

NOTE : 45 SEAT BUS, CAPITAL COST \$200,000 1982 DOLLARS

SCENARIO: ARTICULATED OR DOUBLE DECK BUS

PERIOD : PASSENGER DATA FOR THE YEAR 1976

LOAD FACTOR = 70%

ROUTE	PASSENGER IN KM	DIST PASSENGER IN KM	RUSES - KM	RUS COST (0000'S)	DRIVER COST (0000'S)	OVERHEAD COST (0000'S)	TOTAL COST (0000'S)	COST PER PASS.KM	COST PER RUS.KM	COST PER SEAT.KM
MONTREAL - TORONTO	207000	540	111700000	4180	100.63647	143.98550	41.08677	366.50076	.03279	1.40000
MONTREAL - OTTAWA	675000	175	131625000	13008	217.69564	169.54630	19.32096	431.55830	.03279	1.40000
MONTREAL - QUEREZ CITY	702000	253	177606000	16441	287.01053	228.77651	66.55517	582.34018	.03279	1.40000
TORONTO - OTTAWA	283000	395	111785000	6678	100.64613	143.99430	41.08896	365.52830	.03279	1.40000
TORONTO - WINNOSOR	45000	380	17100000	1034	27.63388	27.02860	6.40837	56.07280	.03279	1.40000
TORONTO - LONDON	135000	190	25650000	3162	41.45487	33.04280	9.61240	84.10920	.03279	1.40000

NOTE : 41 SEAT BUS, CAPITAL COST \$300,000 1982 DOLLARS

SCENARIO: ARTICULATED OR DOUBLE DECK BUS
PERIOD : PASSENGER DATA FOR THE YEAR 1976

ROUTE	PASSENGER IN KM	DIST PASSENGER MILES - KM	RUS COST (0000'S)	DRIVER COST (0000'S)	OVERHEAD COST (0000'S)	TOTAL COST (0000'S)	COST PER PASS.KM	COST PER BUS.KM	LOAD FACTOR = 70%
MONTREAL - TORONTO	267000	340 111700000	4225 157.4248	125.48750	56.50400	319.40997	.02857	1.40000	.02000
MONTREAL - OTTAWA	675000	195 131625000	13776 185.35600	147.74760	42.98112	376.08478	.02857	1.40000	.02000
MONTREAL - QUEBEC CITY	702000	255 177605000	14571 250.10644	199.36020	57.99569	507.46241	.02857	1.40000	.02000
TORONTO - OTTAWA	281000	395 111785000	5775 157.42487	125.48360	46.50432	319.41278	.02857	1.40000	.02000
TORONTO - WINDSOR	45000	380 17100000	919 24.09618	19.20710	5.58752	48.89079	.02857	1.40000	.02000
TORONTO - LONDON	135000	190 25650000	2756 36.13116	28.80020	8.32874	73.30950	.02858	1.40000	.02000

NOTE : 70 SEAT BUS, CAPITAL COST \$300,000 1982 DOLLARS

SCENARIO: ARTICULATED OR DOUBLE DECK BUS
PERIOD : PASSENGER DATA FOR THE YEAR 1976

ROUTE	PASSENGER IN KM	DIST PASSENGER MILES - KM	RUS COST (0000'S)	DRIVER COST (0000'S)	OVERHEAD COST (0000'S)	TOTAL COST (0000'S)	COST PER PASS.KM	COST PER BUS.KM	LOAD FACTOR = 70%
MONTREAL - TORONTO	267000	340 111780000	3691 137.75071	109.80050	31.94208	279.49416	.02850	1.40000	.01750
MONTREAL - OTTAWA	675000	195 131625000	12054 162.18657	129.27915	37.60848	329.07419	.02850	1.40000	.01750
MONTREAL - QUEBEC CITY	702000	255 177605000	12736 218.84095	174.43844	50.74573	444.02509	.02850	1.40000	.01750
TORONTO - OTTAWA	281000	395 111785000	5054 137.74676	109.79815	31.94128	279.48618	.02850	1.40000	.01750
TORONTO - WINDSOR	45000	380 17100000	804 21.08098	16.80360	4.08832	42.77279	.02850	1.40000	.01750
TORONTO - LONDON	135000	190 25650000	2411 31.60821	26.15695	7.32944	64.13460	.02850	1.40000	.01750

NOTE : 60 SEAT BUS, CAPITAL COST \$300,000 1982 DOLLARS

SCENARIO: ARTICULATED OR DOUBLE DECK BUS

PERIOD : PASSENGER DATA FOR THE YEAR 1976

LOAD FACTOR = 70%

ROUTE	PASSENGER IN KM	DIST PASSENGER IN KM	RUSES - KM	RUS COST (0000'S)	DRIVER COST (0000'S)	OVERHEAD COST (0000'S)	TOTAL COST (0000'S)	COST PER PASS.KM	COST PER RUS.KM	COST PER SEAT.KM	
MONTREAL - TORONTO	207000	540	111780000	4040	201.57983	143.98550	41.08872	397.45215	.01466	1.40000	.02426
MONTREAL - OTTAWA	675000	195	131625000	15800	277.35712	169.54080	49.32096	453.21087	.01466	1.40000	.02426
MONTREAL - QUERE CITY	702000	253	177405000	16441	320.20211	228.77451	66.53317	615.61676	.01466	1.40000	.02426
TORONTO - OTTAWA	283000	395	1117805000	6370	201.59051	143.99330	41.08896	387.47587	.01466	1.40000	.02426
TORONTO - WINDSOR	45000	390	171000000	1054	30.94004	22.07050	6.40832	59.77695	.01466	1.40000	.02426
TORONTO - LONDON	135000	190	256500000	3152	46.25006	33.04290	9.51240	88.91544	.01466	1.40000	.02426

NOTE : 61 SEAT BUS, CAPITAL COST \$350,000 1982 DOLLARS

SCENARIO: ARTICULATED OR DOUBLE DECK BUS
PERIOD : PASSENGER DATA FOR THE YEAR 1976

LOAD FACTOR = 70%

ROUTE	PASSENGER IN KM	DIST PASSENGER IN KM	RUSES - KM	RUS COST (0000'S)	DRIVER COST (0000'S)	OVERHEAD COST (0000'S)	TOTAL COST (0000'S)	COST PER PASS.KM	COST PER RUS.KM	COST PER SEAT.KM	
MONTREAL - TORONTO	207000	540	111780000	4225	175.67549	125.40250	36.50400	337.66199	.03021	1.40000	.02114
MONTREAL - OTTAWA	675000	195	131625000	13776	206.04664	147.74760	42.90112	397.57535	.03021	1.40000	.02114
MONTREAL - QUERE CITY	702000	253	177606000	14327	279.10428	199.36020	57.99559	536.46010	.03021	1.40000	.02114
TORONTO - OTTAWA	283000	395	1117805000	5776	175.67704	125.40360	36.50432	337.66495	.03021	1.40000	.02114
TORONTO - WINDSOR	45000	390	171000000	919	26.08994	19.20710	5.50752	51.60455	.03022	1.40000	.02114
TORONTO - LONDON	135000	190	256500000	2756	40.33028	28.00020	0.37024	77.49072	.03021	1.40000	.02114

NOTE : 70 SEAT BUS, CAPITAL COST \$350,000 1982 DOLLARS

SCENARIO: ARTICULATED OR DOUBLE DECK BUS
PERIOD : PASSENGER DATA FOR THE YEAR 1976

LOAD FACTOR = 70%

ROUTE	PASSENGER	DIST IN KM	PASSENGER MILES - KM	RUS COST (0000'S)	DRIVER COST (0000'S)	OVERHEAD COST (0000'S)	TOTAL COST (0000'S)	COST PER PASS.KM	COST PER RUS.KM	COST PER SEAT.KM	
MONTREAL - TORONTO	207000	540	111780000	3697	153.72125	109.80090	31.94208	295.46420	.02643	1.48000	.01850
MONTREAL - OTTAWA	675000	195	131625000	12054	180.99081	129.27915	37.60848	347.87042	.02643	1.40000	.01850
MONTREAL - QUÉBEC CITY	702000	253	177606000	12536	244.21381	174.43044	50.74573	469.39795	.02643	1.40000	.01050
TORONTO - OTTAWA	283000	395	111780500	5054	153.71741	109.79815	31.94128	295.45602	.02643	1.40000	.01050
TORONTO - WINDSOR	45000	380	17100000	804	23.52504	16.80360	4.08032	45.21696	.02644	1.40000	.04850
TORONTO - LONDON	135000	190	25650000	2411	35.27293	25.19475	7.32944	67.79732	.02643	1.40000	.01050

NOTE : 80 SEAT BUS, CAPITAL COST 1350,000 1982 DOLLARS

SCENARIO: ARTICULATED OR DOUBLE DECK BUS

PERIOD : PASSENGER DATA FOR THE YEAR 1976

LOAD FACTOR = 70%

ROUTE	PASSENGER IN AM	DIST IN KM	PASSENGER MILES - KM	RUS COST (0000'S)	DRIVER COST (0000'S)	OVERHEAD COST (0000'S)	TOTAL COST (0000'S)	COST PER PASS.KM	COST PER RUS.KM	COST PER SEAT.KM	
MONTREAL - TORONTO	207000	540	111780000	4040	225.14112	143.90560	41.89672	411.01343	.03677	1.57000	.02574
MONTREAL - OTTAWA	675000	195	131625000	15808	265.10013	169.54080	49.32096	483.96108	.03677	1.57000	.02574
MONTREAL - QUEBEC CITY	702000	253	177606000	16441	357.72327	228.77651	66.55317	653.05292	.03677	1.57000	.02574
TORONTO - OTTAWA	283000	395	111780500	6620	225.15315	143.99330	41.88876	411.03540	.03677	1.57000	.02574
TORONTO - WINDSOR	45000	380	17100000	1054	34.44472	22.02860	6.40832	62.88164	.03677	1.57000	.02574
TORONTO - LONDON	135000	190	25650000	3162	51.66700	33.04290	9.61748	94.32245	.03677	1.57000	.02574

NOTE : 61 SEAT BUS, CAPITAL COST 1400,000 1982 DOLLARS

SCENARIO: ARTICULATED OR DOUBLE-DECK BUS
PERIOD: PASSENGER DATA FOR THE YEAR 1976

LOAD FACTOR = 70%

ROUTE	PASSENGER IN KM	PASSENGER IN KM	RUSES - KM	RUS COST (0000'S)	DRIVER COST (0000'S)	OVERHEAD COST (0000'S)	TOTAL COST (0000'S)	COST PER PASS.KM	COST PER BUS.KM	COST PER SEAT.KM
MONTREAL - TORONTO	207000	340 111780000	4223	196.70900	120.48200	36.50460	358.19560	.03204	1.57000	.02243
MONTREAL - OTTAWA	675000	195 131625000	13773	231.02352	147.74760	42.90117	421.75229	.03204	1.57000	.02243
MONTREAL - QUEBEC CITY	702000	253 177606000	14377	311.72504	199.38020	57.99569	569.08093	.03204	1.57000	.02243
TORONTO - OTTAWA	283000	395 111735000	5776	196.71071	120.48160	36.50432	358.19363	.03204	1.57000	.02243
TORONTO - WINDSOR	45000	390 17100000	919	30.03297	19.70710	5.50752	54.87759	.03205	1.57000	.02243
TORONTO - LONDON	135000	190 25650000	2756	47.03304	29.80070	8.37824	87.21198	.03205	1.57000	.02243

NOTE: 70 SEAT BUS, CAPITAL COST \$400,000 1982 DOLLARS

SCENARIO: ARTICULATED OR DOUBLE-DECK BUS
PERIOD: PASSENGER DATA FOR THE YEAR 1976

LOAD FACTOR = 70%

ROUTE	PASSENGER IN KM	PASSENGER IN KM	RUSES - KM	RUS COST (0000'S)	DRIVER COST (0000'S)	OVERHEAD COST (0000'S)	TOTAL COST (0000'S)	COST PER PASS.KM	COST PER BUS.KM	COST PER SEAT.KM
MONTREAL - TORONTO	207000	340 111780000	3697	171.68868	109.80090	31.94208	313.43164	.02804	1.57000	.01962
MONTREAL - OTTAWA	675000	195 131625000	12054	202.14558	129.27915	37.60048	369.03320	.02804	1.57000	.01962
MONTREAL - QUEBEC CITY	702000	253 177606000	12536	272.75827	174.43844	50.74573	497.94241	.02804	1.57000	.01962
TORONTO - OTTAWA	283000	395 111735000	5054	171.68437	109.79815	31.94120	313.42300	.02804	1.57000	.01962
TORONTO - WINDSOR	45000	380 17100000	804	26.27472	16.80360	4.80032	47.96563	.02805	1.57000	.01962
TORONTO - LONDON	135000	190 25650000	2411	39.39574	25.19495	7.32944	71.92013	.02804	1.57000	.01962

NOTE: 80 SEAT BUS, CAPITAL COST \$400,000 1982 DOLLARS

LOAD FACTOR = 70%

SCENARIO: ARTICULATED DOUBLE DECK BUS (JUMBO BUS)
PERIOD : PASSENGER DATA FOR THE YEAR 1976

ROUTE	PASSENGER IN KM	DIST PASSENGER IN KM	RUSES - KM	BUS COST (0000'S)	DRIVER COST (0000'S)	OVERHEAD COST (0000'S)	TOTAL COST (0000'S)	COST PER PASS. KM	COST PER BUS. KM	COST PER SEAT. KM	
MONTREAL - TORONTO	207000	540	111780000	2958	167.71859	07.85260	25.55712	201.12830	.02515	1.76000	.01760
MONTREAL - OTTAWA	675000	195	131625000	9643	197.44041	103.42117	30.00616	330.94772	.02514	1.76000	.01760
MONTREAL - QUEBEC CITY	702000	253	177606000	10029	266.42032	139.55353	40.59739	446.57123	.02514	1.76000	.01760
TORONTO - OTTAWA	283000	395	111785000	4043	167.60341	07.03417	25.55176	201.06934	.02514	1.76000	.01760
TORONTO - WINDSOR	45000	380	17100000	643	25.65570	13.43870	3.90944	43.00304	.02515	1.76000	.01760
TORONTO - LONDON	135000	190	25650000	1929	38.40355	20.15005	5.84416	64.50575	.02515	1.76000	.01760

NOTE : 100 SEAT BUS, CAPITAL COST \$500,000 1902 DOLLARS

END

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