RTQ-88-13

TP 8955E

FEASIBILITY STUDY ON A FREEWAY TRAFFIC MANAGEMENT SYSTEM FOR THE MONTREAL REGION

SNC/DELUC/JOINT VENTURE

March 1988

Québec

Canada

Feasibility Study on a Freeway Traffic Management System for the Montreal Region

A-25/Métropolitaine/Décarie/Ville-Marie Bonaventure/Champlain Bridge

Final Report

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16. Abstract

This report synthesizes a feasibility study for a Freeway Traffic Management System (FTMS) in Montreal. The study covered the evaluation of traffic problems, elaboration of management strategies, clarification and evaluation of system alternatives and, finally, specification of an implementation plan.

Five first level strategies were kept for evaluation: incident management, ramp diversion, changeable message signs, ramp metering and lane metering. Five second level strategies were added: traffic data management, communication and coordination, trip planning, highway advisory radio and in-vehicle route guidance.

In the light of various evaluations, the recommended system includes: a control centre, automatic incident detection and data collection system, changeable message signs system and finally a communication network allowing transmission of necessary data.

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16. Résumé

Ce rapport fait la synthèse d'une étude de faisabilité pour un système de gestion de circulation autoroutière à Montréal. L'étude a couvert l'évaluation des problèmes de circulation, l'élaboration de stratégies de gestion, la mise au point et l'évaluation des variantes de système et finalement la mise au point d'un plan d'implantation.

Cinq stratégies de premier niveau ont été retenues pour évaluation, soit : la gestion des incidents, le délestage aux rampes d'accès, la signalisation à messages variables, la régulation des rampes d'accès et la régulation des voies. À ces dernières s'ajoutent cinq stratégies de second niveau, soit : la gestion des données de circulation, la communication et coordination, la planification des déplacements, le radioguidage routier et le guidage routier embarqué.

À la lumière des diverses évaluations, le système de base recommandé comprend : un centre de contrôle, un système de détection automatique des incidents et de collecte de données, un système de signalisation à messages variables et finalement un réseau de communication permettant la transmission des données nécessaires.

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CANADA-QUÉBEC SUBSIDIARY AGREEMENT ON TRANSPORTATION DEVELOPMENT

On December 14, 1984, the governments of Canada and Québec concluded an agreement on regional and economic development, which identified transportation as a strategic priority.

As a result of this agreement on regional and economic development, a subsidiary agreement was signed on July 8, 1985, on transportation development. The objective of this subsidiary agreement, which will end on March 31, 1990, is to foster cooperation between the governments of Canada and Québec in the field of transportation, in order to support regional and economic development by facilitating the movement of people and goods in and between the regions of Canada and Québec as well as abroad.

One of the five aspects covered in the subsidiary agreement is an R&D program whose objective is to increase and accelerate the research and development effort in the field of transportation in Québec, by preserving and strengthening the manufacturing capacity of the sector, and by increasing the productivity of the transportation system in order to ensure that it benefits from technological advances and remains highly competitive.

The program comprises four main sectors:

- the technology of road transportation systems;
- the technology of railway transportation systems;
- the applications of microprocessing and microelectronics in transportation;
- intermodal transportation.

This document, prepared within the framework of this program, is the final report of a project financed jointly by Transport Canada and the ministère des Transports du Québec.

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SUMMARY

The number of vehicles using the expressway corridors in the metropolitan region grows from one year to the next, giving rise to serious traffic problems that users find increasingly difficult to accept.

Traditionally, such problems have been solved by adding new lanes to the original road network. Today, the cost of this kind of work has become exorbitant and other approaches are being studied, using new techniques. With these new techniques, traffic can be managed in such a way that user safety and traffic flow are improved. As a result, trip time is reduced, as are fuel consumption and pollution.

Studies have confirmed that with the introduction of freeway management techniques in Europe and the United States, general traffic conditions and user comfort improved considerably. Results from abroad of improved management techniques and the extension of systems in operation indicate that this is the best and the least costly solution to traffic problems.

Under the 1985-1990 Canada-Québec subsidiary agreement on transportation development, the ministère des Transports du Québec entrusted SNC/DeLuC/Joint Venture with a feasibility study on a freeway traffic management system for two separate corridors measuring some fifty kilometres in all.

The original corridor included the A-25, Métropolitaine, Décarie and Ville-Marie expressways and the second corridor, the Bonaventure expressway and the Champlain bridge.

The study consisted of five stages: locating and evaluating traffic problems, developing management strategies, determining the costs and advantages of system alternatives, evaluating and estimating those costs and advantages, and preparing a plan for implementing the system. The analysis of the various possible strategies led to the identification of those that could be applied to the corridor under study.

Initially, only those techniques that offer the greatest advantages in relation to cost and that minimize the risk for the operator, such as incident detection and user information, will be set up in the original corridor.

A-25, Métropolitaine, Décarie and Ville-Marie corridor

The recommended system includes a control centre and the following sub-systems:

- an incident detection system that incorporates the permanent collection of traffic data;
- a changeable message sign system, warning users of danger spots, difficult traffic conditions, and road conditions;
- a communications system for the transmission of data.

The recommended system also includes the implementation of two additional techniques, on the Métropolitaine expressway, on an experimental basis: ramp diversion for all access ramps and metering on the seven access ramps best suited to this technique. Since it is more difficult to prove the advantages of these two techniques for the corridor within the framework of a study, they will be the object of special pilot projects.

The system should result in a decrease in the number of accidents and, consequently, increased user safety. It will also reduce waiting time and therefore travel time, resulting in a reduction in fuel consumption. These three points were translated into dollar figures, using a series of hypotheses for each technique and each section of the corridor.

At present, incidents cause 6.5 million hours of delay and 51 million litres of wasted fuel each year. With this management system, these figures will be reduced to 2.2 million hours and 13.2 million litres of fuel.

Other benefits of the system, more difficult to quantify, include less pollution, a better quality of life and greater user comfort.

Conservative hypotheses suggest that the corridor management system will generate total savings of $8 million annually, that is, $1 million in savings attributed to accidents and $7 million to fuel costs. If the time saved is evaluated at one dollar an hour for motorists, representing 90 percent of traffic, and $22 an hour for truck drivers, representing 10 percent of traffic, an additional saving of $6.9 million may be attained, for a total saving of about $15 million.

The capital investment required to set up the management system is $16.6 million for equipment and 3.3 million for engineering and start-up costs, including the two pilot projects at a cost of $1.3 million.

Implementation and start-up operations will take four years, even though all aspects of the project will be dealt with simultaneously in order to gain time.

It is important to realize that the system will not increase corridor capacity or solve all Montréal's expressway traffic problems. It will improve traffic conditions and make them more acceptable to users.

Bonaventure corridor, Champlain bridge

The system recommended refers only to the Champlain bridge. It includes:

- incident and data management;
- toll booth metering on the bridge;
- metering the convergence of highway 132 with the approaches to the bridge;
- changeable message signs at problem points.

The system should result in fewer accidents, and therefore greater user safety. It will reduce waiting time and, consequently, travel time, resulting in less fuel consumption. These three aspects have been translated into dollar figures, using a series of hypotheses for each technique and each section of the corridor.

On the basis of conservative hypotheses, the bridge management system will generate savings of $1 million annually, that is $600 000 savings attributed to accidents and $423 000 to fuel costs. If the time saved is evaluated at one dollar an hour for motorists, representing 90 percent of traffic, and $22 an hour for truck drivers, representing 10 percent of traffic, an additional saving of $395 000 may be attained, for a total saving of about $1.4 million.

The capital investment required to implement the management techniques is $2.2 million for equipment and $400 000 for engineering and start-up operations, for a total of $2.6 million.

It must be understood that this system will not increase bridge capacity or end all traffic congestion, but it will improve traffic flow and make conditions more comfortable for users.

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EXPRESSWAY CORRIDOR NETWORK

EXPRESSWAY CORRIDOR NETWORK

1.1 INTRODUCTION

Traffic management systems for freeway corridors are of interest mainly because, given budgetary and environmental constraints, existing highway infrastuctures must be rationalized before there can be any thought of improving them or building new ones. Not only do traffic management systems optimize corridor use, but they reduce waiting time due to traffic jams and incidents, as well as reducing fuel consumption, accident rates, noise levels and pollution. These systems can register and analyze traffic data automatically, transmit information on traffic conditions to system operators and motorists in real time, and monitor traffic during road repair work.

For these reasons, Québec's ministère des Transports has undertaken to evaluate the feasibility of a freeway traffic system in the Montreal region. The corridors chosen cover some fifty kilometres and include the A-25, Métropolitaine, Décarie and Ville-Marie expressways, as well as the Bonaventure expressway and the Champlain bridge. These expressways are known for their traffic problems:

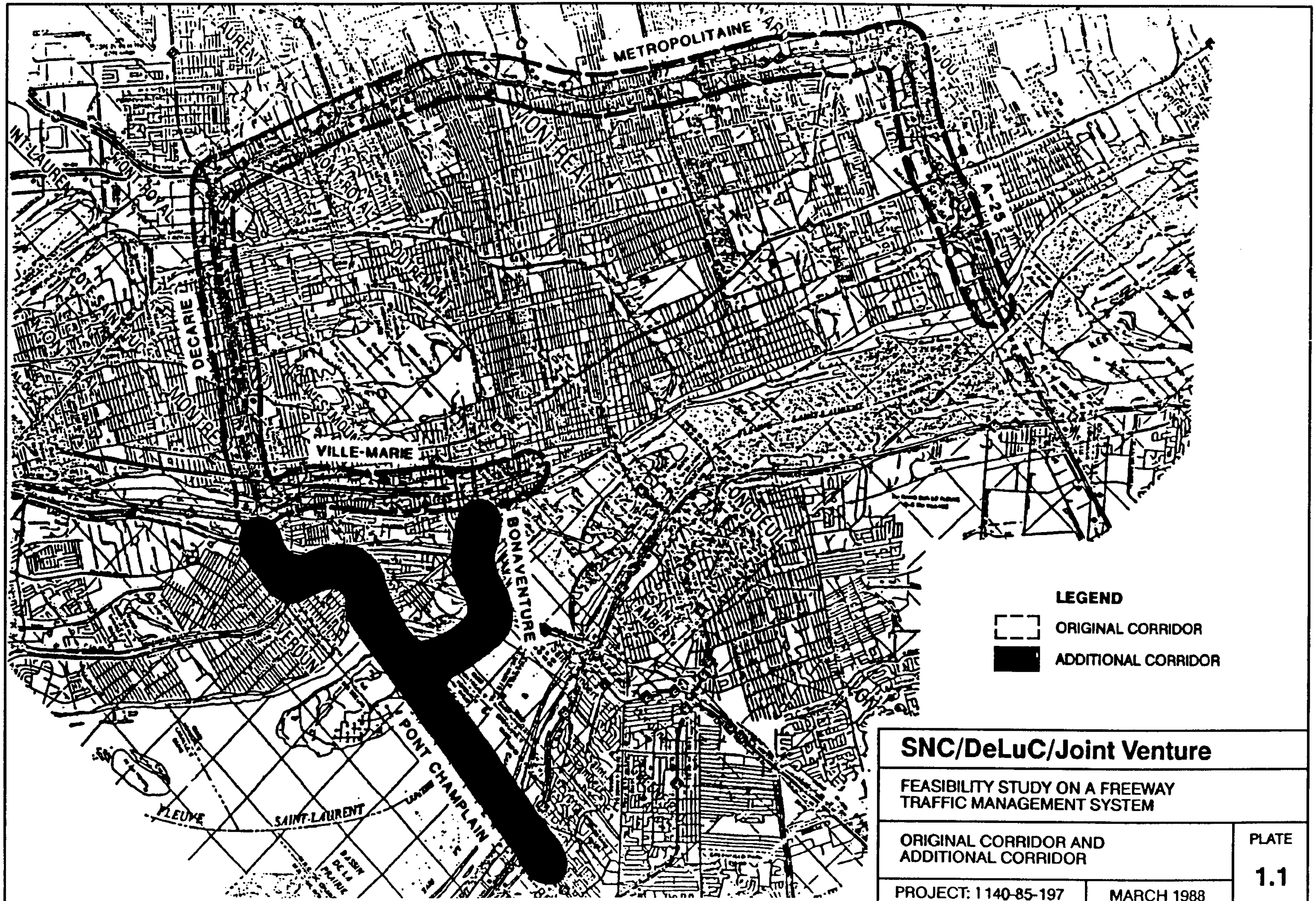
- recurring traffic jams (inadequate capacity, outdated physical characteristics, etc.);
- non-recurring traffic jams (due to incidents or accidents);
- lack of real-time information on traffic conditions for users;
- very high accident rates on some sections.

This feasibility study on a freeway traffic management system was divided into five stages. Stage 1 consisted in identifying the causes and consequences of the problems mentioned above. Stage 2 consisted in preparing an exhaustive list of possible solutions for the corridors under study. Stages 3 and 4 were devoted to defining the recommended system following a quantitative and qualitative evaluation of the strategies with the greatest potential. In stage 5, a plan for implementing the recommended components was submitted.

This report is a synthesis of the five stages. It ends with a summary of the system recommended, the costs involved and the results expected.

1.2 THE CURRENT SITUATION

Most of the advantages of a freeway traffic management system are felt during peak periods. It was shown during a study on expressways in the Toronto region that 84 percent of the savings in energy and time and of the reduction in damages due to accidents can be made during peak periods on workdays. The data for this study was therefore generally gathered during these periods, that is, between 5:00 a.m. and 10:00 a.m. and between 2:00 p.m. and 7:00 p.m. The information referred to the physical characteristics of the corridor, traffic characteristics, detour network, accidents and incidents, and existing management systems.



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FEASIBILITY STUDY ON A FREEWAY TRAFFIC MANAGEMENT SYSTEM

ORIGINAL CORRIDOR AND ADDITIONAL CORRIDOR

PLATE 1.1

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1.2.1 Physical characteristics of the corridor

The entire expressway corridor is shown in plate 1.1. The original corridor consisted of the A-25, Métropolitaine, Décarie and Ville-Marie expressways and the additional corridor consisted of the Bonaventure expressway and the Champlain bridge.

The expressway studied is rarely at grade: a major portion of the Métropolitaine and Bonaventure expressways and the Champlain bridge are elevated, with a few sections at grade; the Décarie and A-25 expressways are depressed, while the Ville-Marie expressway is elevated west of the downtown area and underground in the downtown area.

The number of traffic lanes on the expressways varies: three each way on the A-25, Métropolitaine and Décarie expressways and four each way on the Ville-Marie expressway. The Bonaventure expressway and the Champlain bridge generally have three lanes in each direction, with a few sections that have only two. There is also a reverse-flow lane reserved for northbound buses in the morning and southbound buses in the evening, which changes the number of lanes available on the Champlain bridge during peak periods.

Canadian geometric highway design standards recommend that the maximum grade of a divided urban highway not exceed 4 percent on rolling terrain and 5 percent on mountainous topography. Generally, the grades of the corridor expressways are within these limits, rarely exceeding 3 percent. Only the Ville-Marie expressway has places where gradients equal or exceed these standards.

The design speed is the speed for which the highway was designed. It is the basis for certain geometric characteristics such as curvature, superelevation and sight distance, which are essential to the safety of moving vehicles. It does not necessarily represent the speed at which vehicles are allowed to travel.

The design speed is 100 km/h for all corridor sections, except the Métropolitaine expressway, for which the design speed is 90 km/h. There are stretches on some sections, however, with a geometry whose design speed is lower.

The corridors studied cover some fifty kilometres and have 63 access ramps and 61 exit ramps. With a few exceptions, all of these ramps are on the right-hand side.

The corridor expressways, on the whole, respect minimum design criteria for comparable infrastructures, except as regards the length of speed-change lanes for ramps, the width of the lanes (12 feet everywhere, except on the Métropolitaine expressway where it is 11 feet and the Ville-Marie expressway, where it is 13 feet) and the grade of some access ramps. Nevertheless, given the very high volume of traffic on these expressways, it would be most advantageous if their characteristics significantly exceeded the required minima. Unfortunately, this is unlikely, given the physical restrictions on the corridor and the financial implications of such a change.

1.2.2 By-pass network

A network of roads and arteries to which traffic can be diverted allows flow to continue despite congestion or incidents on the expressways during peak periods.

In this study, a by-pass road is defined as a road enabling traffic to move around a congested area and regain the expressway. A by-pass artery is defined as a road enabling traffic to leave the expressway and disperse into the road network.

Since the expressway network is congested at peak periods, service roads can be used as alternative routes.

In addition to the service roads, by-pass roads were selected for the Métropolitaine, Décarie and Ville-Marie expressways. They make it possible to leave the expressways to avoid certain sections, returning to them further on.

The Bonaventure expressway is a good by-pass for the Ville-Marie expressway in case of a major problem on the latter. It involves a longer trip but, since it is an expressway, is a better alternative than the local arteries paralleling the Ville-Marie expressway.

A number of by-pass arteries were studied as possible alternatives to congested sections of expressway, but failed to meet expectations because of their low capacity reserve at peak hours.

Since motorists consider them risky, these by-pass arteries can be more useful in terms of planning detours rather than as by-pass roads integrated into the management system.

The traffic lights on the service roads and by-pass arteries are not interconnected and so could not be controlled from a control centre.

1.2.3 Traffic characteristics

At peak hours, cars account for 91 to 93 percent of the traffic on the A-25, Métropolitaine, Décarie and Ville-Marie expressways. Trucks account for the rest of the traffic, since there are very few buses or recreational vehicles on the corridor. On the Bonaventure expressway and the Champlain bridge, 93 to 97 percent of the traffic is made up of passenger cars. Since only a small number of recreational vehicles and buses (except for buses returning on the Champlain bridge, outside the reserved lanes, and those travelling to or from the STRSM terminus downtown) use the corridor, 3 percent to 7 percent of the traffic on these sections is made up of trucks.

1.2.3.1 Volume

Under ideal conditions, the theoretical capacity of an urban expressway is 2 000 vehicles per hour per lane, or 6 000 vehicles an hour in each direction on a three-lane highway. These maximum figures are reduced by certain factors, depending on local conditions: gradients, shoulders, percentage of trucks, geometry, visibility, etc. The maximum theoretical hourly capacity therefore varies between 5 000 and 5 500 vehicles in each direction for the A-25, Métropolitaine and Décarie expressways, and between 7 000 and 7 500 for the Ville-Marie expressway. The counts given in plates 1.2 to 1.7 show that this theoretical capacity is exceeded at rush hour, sporadically on the A-25 and regularly on the Métropolitaine and Décarie expressways and the Champlain bridge, especially in the peak evening hours. This situation, aggravated each year by the increase in traffic, affects the corridor as a whole and creates major areas of congestion wherever the increase is greatest, such as on the Décarie-Métropolitaine interchange. The duration of the congestion is prolonged because of these increases.

The great number of vehicles on the corridor renders the flow of traffic unstable, so that the smallest incident, particularly when traffic is heaviest, can block the traffic and quickly create a very large area of congestion.

1.2.3.2 Variations in volume

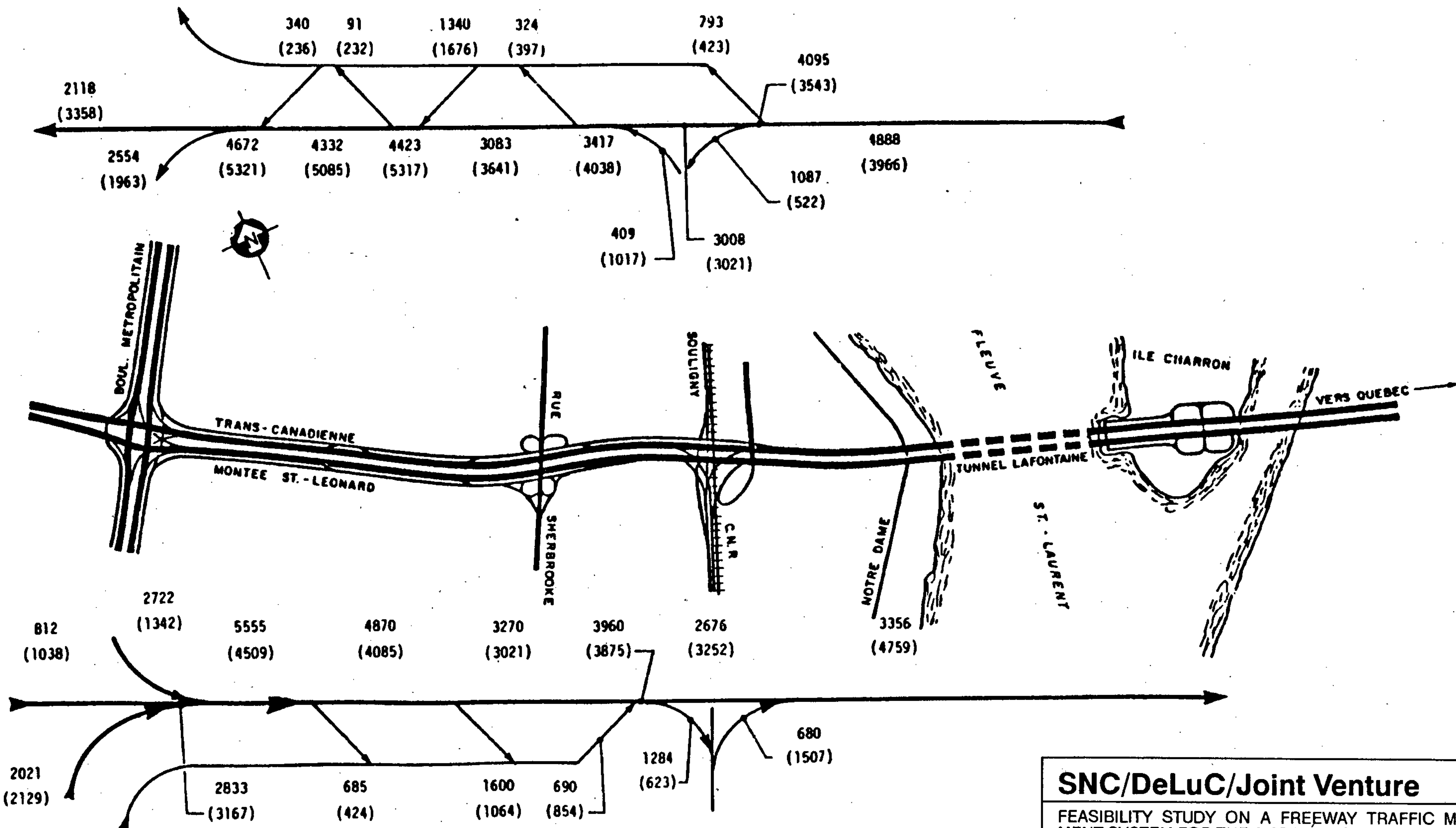
On working days, the peak period is worse in the evening, lasting four hours on the A-25, Décarie and Métropolitaine expressways. However, traffic becomes heavy on these expressways at about 7:00 a.m. on working days and remains heavy until 8:00 p.m. This is especially true of the Décarie and Métropolitaine expressways where there does not seem to be any letup between the morning and the evening rush hours. In addition, daily traffic increases during the week, reaching a maximum on Friday.

There is a drop in the volume of traffic in the winter, when there are fewer activities, vehicles are put in storage, public transport is more often used, etc. The worst period on the A-25 and Métropolitaine expressways is the month of August, while the Décarie expressway is most heavily used in October and November. The expressways in the corridor have similar monthly variations.

The average increase in traffic in the corridor during the peak period is about 1 to 2 percent on all sections except the Champlain bridge where the rate of growth is about 4.5 to 5 percent.

1.2.3.3 Simulation of existing conditions

Various models were evaluated on the basis of desired characteristics to simulate existing conditions and evaluate the impact of various control strategies in the corridor. Although none of the models evaluated is perfectly adapted to the needs of this feasibility study, the FREQ model meets most of the objectives set and was consequently used for analysis. The FREQ model requires a large amount of data, including volumes at all access and exit ramps on the corridor (at quarter-hour intervals), the geometric characteristics of the different sections, the capacity of the corridor sections, the composition of traffic and the rate of occupancy of the vehicles. A data bank was created for each period of analysis and each direction. A study of the speed in the corridors completed the data required for effective use of the model.



LEGEND

3518 VEHICLES/HOUR – MORNING RUSH HOUR (7:00 – 8:00)
(5038) VEHICLES/HOUR – EVENING RUSH HOUR (4:15 – 5:15)

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FEASIBILITY STUDY ON A FREEWAY TRAFFIC MANAGEMENT SYSTEM FOR THE A-25/MÉTROPOLITAINE/DÉCARIE/VILLE-MARIE EXPRESSWAY CORRIDOR

TRAFFIC VOLUME AT PEAK PERIODS
A-25 EXPRESSWAY (fall 1986)

PLATE 1.2

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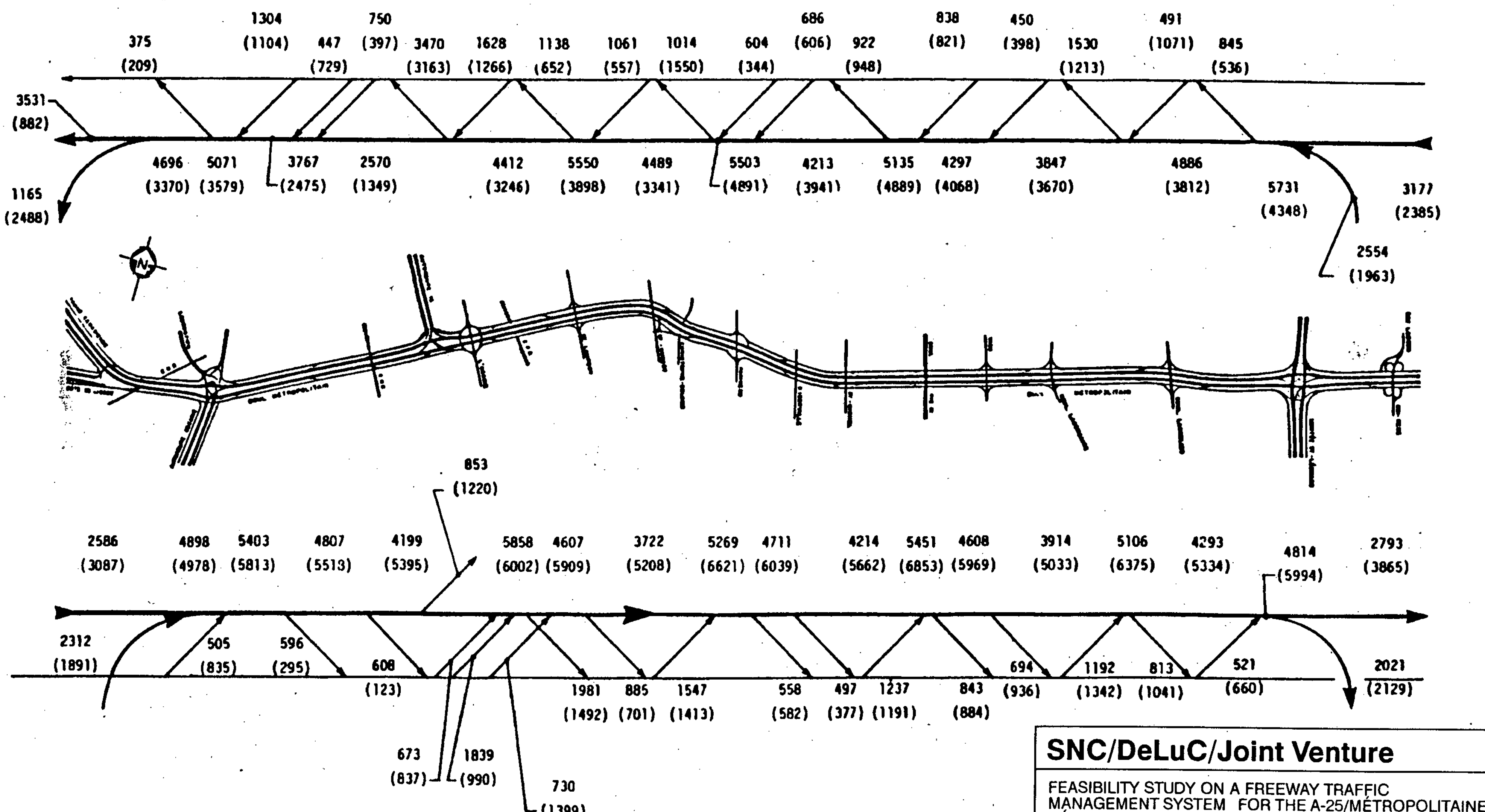
MARCH 1988



LEGEND

3518 VEHICLES/HOUR - MORNING RUSH HOUR (7:00 - 8:00)

(5038) VEHICLES/HOUR - EVENING RUSH HOUR (4:15 - 5:15)

SNC/DeLuC/Joint Venture

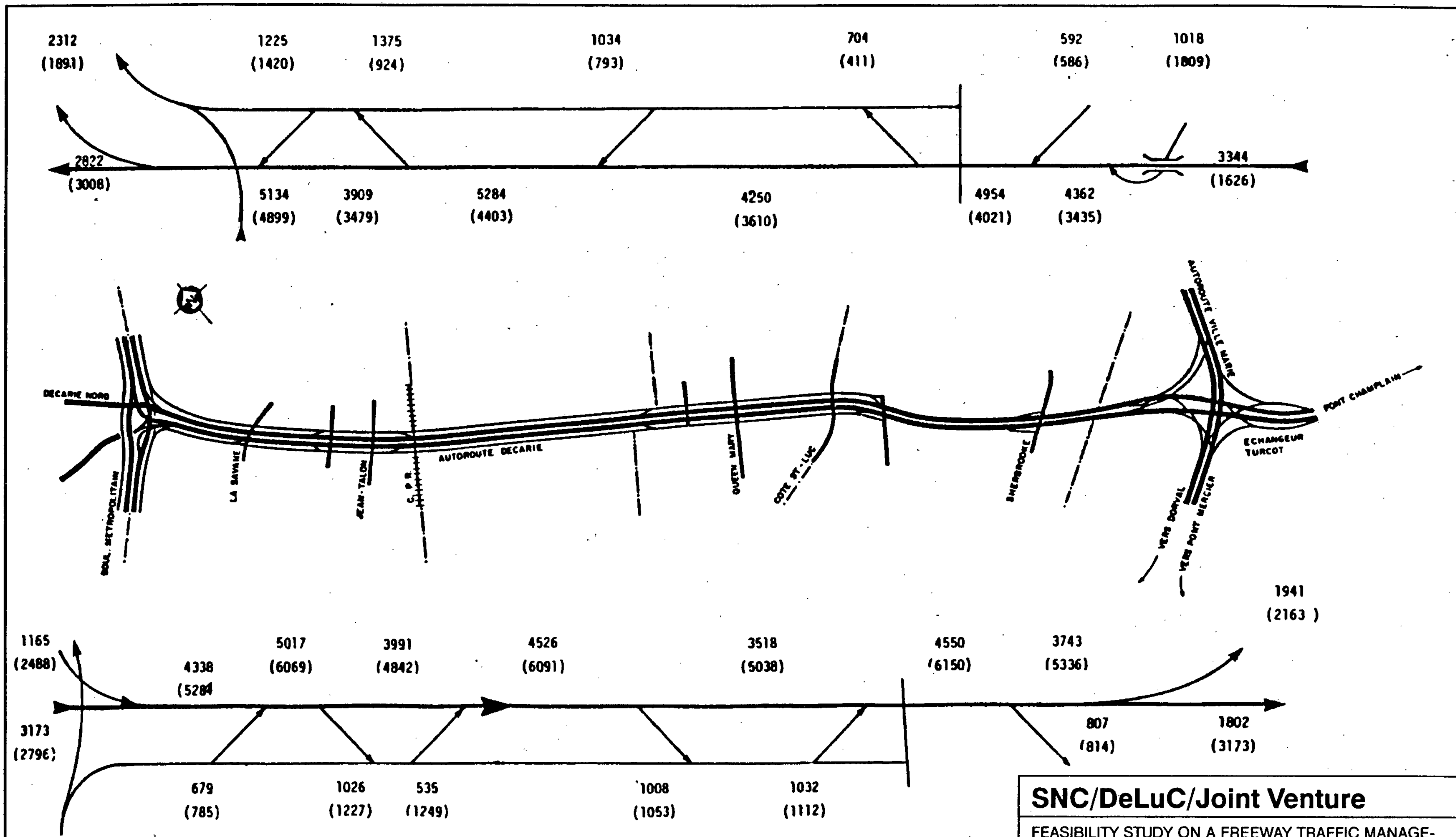
FEASIBILITY STUDY ON A FREEWAY TRAFFIC MANAGEMENT SYSTEM FOR THE A-25/MÉTROPOLITAINE/ DÉCARIE/VILLE-MARIE EXPRESSWAY CORRIDOR

TRAFFIC VOLUME AT PEAK PERIODS MÉTROPOLITAINE EXPRESSWAY (Fall 1986)

PLATE 1.3

PROJECT: 1140-85-197

MARCH 1988



LEGEND

3518 VEHICLES/HOUR – MORNING RUSH HOUR (7:00 – 8:00)

(5038) VEHICLES/HOUR – EVENING RUSH HOUR (4:15 – 5:15)

SNC/DeLuC/Joint Venture

FEASIBILITY STUDY ON A FREEWAY TRAFFIC MANAGEMENT SYSTEM FOR THE A-25/MÉTROPOLITAINE/DÉCARIE/VILLE-MARIE EXPRESSWAY CORRIDOR

TRAFFIC VOLUME AT PEAK PERIODS
DÉCARIE EXPRESSWAY (Fall 1986)

PLATE **1.4**

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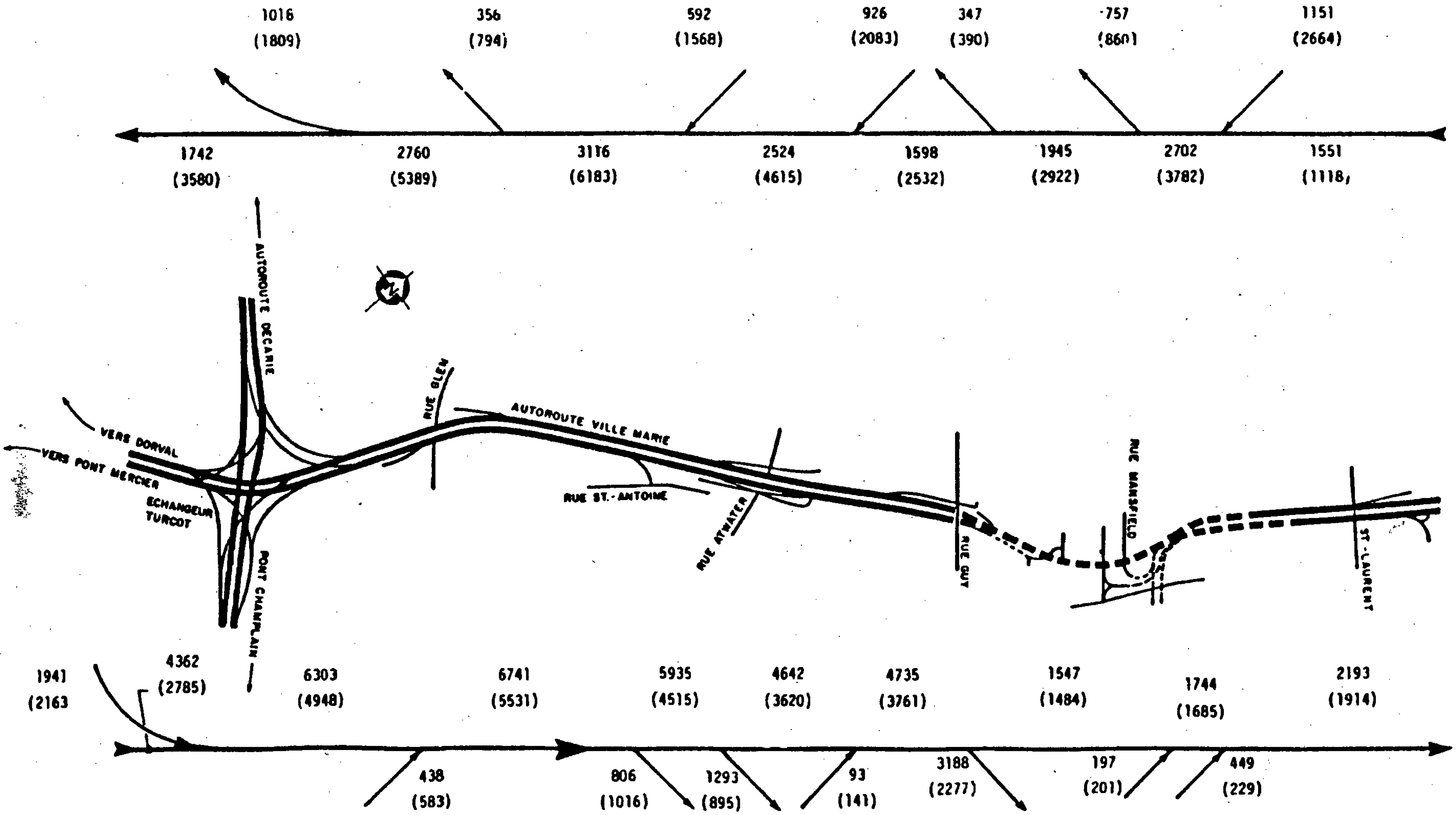
MARCH 1988



LEGEND

3518 VEHICLES/HOUR – MORNING RUSH HOUR (7:00 – 8:00)
(5038) VEHICLES/HOUR – EVENING RUSH HOUR (4:15 – 5:15)

* DATA GATHERED BEFORE THE VILLE-MARIE EXPRESSWAY EXTENSION EAST OF ST-LAURENT WAS OPENED.

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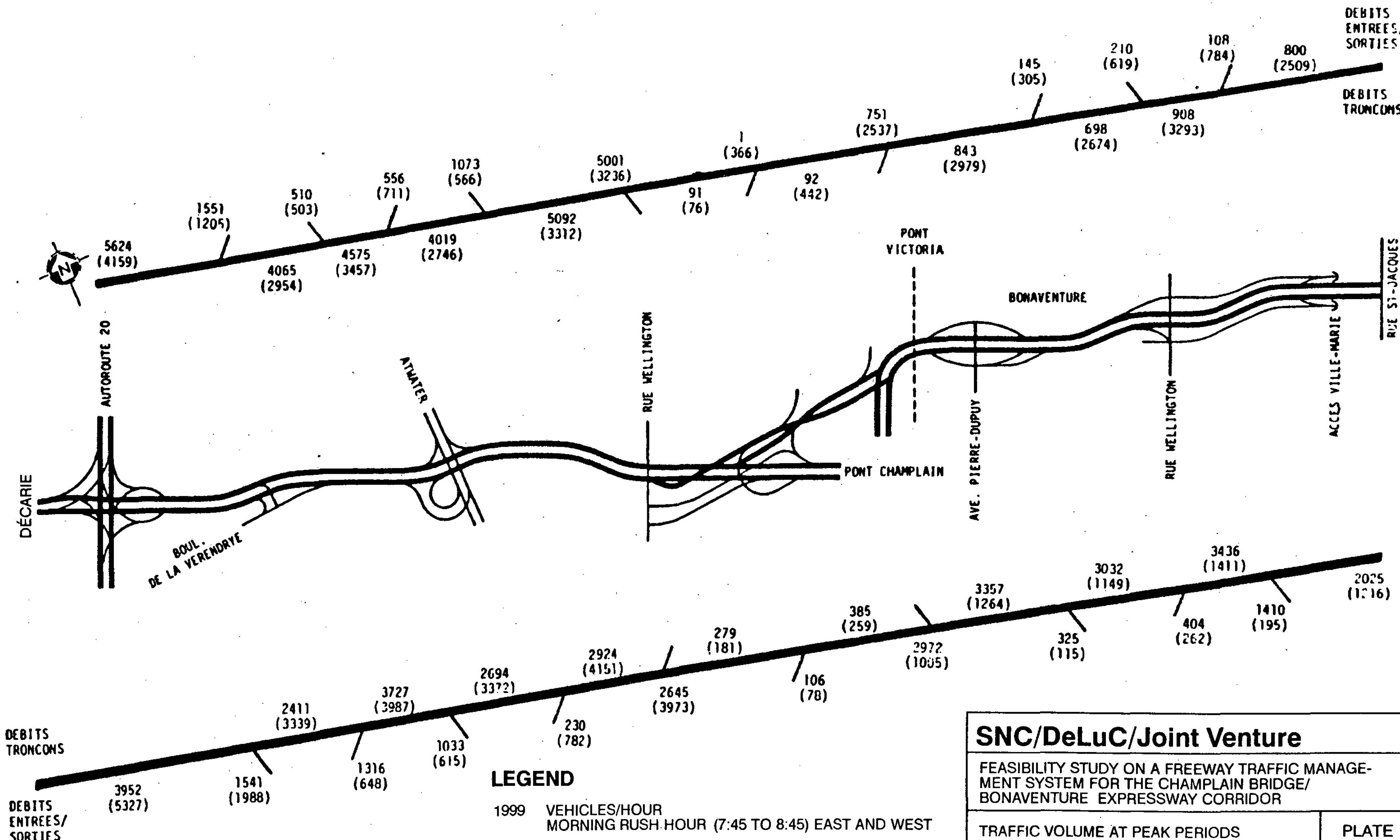
FEASIBILITY STUDY ON A FREEWAY TRAFFIC MANAGEMENT SYSTEM FOR THE A-25/METROPOLITAINE/ DÉCARIE/VILLE-MARIE EXPRESSWAY CORRIDOR	
TRAFFIC VOLUME AT PEAK PERIODS VILLE-MARIE EXPRESSWAY (Fall 1986)	PLATE 1.5
PROJECT: 1140-85-197 — MARCH 1988	



LEGEND

1999	VEHICLES/HOUR MORNING RUSH HOUR	(7:45 TO 8:45) EAST AND WEST
(1999)	VEHICLES/HOUR EVENING RUSH HOUR	(3:45 TO 4:45) EASTBOUND (4:30 TO 5:30) WESTBOUND

SNC/DeLuC/Joint Venture

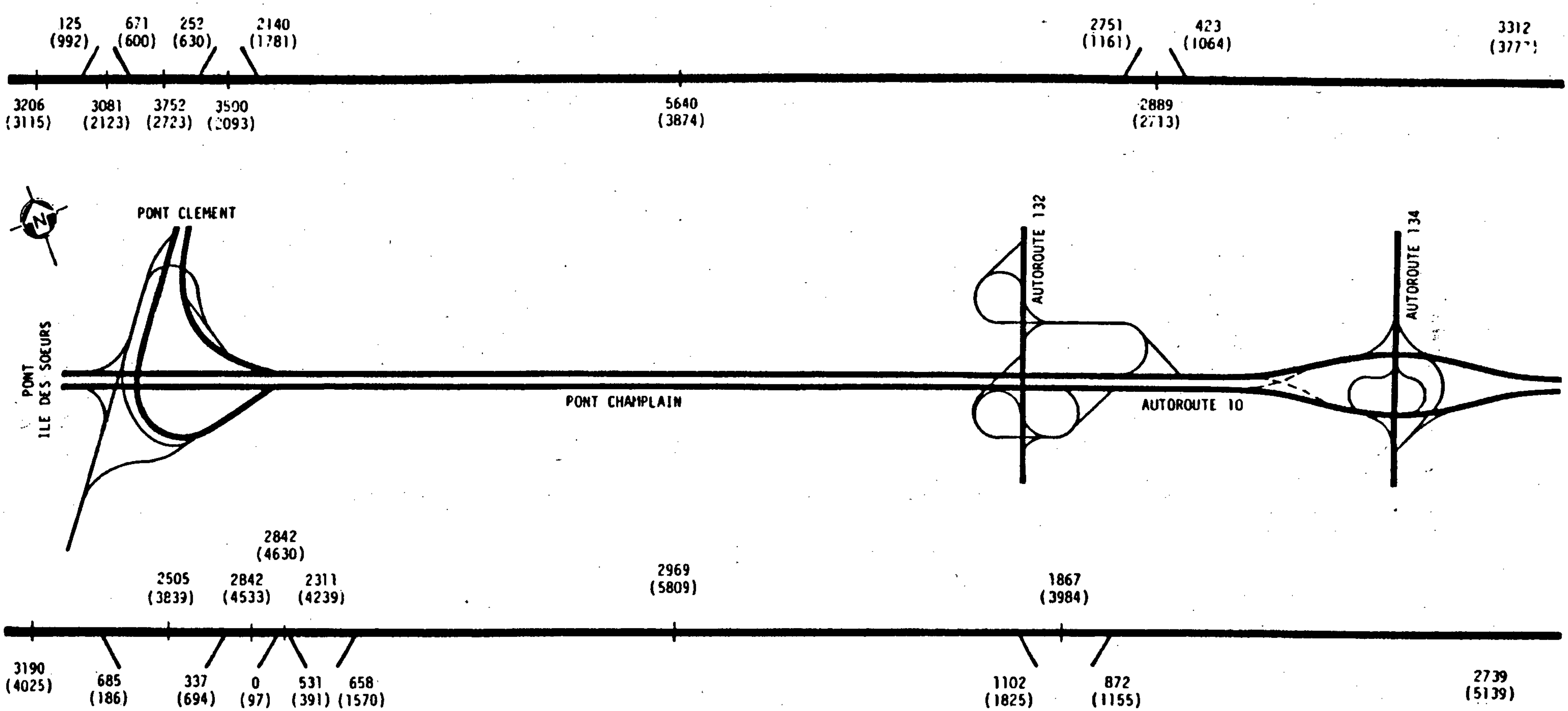
FEASIBILITY STUDY ON A FREEWAY TRAFFIC MANAGEMENT SYSTEM FOR THE CHAMPLAIN BRIDGE/ BONAVENTURE EXPRESSWAY CORRIDOR

TRAFFIC VOLUME AT PEAK PERIODS BONAVENTURE EXPRESSWAY (May 1987)

PLATE 1.6

PROJECT: 1140-85-197

MARCH 1988



LEGEND

1999 VEHICLES/HOUR
MORNING RUSH HOUR (6:30 TO 7:30) NORTHBOUND
(8:00 TO 9:00) SOUTHBOUND

(1999) VEHICLES/HOUR
EVENING RUSH HOUR (4:30 TO 5:30) NORTHBOUND
(3:45 TO 4:45) SOUTHBOUND

--- BUS RAMPS

SNC/DeLuC/Joint Venture

FEASIBILITY STUDY ON A FREEWAY TRAFFIC MANAGEMENT SYSTEM FOR THE CHAMPLAIN BRIDGE/ BONAVENTURE EXPRESSWAY CORRIDOR

TRAFFIC VOLUME AT PEAK PERIODS
CHAMPLAIN BRIDGE (May 1987)

PLATE 1.7

PROJECT: 1140-85-197

MARCH 1988

Version 9 of the FREQ model (on mainframe) was used for the A-25/Métropolitaine/Décarie/Ville-Marie corridor, since the number of corridor sections and access and exit ramps justified such a choice. A microcomputer programmed with FREQ-8 was used for the Bonaventure/Champlain bridge corridor, which is smaller.

Three objectives were set for the model:

1. It had to provide a good simulation of existing traffic conditions;
2. It had to illustrate the impact of possible increases in demand on traffic; and
3. It had to evaluate the impact of metering access ramps on flow conditions in the corridor.

Once adjusted, the FREQ model provided an adequate simulation of existing conditions. The results obtained in studies of speed compared favourably with those provided for by the model for all the sections and times used in the analysis. With these results, it was possible to reproduce the difficulties encountered at problem points in the corridors.

The effects of growth have left little leeway in the corridors under study. A 5 to 10 percent increase in traffic in the corridor would noticeably decrease service, resulting in highly unstable flow conditions and very low average speeds. It would seem, then, that the corridor cannot accommodate a 10 percent increase in traffic and that a 5 percent increase, while tolerable, would have a major impact on traffic conditions. Similarly, the FREQ model was used to evaluate the effects of a drop in traffic. A decrease of the same extent would have a beneficial effect on traffic flow, which would be much more stable and would allow a marked increase in average speed.

The results obtained from ramp metering will be discussed further on in this report.

The Federal Highway Administration's delay evaluation software (DELAYS) was also used in order to simulate the impact of incidents and accidents on existing conditions. The EMME/2 software was used to evaluate the Ville-Marie/Bonaventure by-pass under existing conditions.

1.2.4 Accidents and incidents

1.2.4.1 Accidents

There were 4 300 accidents in the entire corridor in 1985, compared to 3 500 in 1984, for an average of 12 per day. The largest proportion of accidents, 49 percent, occurred on the Métropolitaine expressway; 22 percent took place on Décarie and 15 percent on the Champlain bridge.

The accident potential is proportional to the volume of traffic and the length of the section of corridor.

Calculated on the basis of 1.6 million vehicle-kilometres (1 million vehicle-miles), the accident rates show that the most dangerous sections, in descending order, are the westbound

Métropolitaine, between the Acadie Circle and the Décarie interchange; the northbound Décarie expressway between Queen Mary and the Décarie-Métropolitaine interchange; and the Champlain bridge near the toll booths and at the approaches to highway 132. The rates are given in plates 1.8 to 1.10.

About 25 percent of the accidents on the A-25/Métropolitaine and Décarie sections and 35 percent of those on the Bonaventure and Champlain bridge sections involve only one vehicle. The Ville-Marie expressway is the only section with a higher percentage: 45 percent involving a single vehicle.

A large number of accidents happen between 7:00 a.m. and 7:00 p.m., corresponding basically to the period when traffic is heaviest on the expressways. About one third of the accidents occur during the afternoon peak period and about 17 percent in the morning peak period on the A-25, Métropolitaine, Décarie and Ville-Marie expressways. In the Bonaventure/Champlain bridge corridor, the concentration of accidents during peak periods is slightly greater than on the other sections. Together, the two peak periods account for almost 60 percent of all the accidents on these sections, compared to 50 percent in the other cases.

The impact of winter is obvious: each year 36 percent of the accidents on the A-25, Métropolitaine, Décarie and Ville-Marie expressways occur during the months of December, January and February. These months account for 28 percent of the accidents on the Bonaventure/Champlain bridge section. October is the worst month on this section, with 11 percent of the accidents.

Most accidents (84%) involve material damages, while 15 percent involve minor injuries. Accidents responsible for major injuries or death represent only about 1 percent of the accidents in the corridors.

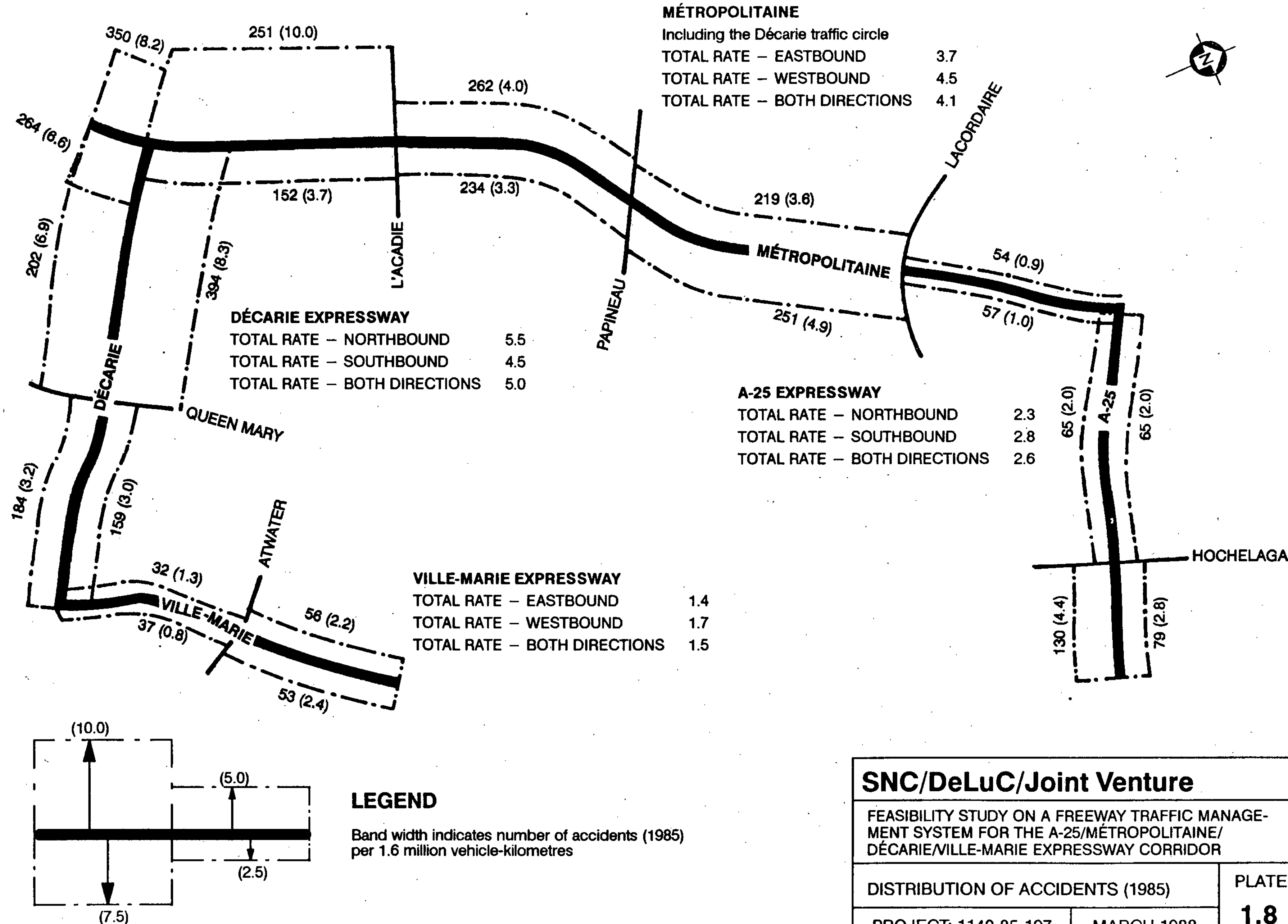
Of the vehicles involved in accidents, 56 percent are cars, 26 percent are trucks, 9 percent are motorcycles and 7 percent are buses. The remaining 2 percent are other types of vehicles.

About 26 percent of the vehicles involved in accidents were slowing down, stopping or had stopped. This phenomenon is related to the many slowdowns and stops on the A-25, Métropolitaine, Décarie and Ville-Marie expressways. Traffic conditions are much better on the Bonaventure/Champlain bridge section, and here the proportion of accidents caused by decelerating or stopped vehicles is lower than elsewhere.

1.2.4.2 Incidents

Incidents include accidents, breakdowns and lane closures for maintenance or construction work.

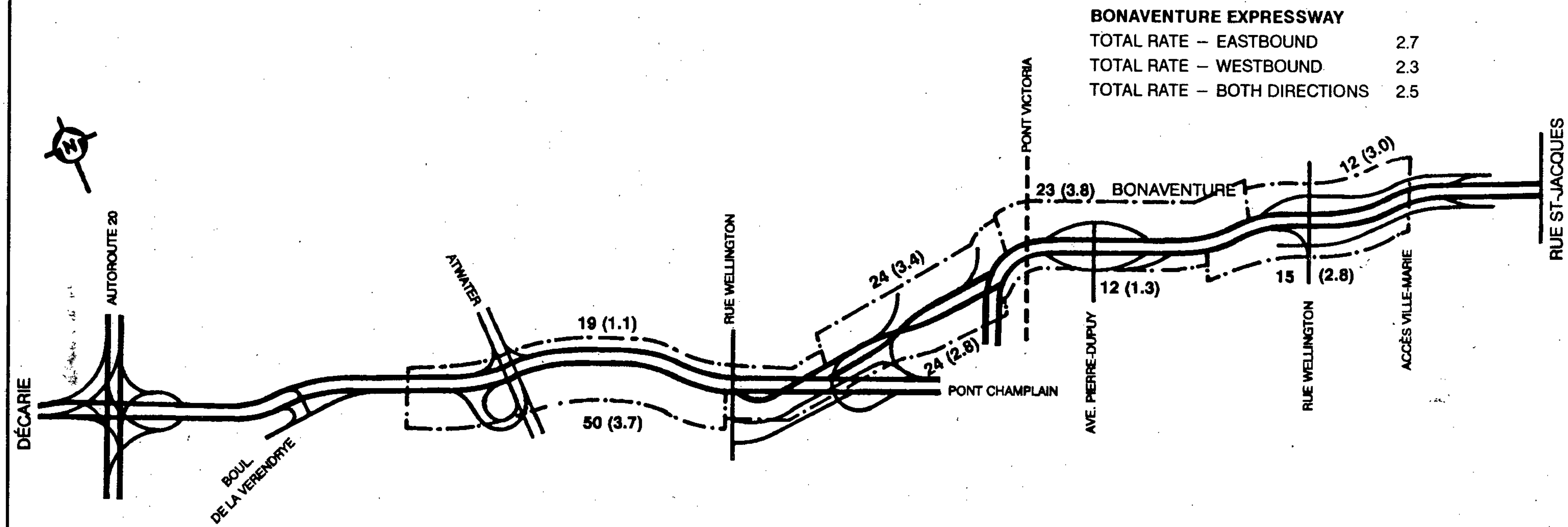
Data from the Ville-Marie tunnel (VMT) indicate that about 50 percent of incidents require the intervention of a third party (police, ambulance, tow truck). Some of these incidents, when a lane is blocked, for example, have a greater impact on traffic flow than others, such as an incident on a shoulder.

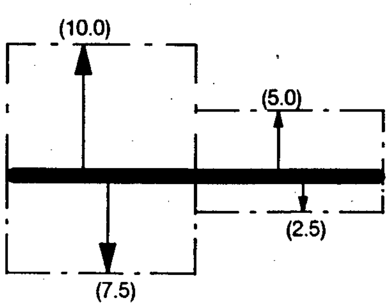


SNC/DeLuC/Joint Venture

FEASIBILITY STUDY ON A FREEWAY TRAFFIC MANAGEMENT SYSTEM FOR THE A-25/MÉTROPOLITAINE/DÉCARIE/VILLE-MARIE EXPRESSWAY CORRIDOR

DISTRIBUTION OF ACCIDENTS (1985)	PLATE 1.8
PROJECT: 1140-85-197	MARCH 1988





LEGEND

Band width indicates number of accidents per 1.6 million vehicle-kilometres (April 1986 to March 1987)

Source for location: National Harbours

SNC/DeLuC/Joint Venture

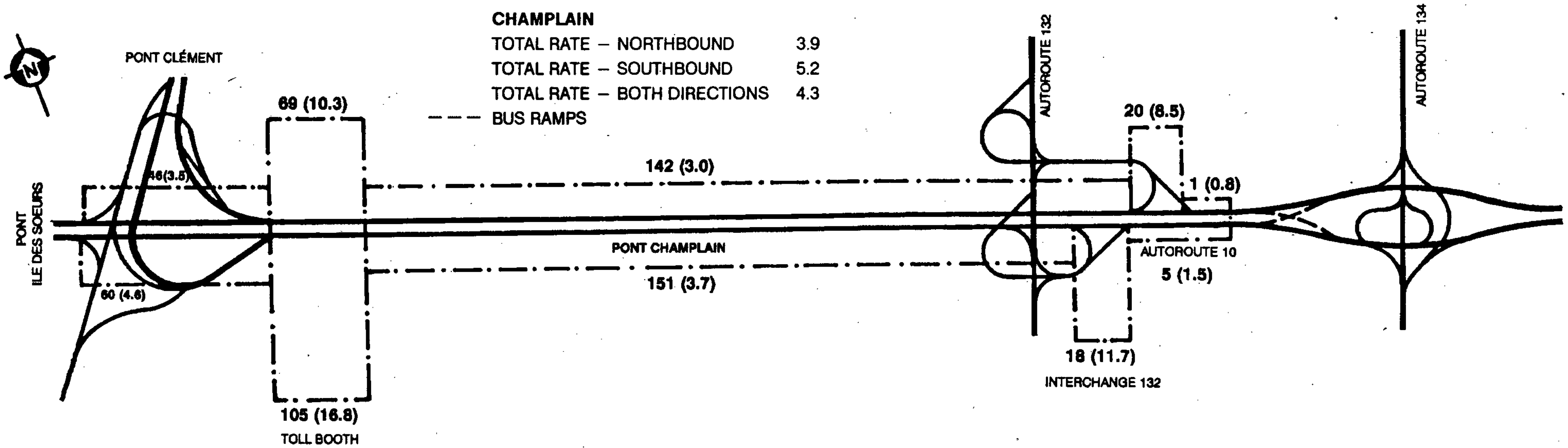
FEASIBILITY STUDY ON A FREEWAY TRAFFIC MANAGEMENT SYSTEM FOR THE CHAMPLAIN BRIDGE/ BONAVENTURE EXPRESSWAY CORRIDOR

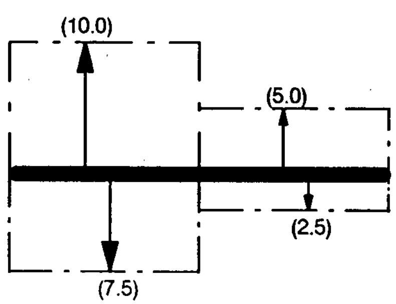
DISTRIBUTION OF ACCIDENTS BONAVENTURE (APRIL 86 TO MARCH 87)

PLATE 1.9

PROJECT: 1140-85-197

MARCH 1988





LEGEND

Band width indicates number of accidents per 1.6 million vehicle-kilometres (April 1986 to March 1987)

Source for location: National Harbours

SNC/DeLuC/Joint Venture

FEASIBILITY STUDY ON A FREEWAY TRAFFIC MANAGEMENT SYSTEM FOR THE CHAMPLAIN BRIDGE/ BONAVENTURE EXPRESSWAY CORRIDOR

DISTRIBUTION OF ACCIDENTS
CHAMPLAIN BRIDGE (APRIL 86 – MARCH 87)

PLATE 1.10

PROJECT: 1140-85-197

MARCH 1988

The duration of an incident depends on the following factors:

- the time it takes to detect it;
- the time it takes to respond;
- the time it takes to clear the site; and
- in the case of an accident, the time required for an investigation of the site, where necessary.

The estimated time required to detect an incident in the corridors is 10 minutes, except on the Ville-Marie expressway where a camera monitoring system reduces this time to between two and five minutes.

The time it takes to respond, that is, the time it takes for assistance (police, ambulance, tow truck) to arrive at the site of the incident is estimated at 13 minutes.

With data from the VMT, the average time required to clear the lane or lanes involved was estimated at about nine minutes for breakdowns and 16 minutes for accidents. These estimates do not include the time required for police investigations.

The total duration of an incident blocking traffic is therefore 24 to 40 minutes for a breakdown and 30 to 53 minutes for an accident, depending on the number of lanes involved.

Generally speaking, any incident has a significant impact on the corridor, even when it occurs on the shoulder. Line-ups stretching back over 14 km (the average is 5 km) have been seen on the Métropolitaine expressway. An incident therefore interferes significantly with traffic even after the lanes have been cleared.

Construction and repair work on the expressway infrastructures are planned on the basis of need and available budget. This type of work is carried out regularly along the corridor along with maintenance work, street cleaning and snow removal.

The ministère des Transports du Québec (MTQ) and the Société des ponts Jacques Cartier et Champlain (SPJCC) usually require the contractor to keep two lanes out of three open for traffic during rush hours and one out of three at other times. During some night-time operations, such as snow removal, the MTQ completely closes an expressway to traffic rather than spread the work over several nights.

Work of this nature obviously has a major impact on traffic flow since it reduces the number of traffic lanes available, depending on the scope of the work to be done and the time at which it is done.

1.2.5 Existing management systems

The corridor has no management system as such, but three systems are used to observe and control traffic conditions: monitoring and control systems operated by the Sûreté du Québec, the National Harbours police, the MTQ and the SPJCC, radio stations and tow truck services. A telecommunications network enables these different systems to transmit information to each other.

1.2.5.1 Police departments

Ports Canada Police monitor and control traffic on the Champlain bridge and the section of the Bonaventure expressway under SPJCC jurisdiction. The Sûreté du Québec monitor and control traffic along the rest of the corridor.

The police patrol the corridor to ensure that the traffic laws are respected and to keep traffic moving. They also ensure safety by controlling traffic and calling for the necessary help whenever there are accidents.

In addition to monitoring and controlling traffic, the police departments provide liaison between the various parties concerned. Two-way radio is used to report everything to headquarters, which re-transmits the information to the appropriate services.

The Sûreté du Québec use three telecommunications networks: radiocommunications, computer communications and the telephone system leased from Bell Canada.

The communications network used by Ports Canada Police is more complete. A direct line connects headquarters with the Champlain bridge toll plaza and with CJAD radio station, so that the police can receive information on incidents observed by traffic reporters flying over their territory. STRSM (Société de transport de la Rive Sud de Montreal) bus drivers also send information to the police using the radios installed in all STRSM buses, with a direct line to police headquarters. Some information is also transmitted at the toll plaza by motorists using the bridge.

1.2.5.2 Breakdown service

The effectiveness of a breakdown service depends on the time it takes to detect the incident and the type of equipment used. The more quickly help arrives, with the appropriate equipment, the more quickly traffic conditions will return to normal and the shorter the delays will be for motorists. Effective communication between officials and the breakdown service is therefore essential.

Each sector is covered by a towing company that has an agreement with the MTQ or the SPJCC. These companies have an exclusive contract for their sector and are the only ones allowed to tow vehicles on the expressway.

When an incident requires the intervention of a tow truck, the company is usually contacted by the Sûreté du Québec or Ports Canada Police.

1.2.5.3 Other services

As owners of the expressway corridor, the MTQ and the SPJCC are responsible for its management and maintenance. Department officials patrol the network 24 hours a day, working with the police forces. There are two types of patrol: patrols responsible for monitoring the network and for general maintenance, and teams of specialists.

The two tunnels in the system, the Ville-Marie tunnel and the Louis-Hippolyte Lafontaine tunnel, have traffic monitoring and control systems under MTQ departmental authority.

Some dozen FM stations and a similar number of AM stations operate in Montreal. With one or two exceptions, they all report traffic conditions during rush hours. The means used to obtain the information and the report itself vary considerably.

1.2.6 Summary of traffic problems

Each of the problems has been identified and described in detail. To facilitate understanding, they have been divided into eight classes:

- inadequate highway geometry;
- recurring congestion during peak periods;
- non-recurring congestion due to incidents;
- congestion and risk of accidents due to road work;
- non-recurring congestion and risk of accidents due to weather conditions;
- limited availability of data for planning and using the highway network;
- non-existence of real-time data on traffic conditions;
- limited communications and coordination between the parties and organizations involved.

Some of the problems noted are aggravated by an increase in traffic along the corridor, especially those related to recurring and non-recurring congestion.

An analysis of these elements led to the conclusion that rush hour traffic at certain points regularly exceeds the maximum flows provided for. Consequently the flow is highly unstable. The slightest momentary disturbance can immediately destabilize traffic conditions. The corridor can accommodate traffic increases of about 5 percent; the impact will be appreciable but conditions will remain tolerable. Should the increase reach 10 percent, however, the result would no longer be acceptable. This instability in flow means:

- an increase in waiting time for motorists;
- a considerable drop in average speed;
- an increase in the number of incidents, especially rear-end collisions;
- an increase in the number of breakdowns;
- an increase in stress among drivers;
- increased fuel consumption and pollution.

Given traffic trends in past years, this sombre picture will become a reality in five to ten years. There are two separate approaches to solving the problem, which are not necessarily independent of each other. One is major expressway construction work in order to increase capacity at critical points; the other is the implementation of freeway traffic management strategies designed to control traffic.

1.3 TRAFFIC MANAGEMENT STRATEGIES

The problems identified can be divided into four categories: recurring congestion, non-recurring congestion, data availability, and communications and coordination. For each of these categories, possible solutions were identified, as well as freeway corridor management strategies, the applicability of which was studied. The strategies selected gave rise to an iterative evaluation procedure in order to identify the most promising.

The strategies with potential for solving traffic problems in the corridor and suitable for a freeway traffic management system (FTMS) were ranked in two groups.

The first level strategies can form the basis of a FTMS, either alone or with other first level strategies. They have the potential to significantly reduce the problems identified, particularly recurring and non-recurring congestion problems.

The second level strategies are techniques that can be used with one or more first level strategies to complete the FTMS, and can often be incorporated at low cost. These strategies are designed primarily to improve user information, data availability, and communications and coordination between the agencies involved.

1.3.1 First level strategies

The first level strategies studied include incident management, access ramp metering, ramp diversion, changeable message signs at problem points, and lane control.

Incident management

The purpose of an incident management system is to reduce to a minimum the delays caused by incidents and accidents. For the corridor under study, this objective can be reached mainly by reducing the time required to detect an incident and determine its exact nature. The appropriate assistance can then be sent or any other necessary step taken to return traffic conditions to normal in the shortest possible time. Reducing the total duration of the incident and therefore its effect on traffic flow also cuts down on the number of secondary accidents (especially rear-end collisions).

Incident management thus consists of three separate steps: incident detection, incident confirmation and appropriate action.

Incident detection consists in reporting an incident as soon as it occurs. Confirmation consists in determining the exact nature and location of the incident so that the appropriate assistance can be sent as quickly as possible. Rapid action is necessary in order to return traffic conditions to normal without delay. To this end, the right response equipment must be sent to the site as soon as an incident has been detected and its nature and gravity verified.

Electronic monitoring is the most dependable and most efficient detection method for the corridor under study. This technique was therefore retained as the main component of the system. A closed circuit camera system is also particularly well adapted to confirming incidents detected in the corridor, despite the high cost of installing and operating it. It is a particularly effective complement to the electronic monitoring system selected as the principal means of detecting incidents, and reflects current trends in the design of incident management systems.

An incident management system thus seems to be a good strategy for the corridor. This strategy, divided into principal (electronic monitoring and closed circuit television cameras) and complementary (radio band, cellular telephones, remote control communications) techniques, was selected as a highly promising first level strategy.

Ramp metering

Ramp metering is a frequently used strategy, accomplished with traffic lights that control access to the freeway in order to obtain a smoother flow of traffic. This strategy has been proven effective where local conditions were suitable, and can be implemented rapidly at a reasonable cost once the basic equipment required for the other strategies is in place.

Model results indicate that ramp metering throughout the corridor would not be very effective, since the impact on vehicles using the service roads and access ramps would be greater than the advantages gained for vehicles travelling on the freeway. Given the present volume of traffic on the service roads, modelling traffic conditions for these roads may not be entirely reliable. The potential of metering therefore seems to be limited to ramps located on congested freeway sections where the service roads have a large reserve capacity.

The advantages of local ramp metering are therefore not immediately apparent. The local network has already reached, or is at the point of reaching, maximum capacity, while delays experienced by motorists on the local network vary greatly and are therefore difficult to evaluate with any degree of precision. As a result the same caveat as to the reliability of service road traffic models applies here as in the case of ramp metering throughout the corridor.

Nevertheless, this strategy was identified as a first level one, with reservations. Since the results of the evaluation did not clearly indicate rejection, the possibility was retained of setting up a ramp metering pilot project, or incorporating metering as a sub-system on one or more ramps where the reserve capacity of the service roads throughout the peak period justified it.

Diversion

Diversion systems distribute traffic demand at peak points on the basis of the capacity of the routes adjacent to the freeway.

To implement these systems, the road network must be suitable and have the monitoring equipment required to determine traffic conditions on alternative routes in order to avoid creating new traffic jams.

Three ways of diverting traffic were identified. Freeway to freeway diversion would send traffic from one freeway to another in the same corridor in case of an incident or congestion. As an example, traffic could be diverted between the Ville-Marie and Bonaventure expressways.

Freeway to arterial diversion would send traffic moving towards the site of an incident onto an artery of the local network that parallels or crosses the freeway.

Freeway ramp to arterial network diversion would send traffic moving towards a freeway ramp to a ramp downstream on so that it would avoid a congested section or the site of an incident.

A diversion system whereby vehicles about to move onto a ramp leading to the site of an incident are directed towards a ramp downstream of the incident seems very promising. It would reduce delays for motorists, the number of secondary accidents, fuel consumption and pollution. In order to obtain the greatest benefit from the system and ensure its credibility, a traffic monitoring system will be required on the service roads as well as direct communication with the traffic lights that regulate traffic flow.

Changeable message signs at trouble spots

Changeable message signs (CMS) can be installed at the approach to any particularly dangerous spot on a freeway, where the risk of an accident is high, to warn motorists of what is ahead. Ice detection, based on tried and true techniques, can be included in this strategy.

A CMS system seems promising and would considerably reduce the risk of accidents and the delays they entail for motorists, as well as cutting down on fuel consumption and pollution.

Lane control

Lane control is a strategy that warns motorists of abnormal conditions on a specific lane of the freeway and recommends appropriate action, whether it be to change lanes or reduce speed.

Lane control systems increase the safety of lane changing manoeuvres on the freeway and reduce the risk of secondary accidents following an incident. They also contribute to better management of road work.

These systems have been used most often in bridge and tunnel management in North America. The European experience nevertheless has enough potential to justify selecting this strategy for further evaluation in the present context.

Traffic control at the Champlain bridge toll plaza

With this strategy, it is possible to regulate southbound traffic in keeping with bridge capacity, in order to reduce the impact of recurring congestion and to adjust flow to capacity when a lane has been closed following an incident.

The purpose of this strategy is to reduce response time by reducing the length of line-ups, in hopes of reducing accidents and fuel consumption.

Merge control on access ramps (southern approach to the Champlain bridge — highway 132)

This strategy involves the use of traffic lights to control traffic entering the access ramp to the Champlain bridge, on the basis of demand upstream of the ramp, at each approach to the bridge. It would result in fewer delays caused by uneven access and should reduce accident rates and fuel consumption.

Removable barriers for the reserved lane on the Champlain bridge

The purpose of this strategy is to place a physical barrier between cars and buses travelling in the opposite direction. It should substantially reduce the number of head-on collisions and consequent slow-downs.

1.3.2 Second level strategies

These strategies include highway advisory radio, pre-trip planning, in-vehicle route guidance, traffic data management, communications and coordination.

A qualitative method has been adopted to determine whether these strategies are justified, since, generally, they can be installed at a low cost along with first level strategies, and since it is difficult to quantify their advantages.

Highway advisory radio

Motorists may be informed of traffic flow conditions in real time over an AM radio station reserved for that purpose. Signs set up along the freeway tell motorists that such a service exists and give them the frequency. Messages concerning specific stretches of corridor are transmitted live over cable radiator or monopole antennas.

Pre-trip planning

Motorists can be informed of traffic conditions before they start their journey so that they can choose the route or mode of transportation that will get them to their destination within an acceptable lapse of time. This information can be given by telephone, on private radio stations, on television or through news bulletins to major sources of traffic (office buildings, for example).

It is difficult to prepare and broadcast live messages, and traffic conditons may have changed by the time the motorist enters the corridor. Therefore, telephone and television services were not retained for further assessment. Some flexibility should nevertheless be built into the system design so that these techniques can be added later on.

However, traffic conditions for a particular freeway corridor can be broadcast over private radio stations.

In-vehicle route guidance

The electronic equipment in a vehicle can be used to give the in-vehicle route guidance system the motorist's position and destination. The motorist then receives instructions based on current traffic conditions, allowing a choice of the best possible route.

An interface between the traffic management system and an in-vehicle route guidance system will probably not be required in the short term. However, if such an interface can be incorporated, at low cost, into the corridor management system being studied, it should be.

Traffic data management

With some systems, such as incident management and lane control, data management can be provided at little cost. Equipment such as vehicle detectors, the communications network and the control centre computer are used for the collection, compilation and automatic analysis of data. When necessary, some data processing can also be carried out on request. The traffic data management system is a very promising technique that has been retained for further analysis.

Communications and coordination

Preparing a program for responding to incidents requires inter-agency cooperation. A traffic management committee should be created to this end. The main duty of this committee would be to set up communication lines between the agencies required at the site of an incident and to identify and update response procedures.

This committee would also be responsible for preparing a plan for installing equipment designed to monitor flow conditions on the local network and for interfacing it with the traffic lights along the corridor (where there is a freeway ramp to arterial diversion system). It must therefore be possible to interface the chosen system with the arterial traffic lights, even if the traffic light controls are only adapted to the system later on.

1.3.3 Promising strategies

In short, the following strategies were retained for further evaluation:

First level strategies

Very important: incident management system

Important:
- access ramp diversion system
- changeable message signs at trouble spots
- access ramp merge control system (Champlain bridge/highway 132)
- control system for the Champlain bridge toll booths

Uncertain:
- access ramp metering system[1]
- lane control system

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1 *Model results, modified on the basis of the consultant's judgment and experience, suggest that a pilot project be carried out to confirm the applicability of this strategy in the corridor.*

Second level strategies

Very important:
- traffic data management system[2]
- communications and coordination system[2]

Important:
- pre-trip planning system
- highway advisory system

Slight importance: in-vehicle route guidance system

2 *These strategies could not alone justify the implementation of the system. They are nevertheless considered very important because they guarantee efficient system operation and will therefore be ranked later on as first level strategies.*

Section 2

A-25/MÉTROPOLITAINE/DÉCARIE/VILLE-MARIE CORRIDOR

2.1 EVALUATION OF SYSTEM VARIANTS

In order to evaluate alternative design configurations for a freeway traffic management system from a benefit/cost point of view, the different ways in which the management strategies described earlier can be used together must be examined.

A number of management strategies have common components (subsystems, equipment):

- most strategies include a mainframe, a communications system and a vehicle detection system;
- a closed-circuit television system is desirable in most cases.

It has been shown that the implementation of an incident management strategy is desirable throughout the corridor. Since this strategy uses equipment common to most other strategies, it would be advantageous to include the equipment for this strategy in the basic design configuration of the FTMS.

The benefits, disadvantages and costs of additional configurations were thus evaluated on an incremental basis, that is, by adding any new components required for the other strategies. In this way, the basic configuration of the components (subsystems) required to carry out a particular strategy was designed to make the most of the components common to several strategies.

The second level strategies do not require any new component (subsystem). All that is needed are low-cost interfaces ($35 000 to $100 000). These additional interfaces will therefore be incorporated into the basic configuration without any detailed evaluation.

2.1.1 Method of evaluation

The strategies to be implemented are chosen on the basis of performance and the cost and benefits of each configuration.

The method chosen to identify the optimum FTMS configuration (in terms of strategy) is an incremental process that evaluates each relevant strategy for each section of expressway both quantitatively and qualitatively. The final choice of strategies to be implemented on any freeway in the corridor was based on performance as well as on benefit/cost ratios.

Costs include:

- present value of capital expenditures, since implementation will be spread over three years; and
- annual operation and maintenance costs, discounted on the basis of a fifteen-year life expectancy.

Benefits comprise elements that can be expressed in dollars to indicate direct benefits (ex: vehicle delay saved). Here again, the annual benefits as of the fourth year were given their present value on the basis of a fifteen-year life cycle.

A sensitivity analysis (discount rate, benefits, etc.) of the resulting benefit/cost ratio provided confidence levels for the hypotheses and methods of computation. The benefit/cost ratios were studied as a function of the possible combinations of strategies by freeway and of a staggered implementation program.

Non-quantifiable elements that were considered important for strategy evaluation were assessed using an evaluation grid in which a rating based on a number of criteria was given to each strategy.

The performance rating of each variant was then evaluated, keeping in mind the combinations of strategies by freeway.

2.1.2 Cost evaluation

It was not possible to determine the specific cost of each strategy, given the constraints of the system's configuration. A basic configuration is required no matter what the strategies adopted. It consists of a control centre, a mainframe, software, and a communications system.

An FTMS providing incident management with vehicle detectors and closed-circuit television (CCT) was therefore evaluated as the basic system to which the costs and benefits of the other strategies could be added.

It is important to note that:

- an access ramp metering system can make use of much of the computerized system used for incident management because of the similarities in the subsystems used for the two strategies.
- a changeable message sign system can be controlled with the same equipment, no matter what the management strategy, using a common communications channel and a single hardware-software system at the control centre.
- ice detection equipment can simply be linked to the changeable message sign subsystem at problem spots, thus reducing the cost of this strategy.

The benefit/cost evaluation was based on geographic and strategic modules so that costs and benefits could be studied by strategy and by corridor section.

Some costs are independent of the extent to which the FTMS covers the freeway corridor, particularly the cost of the control centre, the mainframe, the software and other equipment at the control centre. Moreover, the implementation of different strategies on different sections of freeway, solely on the basis of a benefit/cost analysis, would probably not be a sensible decision.

Each cost was evaluated in terms of 1987 dollars, on the basis of the consultant's experience with similar projects and of discussions with manufacturers, entrepreneurs and the MTQ.

Some decisions related to design that had a significant impact on the cost of the FTMS are described in this section:

- During cost evaluation, it was estimated that half the field cabinets would be served by the 600V a.c. distribution network because of the absence of local 120V a.c. distribution near the freeway corridor.
- Fibre-optics technology would be more expensive than electromagnetic disk matrices for changeable message signing. On the other hand, it would require less maintenance since the type of vane used is basically more reliable than electromagnetic disks; it is also more visible. It was recommended on the basis of these two arguments. The small number of places where CMS is required means that the choice of the more expensive technology will not have a major impact on total system cost.

  Three types of visual changeable messages were retained after cost evaluation:

  — a single static message of up to 15 characters would be used on access ramps;

  — a CMS with limited message capability, composed of three static messages with 15 characters each, would be used to announce known danger spots such as the approach to a tunnel;

  — a CMS with unlimited message capability, composed of three changeable messages with 15 characters each, would be used at major interchanges.

- Communications cables between pieces of equipment can be routed along both sides of the freeway or one side only, with the possibility of crossing if necessary. The costs of the system were evaluated on the basis of a single path.
- Cost estimates indicate that the fibre-optics communication system will cost about $1 million more than a coaxial cable system. However, this technology has a number of advantages:

  — better video performance;

  — no electrical interference;

  — less maintenance;

  — much simpler installation due to very light, flexible cable;

  — greater potential for doubling, with greater reliability;

  — greater basic communication capacity, facilitating future expansion;

  — support given to a growing Canadian high-tech industry.

  These advantages seem to justify the additional cost of this technology.

- About $1 000 can be saved on each cabinet if smaller cabinets are used wherever feasible.
- For elevated and depressed sections of freeway, cabinet sites can be perched on the parapet or installed on the ground. For practical reasons, the cabinets will be installed on the parapet, despite the additional cost this entails, estimated at $2 400 per installation.

2.1.3 Evaluation of benefits

The benefits were evaluated in two stages: the various strategies proposed during the first phases of the project were evaluated quantitatively and the benefits that were not quantifiable were evaluated qualitatively.

2.1.3.1 Quantitative evaluation

Three types of quantifiable benefits were evaluated:

- reduction in vehicle-hour of delay following an incident;
- reduction in annual number of accidents;
- reduction in fuel consumption.

These benefits were selected because they represent the main quantifiable advantages that can be obtained following the implementation of a traffic management system, and the data available make such an evaluation possible. Moreover, using the European and North American experience, it is possible to establish hypotheses and potential profit margins for each benefit and each strategy.

The results, given in Table 2.1, show that the incident management strategy is the most beneficial. These values confirm that this option should be the basic strategy,complemented by one or more other strategies, depending on the section of freeway.

Access ramp metering, although evaluated on only seven ramps on the Métropolitaine expressway, could help reduce the number of accidents (and, indirectly, delays and fuel consumption). The other benefits are very small.

Changeable message sign strategies provide approximately the same benefits. Only a qualitative evaluation will make it possible to decide among them.

The lane control strategy is promising but less so than the other strategies.

2.1.3.2 Qualitative evaluation

Table 2.2 gives a summary of the qualitative analysis of the strategies, the most effective of which are:

- changeable message signs warning of problem spots (including ice detection);
- diversion between the Ville-Marie and Bonaventure expressways;
- incident management (including data management).

TABLE 2.1

SUMMARY OF EVALUATION OF ANNUAL BENEFITS

STRATEGY	EXPRESSWAY (BENEFITS IN THOUSANDS OF DOLLARS)							
	A-25		Métropolitaine		Décarie		Ville-Marie	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Incident management	1 395	2 042	8 026	11 780	3 544	5 536	61	129
Ramp Metering	(1)		176	246	(1)		(1)	
Changeable messages (on ramps)	152	221	1 010	1 466	45	88	(1)	
Changeable messages (problem spots)	100	263	661	1 649	284	785	33	69
Lane control	53	117	280	817	183	373	1	19
Bonaventure/Ville-Marie diversion	(1)		(1)		(1)		26	49

(1) This strategy has not been evaluated for this expressway.

TABLE 2.2

SUMMARY OF QUALITATIVE ANALYSIS OF STRATEGIES

STRATEGY	EVALUATION CRITERIA								
	Potential for reducing recurring congestion	Potential for reducing non-recurring congestion	Potential for reducing technical risks	Acceptability by different levels of government	Ease of implementation	Potential for public awareness of system's existence	Potential for indirect effects (technological trends, technology transfers, local economy, etc.)	Probability of obtaining expected benefits	Overall assessment
1. Incident management (including data management)	0	5	5	5	5	0	5	5	30
2. Access ramp metering	5	0	3	0	0	5	3	0	16
3. Access ramp diversion	0	5	0	0	0	5	5	5	20
4. Changeable signs at problem spots (including ice detection system)	0	5	5	5	5	5	5	3	33
5. Lane control	0	5	0	5	0	5	1	1	17
6. Diversion between Ville-Marie and Bonaventure expressways	0	5	5	3	5	5	5	3	31

Legend: 0 = small impact 5 = major impact

The less promising strategies are:

- access ramp metering;
- lane control;
- access ramp diversion.

The qualitative evaluation identifies the strategies whose implementation would entail certain risks. It would be preferable to implement these strategies gradually, or to carry out pilot projects beforehand so that they could be verified in a local context before they were carried out in the corridor on a larger scale.

2.1.4 Selection of strategies

Strategies were selected systematically by grouping the quantifiable and non-quantifiable factors for each expressway. In this way, the strategies were arranged in a single system that really corresponded to the corridor's management requirements, gave the users the maximum benefit and reduced the operators' risks to a minimum. With this approach, and in view of these same factors, it was also possible to identify the strategies that should be tested in a pilot project or implemented gradually to minimize the risk.

The following hypotheses for the implementation schedule were put forward for the benefit/cost analysis:

- The project's life expectancy is 15 years.
- Design, plans and specifications will be completed in the first year.
- Manufacturing and implementation will be carried out the second and third year and the system will be completely operational in the fourth year.
- The project will begin to incur personnel and maintenance costs during the third year.

These hypotheses have the following implications for costs and benefits:

- first year
  - Design: 10 percent of investment costs
- second year
  - Work supervision: 2.5 percent of total capital costs
  - Capital expenditures: 50 percent of total
- third year
  - Work supervision: 2.5 percent of total capital costs
  - Capital expenditures: 50 percent of total
  - Personnel and maintenance costs
- fourth year
  - System fully operational
  - Operating and maintenance costs
  - Benefits begin

Calculations of the costs and benefits for each year of the project's economic life were based on their real net value, so that the costs and benefits of the system's life cycle could be established by adding them. Initially, a 10 percent discount rate was used for this analysis, in keeping with the recommendations of the federal Treasury Board for this type of calculation. To determine whether results were responding to the discount rate, calculations were also made using rates of 6 percent and 8 percent.

Table 2.3 provides a summary of the overall evaluation of the strategies in terms of capital expenditure, benefit/cost ratios and risk.

Incident management

With an incident management system, it is possible to detect, verify and respond to incidents, and to manage corridor traffic data. This strategy is the springboard from which a corridor management system can be launched. Since the risks inherent in its implementation are small and benefit/cost ratios are generally high, implementation of the strategy is justified throughout the corridor under study. Incident management can even be applied to the Ville-Marie expressway, despite the low benefit/cost ratio, for the following reasons:

- It will make expressway to expressway diversion possible.
- It will ensure smooth integration with the Ville-Marie tunnel control systems.
- It can meet future needs created by increased traffic.
- It will provide the information users require; and
- It will contribute to the standardization of the freeway system.

Incident management should therefore be implemented on all the sections of the A-25/Métropolitaine/Décarie/Ville-Marie corridor. The capital expenditures for this strategy will amount to about $12.6 million.

Access ramp metering

The evaluation of this strategy pinpointed certain potential risks related to the expected benefits (mainly a significant reduction in accidents) and to the ease of implementation. However, it can be carried out at very low cost if it is implemented along with the access ramp diversion strategy, entailing a good benefit/cost ratio. This strategy should therefore be limited at first to a pilot project on the Métropolitaine expressway (involving seven ramps) and the installation of traffic detectors on the other ramps. This would facilitate implementation later on if the pilot project is successful and would improve the coverage of the data management system.

Capital expenditures for this strategy will amount to about $312 000 for the entire Métropolitaine expressway (pilot project and loops on all ramps). This sum represents costs over and above those incurred for the incident management system and the access ramp diversion system.

TABLE 2.3

GLOBAL EVALUATION OF STRATEGIES

STRATEGY	EXPRESSWAY / EVALUATION CRITERIA	A-25	Métro-politaine	Décarie	Ville-Marie	TOTAL	Comments
1. Incident management (including data management) (4)	Capital expenditures (1)	$3.3	$5.6	$2.3	$1.4	$12.6	• High benefit/cost ratios • Low risk factors • Basic system for other strategies
	Benefit/cost (2)	1.8 – 2.6	5.3 – 7.7	5.3 – 8.2	0.1 – 0.3	3.8 – 5.7	
	Risk (3)	low	low	low	low	low	
2. Access ramp metering	Capital expenditures (1)	minimal potential	$0.3	minimal potential	minimal potential	$0.3 (includes cost of detectors on all ramps)	• High benefit/cost ratios • High risk factors • Pilot project recommended • Detectors planned elsewhere for future installations
	Benefit/cost (2)		3.1 – 4.4			3.1 – 4.4	
	Risk (3)		high			high	
3. Access ramp diversion	Capital expenditures (1)	$0.3	$1.0	$0.7	$0.4	$2.4	• Variable benefit/cost ratios • High risk factors • Gradual implementation recommended
	Benefit/cost (2)	3.1 – 4.5	5.6 – 8.2	0.4 – 0.7	not quantifiable	2.8 – 4.1	
	Risk (3)	high	high	high	high	high	
4. Changeable message signing at problem spots	Capital expenditures (1)	$0.4	$1.2	$0.5	$0.4	$2.6	• High benefit/cost ratios • Low risk factors • Required to inform corridor users
	Benefit/cost (2)	1.3 – 3.3	3.0 – 7.4	3.0 – 8.2	0.4 – 0.9	2.3 – 5.8	
	Risk (3)	low	low	low	low	low	
5. Lane control	Capital expenditures (1)	$0.9	$4.3	$1.2	$0.9	$7.3	• Low benefit/cost ratios • High risk factors • No additional implementation recommended
	Benefit/cost (2)	0.3 – 0.7	0.4 – 1.1	0.9 – 1.8	0.0 – 0.1	0.4 – 1.0	
	Risk (3)	high	high	high	high	high	
6. Diversion between Ville-Marie and Bonaventure expressways	Capital expenditures (1)	not applicable	not applicable	not applicable	$0.3	$0.3	• Low costs • Low risk factors • High benefit/cost ratios • Rejected
	Benefit/cost (2)				0.7 – 1.3	0.7 – 1.3	
	Risk (3)				low	low	

LEGEND

- [dotted shading] recommended system
- [hatched shading] pilot projects

NOTES

(1) In millions of 1987 dollars, excluding engineering, management, monitoring and integration.

(2) Discounted on the life expectancy of the project.

(3) Global evaluation equal to or greater than 75 percent – low risk factor (see qualitative evaluation – chapter 6); global evaluation less than 75 percent – high risk factor.

(4) Costs include control centre costs in proportion to the length of each section of expressway.

Access ramp diversion

The diversion of access ramp traffic gives benefit/cost ratios that are high in some cases, low in others, and difficult to quantify in yet others (because of the absence of service roads on some sections). This strategy also has high risk factors (new applications, need to control traffic lights on service roads, etc.). Gradual implementation is therefore recommended to reduce risks to a minimum. The initial application should be restricted to the Métropolitaine expressway which has the highest benefit/cost ratio and is already equipped with facilities that can be used in a ramp metering pilot project. This strategy could be implemented elsewhere on the corridor once the initial installations have proven to be effective.

Capital expenditures for the initial implementation of the strategy would amount to about $1 million.

Changeable message signing

Changeable message signs (CMS) to warn of problem spots generally present few risks and high benefit/cost ratios, except on the Ville-Marie expressway. This strategy is nevertheless justified on that expressway by the same reasoning as given for incident management.

CMS should therefore be implemented at all problem spots on the corridor.

Capital expenditures for this strategy should amount to about $2.6 million for the A-25/ Métropolitaine/Décarie/Ville-Marie expressway corridor.

Lane control

Lane control has too high a risk factor and too low a benefit/cost ratio to be of interest. The specific applications already used in the Ville-Marie and Louis Hippolyte Lafontaine tunnels are still worthwhile, but control methods are technically outdated and do not provide much operational flexibility.

2.1.5 Strategies recommended for implementation

Table 2.4 gives the capital expenditures required by strategy and by section of freeway.

The recommended strategies are an incident management system, including data management and a changeable message signing system for problem spots (including an ice detection subsystem).

There are uncertainties attached to the ramp diversion and metering techniques, which consequently have higher risk factors than the other management techniques recommended. It is therefore suggested that two pilot projects be carried out; if the results are good, the gradual application of these techniques could be contemplated.

The pilot projects would be carried out only on the Métropolitaine expressway, including diversion on all access ramps and metering the seven ramps with the highest potential for that technique.

TABLE 2.4

CAPITAL EXPENDITURES REQUIRED BY STRATEGY
($1 000)

STRATEGY	CONTROL CENTRE	A-25	MÉTROPOLITAINE	DÉCARIE	VILLE-MARIE
Incident and data management	3 940	2 670	3 840	1 420	720
Changeable message signing	30	440	1 230	530	430
Access ramp diversion			1 000		
Access ramp metering			310		

TOTAL COSTS ROUNDED OFF*

System	$15 250
Pilot project	$ 1 310
TOTAL	$16 560

LEGEND

Shaded (dotted)	Recommended system
Hatched	Pilot project

* *Costs exclude engineering, integration and management.*

At present, the interface with the Ville-Marie and Louis-Hippolyte Lafontaine tunnels includes a liaison for exchanging data and information. It will also accept future equipment.

The investment required to implement the proposed system on the A-25/Métropolitaine/Décarie/Ville-Marie corridor is $16.6 million (including $1.3 million for the pilot projects).

2.2 IMPLEMENTATION PLAN

The implementation of a freeway traffic management system is regarded as part of the daily management of traffic conditions in the metropolitan region. With the methods recommended, it will also be possible to collect sufficient data to improve traffic conditions in the short and the medium term and to improve road network management in the long term. The recommended system will thus provide a solid basis.

Once the benefits of the strategies selected to deal with the traffic conditions developing on Montreal's expressways have been confirmed, it will be possible to begin improving and adding to the original installations.

2.2.1 Implementation

Implementation will consist of three stages: initial implementation, evaluation and extension.

Initial implementation includes system design and installation, the integration of system components and the training of operating and maintenance personnel. This stage will last three years.

The evaluation stage will overlap with the initial implementation and continue one year or more, if necessary, during which time motorists will become familiar with the system and personnel will check operation under different traffic and weather conditions.

Once the initial system has been evaluated, two types of extension can be envisaged to complete the gradual process of implementation:

- the use of additional techniques on the same corridor sections; or
- the use of basic techniques on new freeway sections of the network.

The advisability of applying one or both of these options will depend on how traffic conditions develop on and off the corridors, and on the real benefits noted during the evaluation of the system's performance. Extension will lead to a new cycle of implementation/evaluation/extension.

The work required to set up the recommended system will be divided into seven activities or tasks that are not wholly dependent on each other. They are:

- building a control centre;
- obtaining computer hardware and software;

- carrying out the civil engineering work;
- creating a communications subsystem;
- creating a detection subsystem;
- setting up a changeable message signing subsystem;
- creating a system to meter access ramps.

Each of these activities deals with a distinct component of the system, but their development must nevertheless be well coordinated in order to minimize problems as they are integrated. From the very start, there must be detailed management and operation procedures so that all the activities respond simultaneously to the steps of the process: design/plans and specifications/call for tenders/construction.

Design for all the components commences at the beginning of the first year.

Once all seven activities have been completed, the integration, start up and training processes will begin, leading into the evaluation stage and the operation of the system.

2.2.2 Timetable

All the activities will be staggered in order to take into account the road works program, installation priorities, the coordination of the installation of system components and time constraints. The timetable for work on the A-25/Métropolitaine/Décarie/Ville-Marie corridor is given in Figure 2.1.

Computer hardware, whether leased or purchased, will be installed temporarily as early as possible in the first year so that programs can be developed. The communications system and peripheral systems (traffic lights, signs, etc.) will be installed as the support infrastructures become available.

Installation should be completed by the end of the third year. Start-up begins with the integration of the system and personnel training. This will require the cooperation of the project manager, the MTQ's personnel and the suppliers.

The system should be operational early in the fourth year. In order to evaluate it, data will be gathered during the third and fourth years. The equipment installed will not necessarily be used for this evaluation.

2.2.3 Costs

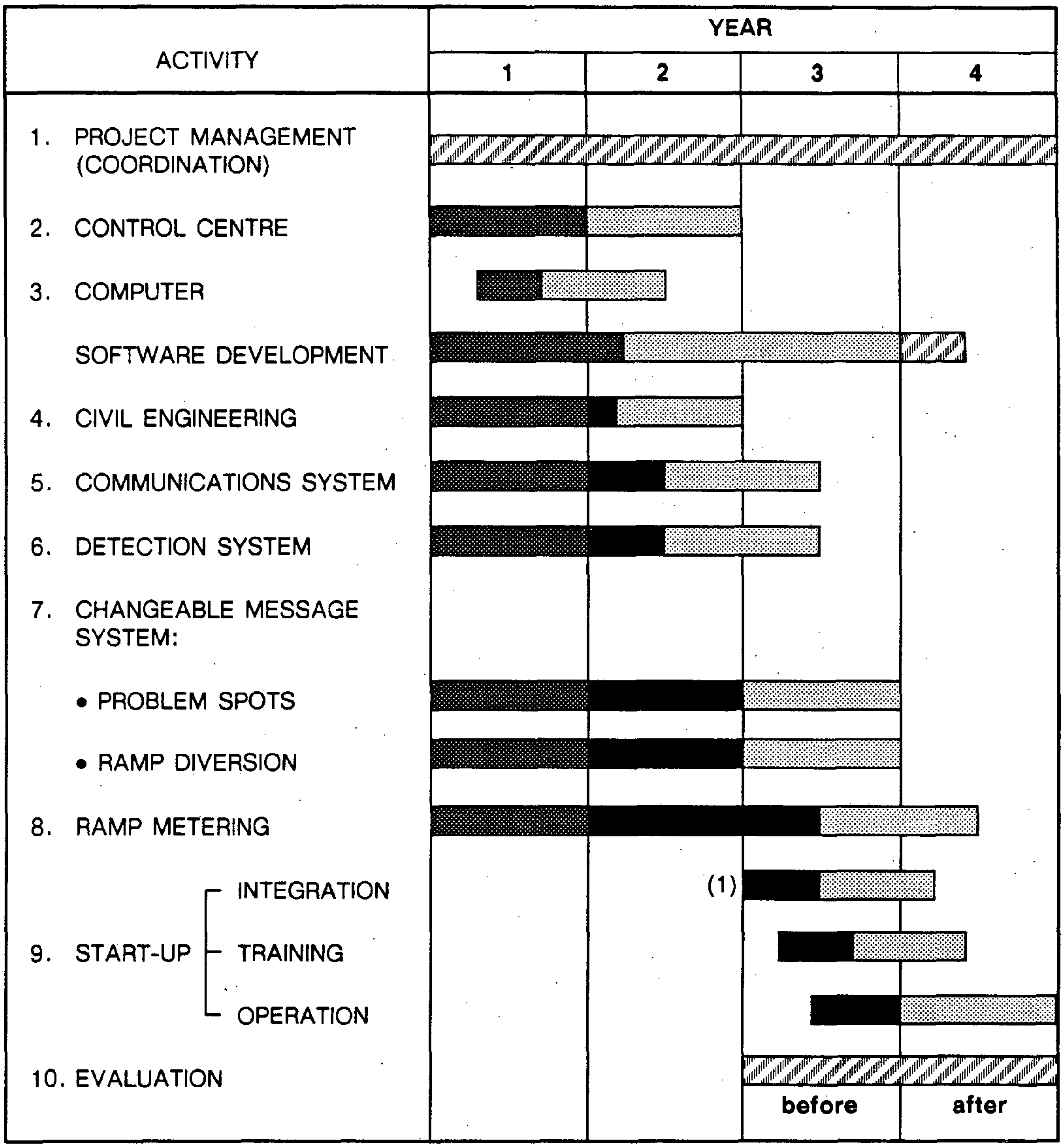
The capital expenditures required for the system can be divided in two on the basis of the most urgent needs and the MTQ's expectations.

One category would cover:

- a control centre;
- an incident management system for all the expressways;
- a changeable message signing system announcing problem spots for all the expressways.

FIGURE 2.1

TIMETABLE FOR IMPLEMENTATION ON THE A-25/MÉTROPOLITAINE/DÉCARIE/VILLE-MARIE CORRIDOR



LEGEND

- Occasional follow-up
- Design stage
- Development and installation
- Staggering for coordination or calls for tenders

(1) Integration begins as soon as possible after equipment is connected.

Special attention should be paid to coordination on the A-25 and Ville-Marie expressways with existing or future facilities (closed circuit TV) in the tunnels.

The other category would cover two pilot projects on the Métropolitaine expressway, one to divert traffic from all ramps, and the other to meter traffic on seven ramps.

Engineering, monitoring and integration costs must be added to capital expenditures. The cost of the two pilot projects is based on the assumption that the basic system is in place.

Table 2.5 gives a summary of the costs involved.

TABLE 2.5
COSTS
A-25/MÉTROPOLITAINE/DÉCARIE/VILLE-MARIE EXPRESSWAYS
(x $1 000)

CATEGORY	EXPENDITURES		
	EQUIPMENT	ENGINEERING[1]	TOTAL
System	15 250	3 128	18 378
Pilot projects	1 310	197	1 507
TOTAL	**16 560**	**3 325**	**19 885**

[1] *Including engineering, monitoring, integration and testing.*

2.3 CONCLUSION AND RECOMMENDATIONS

The system is based on three aspects: detection, analysis and response.

When traffic problems are detected, the information is transmitted directly to the control centre computer, which selects the ways and means that can be put into effect to solve the problems and lessen their impact on traffic. Once this analysis is terminated, the computer transmits messages or signs that give users the instructions to follow on the road network. In the case of an accident, the system operator informs the emergency services of the extent and the details of the problem, so that they can respond rapidly with the appropriate equipment.

Since this is an experimental project, the first of its kind in Québec, several existing techniques for controlling and managing traffic may be included in the system design.

However, initially, only the techniques showing the best benefit/cost ratio, such as incident detection and user information, will be implemented.

2.3.1 System

The system shown in Figure 2.2 includes a control centre and three subsystems:

- automatic incident detection which can also be used for continuous traffic data collection;
- changeable message signing, warning of dangerous or difficult traffic conditions as well as road conditions;
- a communications network for transmitting all the data.

Automatic incident detection is the most important aspect of the system. It provides uninterrupted traffic monitoring of the network from the control centre, making it possible to respond to a situation with the appropriate services without delay and so reduce waiting time.

A computer program compares traffic levels on the expressway between two detectors. When the detectors indicate that there is far more traffic upstream than downstream, an incident is probably to blame. This information and the location of the incident appear on the control centre's synoptic table.

The incident is recorded and transmitted by the camera closest to the incident. It is thus possible to quickly take the necessary steps. Response time is therefore very short and the scope and gravity of the incident are known beforehand.

Incident detection requires the installation of magnetic loops in the road, closed circuit TV cameras, a fibre-optic communications network connected with the control centre, and a telephone link-up with the emergency services.

The computer program also collects and analyses all the traffic information transmitted by the magnetic loops installed in the road, in order to improve system performance and to compile statistics.

The user information subsystem includes changeable message signs to warn users of difficulties ahead and thus make the freeway safer. These signs are located upstream of spots that are dangerous in certain weather conditions or for other specific reasons. They automatically display messages based on a preset program controlled by the operator, or else the operators themselves make up and send the messages. These messages can give traffic conditions, road conditions, "Men at work" warnings or suggestions for other routes in order to balance traffic over the entire network. The data is obtained through incident and road condition detection equipment.

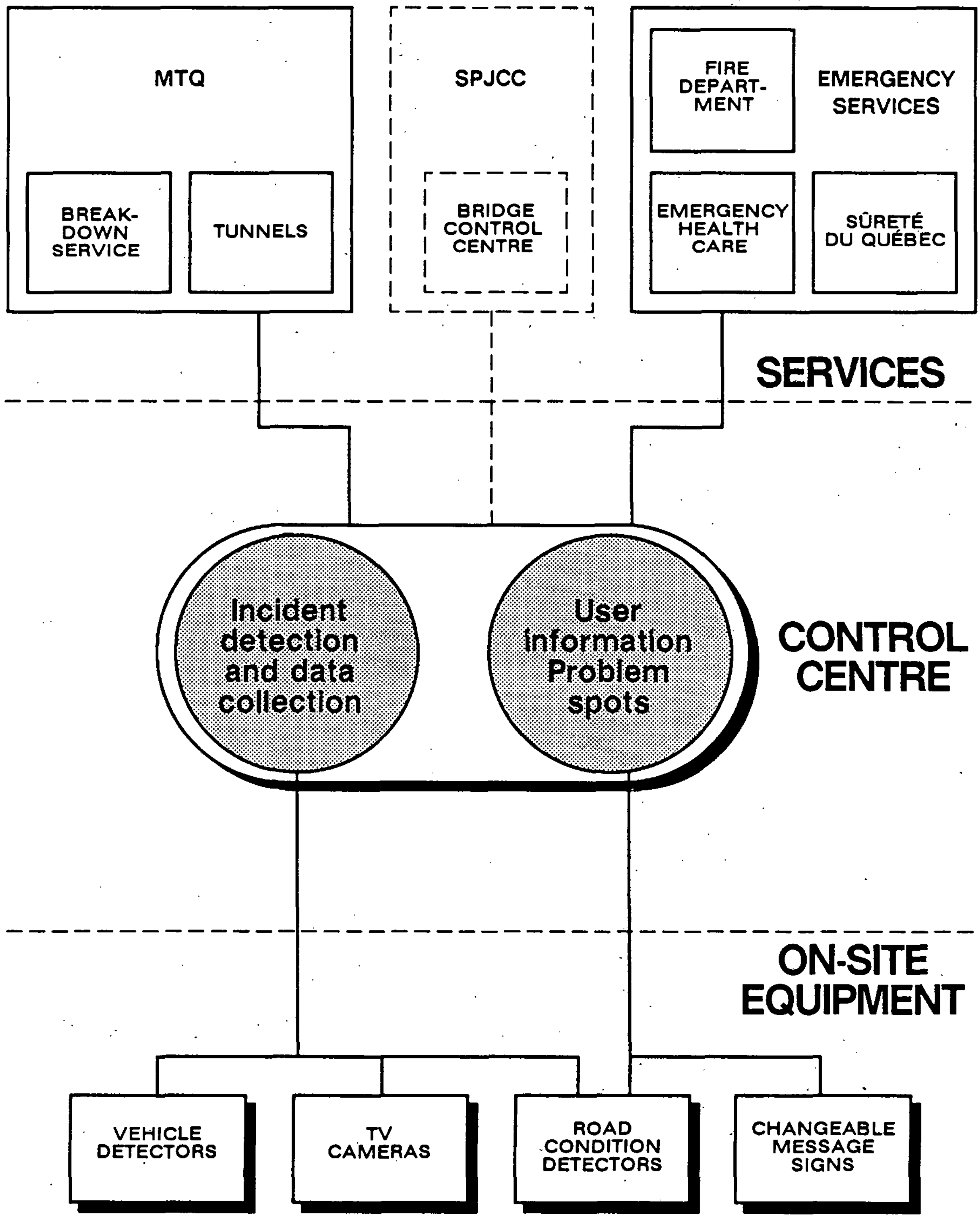
With the communications network, data is transmitted from on-site equipment to the control centre and messages and signals are sent from the control centre to the user information equipment. This network consists essentially of fibre optic cables between pieces of equipment and telephone links between services.

The MTQ is responsible for the traffic management system, operating it 24 hours a day, seven days a week.

The system operates with support services, maintenance teams and traffic analysts. There are a dozen people on the staff, preferably located at the control centre.

FIGURE 2.2

DIAGRAM OF THE RECOMMENDED SYSTEM



2.3.2 Pilot projects

It is more difficult to be sure of the benefits of ramp metering and diversion techniques within the framework of this study. These techniques will therefore be tested on site through specific pilot projects on the Métropolitaine expressway.

Access ramp control

Access ramp control is a method of limiting the congestion which results when traffic demand exceeds freeway capacity. Improved flow can be obtained if the excess demand can be held back on the access ramps.

This metering is accomplished using traffic lights that control the entrance of vehicles onto the expressway in order to restrict traffic flow towards the congested sections. Traffic flow on the expressway is thus optimized during periods of congestion.

This pilot project will be carried out only on the seven ramps of the Métropolitaine expressway that have the greatest potential for applying this technique.

Ramp diversion

Diversion is a method of directing motorists to another ramp downstream of the incident causing congestion on the expressway.

This pilot project will be carried out only on the Métroplitain expressway, on all its ramps.

2.3.3 Expected results

The system should result in fewer accidents and, therefore, greater user safety. It should also reduce waiting time following an incident and, consequently, total travel time and fuel consumption.

These three points have a direct impact on the community and on the quality of life. The first result is, of course, greater user comfort; accident reduction also has a direct beneficial effect on the need for emergency services and on overcrowding in hospital emergency units.

The cutback in waiting time results, for the user, in a better use of time, and in increased profitability for road transportation, resulting in a drop in costs.

Reduced fuel consumption has a major impact on urban pollution, which is becoming increasingly intolerable, and on our dependence on fossil fuels.

These three points were evaluated in terms of dollars using a set of hypotheses for each technique and each section of corridor. Each case evaluated thus has a range of benefits. The results given here correspond to the most conservative hypotheses for peak periods on working days.

As shown in Table 2.6, the freeway traffic management system will generate annual savings of $8 million, that is, $1 million due to the reduction in accidents and $7 million in fuel savings. If the time saved is evaluated at one dollar an hour for motorists, representing 90 percent of the traffic, and $22 an hour for truck drivers, representing 10 percent of the traffic, $6.9 million are saved, for a total of about $15 million.

Even though the economic argument is a powerful one, there are other very important benefits, in terms of quality, that are more easily perceived, such as better management of the MTQ's expressway network, user satisfaction with smoothly flowing traffic and reliable information on traffic conditions, and less air and noise pollution.

2.3.4 Cost of the system

The capital investment required to implement the management system is $19.9 million, including $16.6 million for equipment and $3.3 million for engineering and start-up operations.

In decreasing order of importance, equipment will cost $5 million for the Métropolitaine expressway, $4 million for the control centre, $3.1 million for the A-25 expressway, $2 million for the Décarie expressway and $1.2 million for the Ville-Marie expressway.

Before any investment is made in additional traffic management techniques, the benefits of which are more difficult to quantify, two pilot projects, one for metering on seven ramps and one for traffic diversion on all ramps of the Métropolitaine expressway, at a cost of $1.5 million, will be carried out to determine whether these techniques would be profitable.

The cost of the recommended system is shown in Figure 2.3.

2.3.5 Implementing the system

All aspects of the project will be dealt with simultaneously in order to gain time. All activities will therefore start at the same time. The control centre, the mainframe and the civil engineering work should be in place within two years.

System design and installation, including communications, incident detection, data collection and user information, will be spread over three years.

At the same time, software will be developed and perfected, again over a three-year period, since this activity will depend on the other activities.

The last aspect, and the most delicate, will be the start-up, including system integration and the training of operations personnel, which will begin in the third year and end in the fourth. This aspect will also include testing and system evaluation.

Implementation and start-up will take four years.

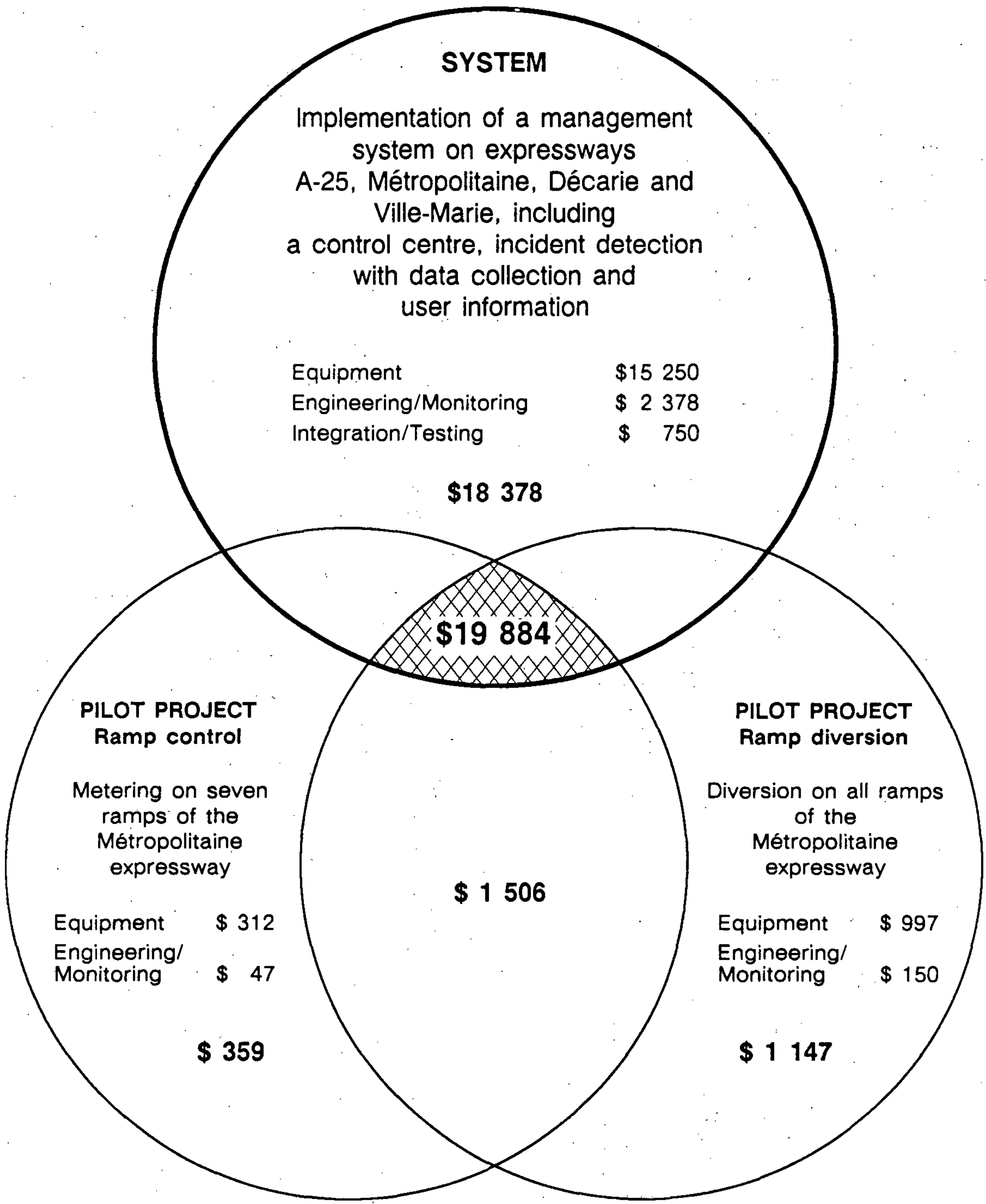
TABLE 2.6

ANNUAL SAVINGS
(x $1 000)

TECHNIQUE	ASPECT	EXPRESSWAY				TOTAL
		A-25	MÉTROPOLITAINE	DÉCARIE	VILLE-MARIE	
Incident detection and data collection	Accidents	20	220	60	20	320
	Delays	720	4 180	1 590	30	6 520
	Fuel	680	3 850	1 960	40	6 530
TOTAL		**1 420**	**8 250**	**3 610**	**90**	**13 370**
User information at problem spots	Accidents	50	430	120	50	650
	Delays	40	200	90		330
	Fuel	50	270	170		490
TOTAL		**140**	**900**	**380**	**50**	**1 470**

FIGURE 2.3

TOTAL COST OF RECOMMENDED SYSTEM
(x $1 000)



2.3.6 Conclusion

Traffic conditions on this Montreal expressway corridor are such that improvements are essential. The implementation of a well-designed, properly installed traffic management system will provide a partial solution.

The implementation of the system will not increase corridor capacity or solve all Montreal's expressway traffic problems. It will improve traffic conditions, making them more acceptable to users.

At present, 6.5 million hours and 51 million litres of fuel are wasted each year, because of incidents on the expressway. With a traffic management system, 2.2 million hours and 13.2 million litres of fuel can be saved.

Economically speaking, an initial investment of $19.9 million will result in an annual saving of $15 million ($1 million saved due to a reduction in accidents, $6.9 million saved in time and $7 million saved in fuel). This does not include benefits that are more difficult to quantify, such as the improved management of the MTQ's expressway corridor and a reduction in pollution and in user stress. We therefore recommend the implementation of the system described in this chapter.

Section 3

BONAVENTURE/CHAMPLAIN BRIDGE CORRIDOR

BONAVENTURE/CHAMPLAIN BRIDGE CORRIDOR

This section deals exclusively with the evaluation of the benefits, the selection of strategies, the costs, the implementation timetable, and the recommendations and conclusions for the Bonaventure/Champlain bridge corridor.

The current situation and the possible strategies are summarized for both corridors (A-25/Métropolitaine/Décarie/Ville-Marie and Bonaventure/Champlain bridge) in Section 1. The evaluation methods and implementation process are the same for both corridors and are described in detail in Section 2 (dealing with the recommendations and conclusions for the A-25/Métropolitaine/Décarie/Ville-Marie corridor). They will not be repeated in this section.

3.1 EVALUATION OF BENEFITS

The benefits were evaluated in two stages: the various strategies proposed during the first phases of the project were evaluated quantitatively and the benefits that were not quantifiable were evaluated qualitatively.

3.1.1 Quantitative evaluation

Three types of quantifiable benefits were evaluated:

- reduction in vehicle-hour delay following an incident;
- reduction in annual number of accidents;
- reduction in fuel consumption.

These benefits were selected because they represent the main quantifiable advantages that can be obtained following the implementation of a traffic management system, and the data available makes such an evaluation possible. Moreover, using the European and North American experience, it is possible to establish hypotheses and potential profit margins for each benefit and each strategy.

The results, given in Table 3.1, summarize the evaluation of annual benefits by strategy and by section of freeway.

The main benefit derived from controlling the merging of highway 132 and the Champlain bridge is that of equity of access to the bridge ramp for users arriving from the east or the west on highway 132. Since this strategy is low-cost, it is worth implementing.

At the other end of the Champlain bridge, controlling the southbound section of the toll plaza presents interesting advantages, whereas the installation of removable barriers on the reserved lane of the bridge would be less advantageous.

TABLE 3.1

SUMMARY OF EVALUATION OF ANNUAL BENEFITS BONAVENTURE/CHAMPLAIN BRIDGE CORRIDOR

STRATEGY	EXPRESSWAY (BENEFITS IN THOUSANDS OF DOLLARS)			
	Bonaventure		Champlain	
	Minimum	Maximum	Minimum	Maximum
1. Incident management	58	125	432	787
2. Ramp metering	(1)		(1)	
3. Changeable messages (on ramps)	(1)		(1)	
4. Changeable messages (problem spots)	39	83	159	383
5. Lane metering	4	39	46	202
6. Merge control on A-132 ramps (Champlain bridge)	(1)		(2)	
7. Toll booth control (Champlain bridge)	(1)		667	909
8. Removable barriers (Champlain bridge)	(1)		123	137
9. Bonaventure/Ville-Marie diversion	138	213	(1)	

(1) This strategy has not been evaluated for this expressway:

(2) This strategy can be quantified, using the methodology developed, but the data required are not available.

The benefits of the expressway to expressway diversion strategy are small for the Bonaventure/ Ville-Marie sections, as are those of the other strategies for these sections.

3.1.2 Qualitative evaluation

Table 3.2 gives a summary of the qualitative analysis of the strategies. The most promising are:

- controlling the toll booths on the Champlain bridge;
- changeable message signs to warn users of problem spots (including the ice detection system);
- controlling merging on the access ramps (southern approaches to the Champlain bridge and highway 132);
- traffic diversion between Ville-Marie and Bonaventure expressways.

This evaluation identifies the strategies which would entail certain risks.

3.1.3 Selection of strategies

Table 3.3 summarizes the global evaluation of the strategies in terms of capital expenditures, benefit/cost ratios and risk.

Incident management

Since the benefit/cost ratios on the Bonaventure expressway are lower than on the other sections studied, incident management was not selected for this section. It is an advantageous strategy for the Champlain bridge, however, where it represents a capital expenditure of about $1.1 million.

Changeable message signing

This strategy is not justified on the Bonaventure expressway, because of the low benefit/cost ratios. CMS should be used only on the Champlain bridge upstream of all problem points. Capital expenditures for this strategy will amount to about $300 000.

From a strictly technical point of view, and in order to be consistent with our evaluation method, the incident management and CMS strategies were not selected for the Bonaventure expressway. From a wider point of view, however, taking into account more general qualitative benefits such as expressway to expressway diversion, smooth integration and standardization with the Champlain bridge, and the users' need for information, these strategies could be justified by the authorities of the SPJCC, on the basis of other criteria or for political reasons.

TABLE 3.2

SUMMARY OF QUALITATIVE ANALYSIS OF STRATEGIES
BONAVENTURE/CHAMPLAIN BRIDGE CORRIDOR

STRATEGY	EVALUATION CRITERIA								
	Potential for reducing recurring congestion	Potential for reducing non-recurring congestion	Potential for reducing technical risks	Acceptability by different levels of government	Ease of implementation	Potential for public awareness of system's existence	Potential for indirect effects (technological trends, technology transfers, local economy, etc.)	Probability of obtaining expected benefits	Overall assessment
1. Incident management (including data management)	0	5	5	5	5	0	5	5	30
2. Changeable message signs at problem spots (including ice detection system)	0	5	5	5	5	5	5	3	33
3. Merge control on access ramps (southern approaches to the Champlain bridge - highway 132)	5	0	5	5	5	5	3	3	31
4. Toll booth control on the Champlain bridge	5	5	5	5	3	5	5	3	36
5. Removable barriers for the reserved lane on the Champlain bridge	5	5	2	5	0	5	3	5	30
6. Traffic diversion between the Ville-Marie and Bonaventure expressways	0	5	5	3	5	5	5	3	31

Legend: 0 = small impact 5 = major impact

TABLE 3.3

GLOBAL EVALUATION OF STRATEGIES

STRATEGY	EXPRESSWAY / EVALUATION CRITERIA	Bonaventure	Champlain bridge	TOTAL	Comments
1. Incident management (including data management) (4)	Capital expenditures (1) Benefit/cost (2) Risk (3)	$1.7 0.1 – 0.4 low	$1.1 2.2 – 4.1 low	$2.8 1.0 – 1.8 low	● High benefit/cost ratios ● Low risk factors ● Basic system for other strategies
2. Access ramp diversion	Capital expenditures (1) Benefit/cost (2) Risk (3)	$0.3 not quantifiable high	$0.03 not applicable	$0.3 not applicable high	● Changeable benefit/cost ratios ● High risk factors ● Implementation by stages is recommended
3. Changeable message signing at problem spots	Capital expenditures (1) Benefit/cost (2) Risk (3)	$0.9 0.2 – 0.5 low	$0.3 2.7 – 6.5 low	$1.3 0.9 – 2.0 low	● High benefit/cost ratios ● Low risk factors ● Required to inform corridor users
4. Lane control	Capital expenditures (1) Benefit/cost (2) Risk (3)	$1.1 0.0 – 0.2 high	$1.0 0.3 – 1.1 high	$2.1 0.1 – 0.6 high	● Low benefit/cost ratios ● High risk factors ● No additional implementation recommended
5. Merge control on access ramps (southern approaches to the Champlain bridge – highway 132)	Capital expenditures (1) Benefit/cost (2) Risk (3)	not applicable	$0.5 not available low	$0.5 not available low	● Low costs ● Low risk factors ● Recommended on the basis of the qualitative evaluation
6. Toll booth control on Champlain bridge	Capital expenditures (1) Benefit/cost (2) Risk (3)	not applicable	$0.2 15.6 – 21.3 low	$0.2 16.6 – 21.3 low	● Low costs ● Low risk factors ● High benefit/cost ratios ● Recommended for southbound lanes during evening rush hours
7. Removable barriers for the reserved lane on the Champlain bridge	Capital expenditures (1) Benefit/cost (2) Risk (3)	not applicable	$8.6 0.07 – 0.08 low	$8.6 0.07 – 0.08 low	● High costs ● Undetermined risk factors ● Low benefit/cost ratios ● Rejected
8. Diversion between Ville-Marie and Bonaventure expressways	Capital expenditures (1) Benefit/cost (2) Risk (3)	$0.6 1.2 – 1.9 low	not applicable	$0.6 1.2 – 1.9 low	● Low costs ● Low risk factors ● High benefit/cost ratios ● Rejected

LEGEND

[shaded box] recommended system

NOTES

(1) In millions of 1987 dollars, excluding engineering, management, monitoring and integration.

(2) Discounted on the life expectancy of the project.

(3) Global evaluation equal to or greater than 75 percent – low risk factor (see qualitative evaluation – chapter 6); global evaluation less than 75 percent – high risk factor.

(4) Costs include control centre costs in proportion to the length of each section of expressway.

Merge control on access ramps (southern approaches to the Champlain bridge-highway 132)

This strategy optimizes the entrance onto the Champlain bridge of eastbound and westbound traffic from highway 132. Since capital expenditures and risk are both low, this strategy is advantageous. The cooperation of motorists in respecting the new signs is an unknown factor. The cost of implementing the strategy is about $500 000.

Toll booth control on the Champlain bridge

This strategy optimizes the entrance of southbound traffic at the Champlain bridge toll booths during evening rush hours. Since the risk and the capital expenditures (about $200 000) are both low, and the benefit/cost ratio is high, this strategy should be considered in the framework of a traffic management system for the corridor.

Removable barriers for the reserved lane of the Champlain bridge

A system of removable barriers for the reserved lane of the Champlain bridge would require a large outlay of about $8.6 million. Moreover, the benefit/cost ratio would be low and the system has not been studied under local weather conditions. Nor has the technical feasibility of this strategy been proven. For these reasons, a system of removable barriers was rejected.

Traffic diversion between the Ville-Marie and Bonaventure expressways

Diverting traffic between the Ville-Marie and Bonaventure expressways will not cost much if the equipment used for related strategies is already in place. Since no strategy is recommended for the Bonaventure expressway, the application of this strategy within the framework of a freeway traffic management system is not recommended.

3.1.4 Recommended strategies to be implemented

In short, the installations given priority include an incident management system with data management, and a changeable message signing system warning of trouble spots (with an ice detection subsystem) for the Champlain bridge. Specific systems for certain points on the corridor would be added to these, such as a system for controlling the merging on the access ramps at the southern approaches to the Champlain bridge (highway 132) and a system for controlling the Champlain bridge toll booths.

If the results of the pilot projects to be carried out on the A-25/Métropolitaine/Décarie/Ville-Marie corridor are promising, diversion to the access ramps on the Bonaventure expressway could be considered. The system of removable barriers for the reserved lane on the Champlain bridge is rejected. If, for security reasons (head-on collisions), the SPJCC should decide to adopt this solution, safety and operation tests would have to be carried out in winter conditions before implementation.

The investment required to implement the system configurations proposed for the Bonaventure/ Champlain bridge corridor amounts to $2.6 million and is shown in Table 3.4.

TABLE 3.4

COSTS
BONAVENTURE/CHAMPLAIN BRIDGE CORRIDOR
(x $1 000)

STRATEGY	COST
Incident and data management	1 100
Changeable message signing	330
Controlling the toll booths and the access ramps from highway 132	770
Total equipment	2 200
Engineering, integration and management	400
TOTAL	**2 600**

3.2 IMPLEMENTATION PLAN

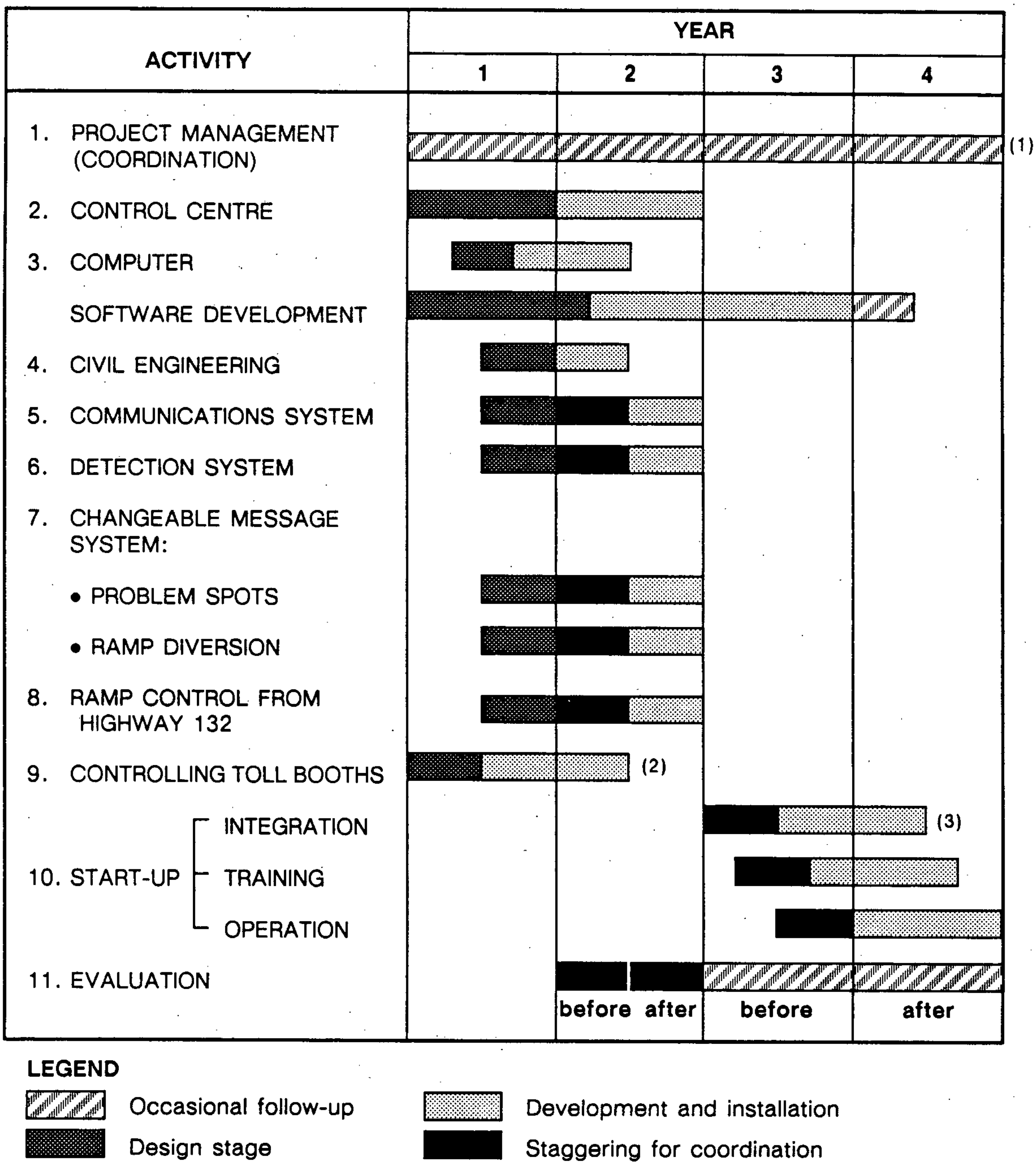
3.2.1 Timetable

All work is staggered to allow for the road repairs program, installation priorities, coordination of the installation of the system components, and time limits. The timetable for work on the Bonaventure/Champlain bridge corridor is shown in Figure 3.1.

The timetable should follow the same order as that established for the work on the A-25/Métropolitaine/Décarie/Ville-Marie corridor, but the Bonaventure/Champlain bridge corridor management system does have one peculiarity: the monitoring system and the system for controlling the toll booths are under the authority of the SPJCC. All the implementation steps will thus be the responsibility of this agency and integration will be based at its control centre. The timetable for this work may therefore be considered independent. The installation of interfaces between the two control centres is nevertheless included in the "communications system" step for the A-25/Métropolitaine/ Décarie/Ville-Marie corridor, but may be pushed back to fit in with the implementation period foreseen by the SPJCC.

FIGURE 3.1

TIMETABLE FOR IMPLEMENTATION ON THE BONAVENTURE/CHAMPLAIN BRIDGE CORRIDOR



NOTES

(1) Coordination of work in two corridors.
(2) Operable by the SPJCC as soon as completed.
(3) Coordinated if possible with the work on the A-25/Métropolitaine/Décarie/Ville-Marie corridor.

3.2.2 Costs

It would seem that the traffic management strategies will be profitable only on the Champlain bridge section of the Bonaventure/Champlain bridge corridor. The installation of an incident management system, changeable message signs warning of trouble spots, and a system to control merging on the access ramps at the southern approaches to the bridge are proposed. Total capital expenditures and engineering costs will amount to about $2.6 million as indicated in Table 3.4. This work is not expected to generate additional management or integration costs if carried out simultaneously with work on the A-25/Métropolitaine/Décarie/Ville-Marie corridor.

3.3 CONCLUSION AND RECOMMENDATIONS

The recommended system applies only to the Champlain bridge and consists of those techniques that offer the best benefit/cost ratio, namely:

- incident and data management;
- changeable message signs to warn users of dangerous spots, difficult traffic conditions and road conditions;
- controlling the Champlain bridge toll booths;
- controlling the merging from highway 132 on the approaches to the Champlain bridge.

The corridor traffic management system is under the responsibility of the SPJCC, but to coordinate the system on the two corridors, in the interests of efficiency, there will be an interface between the SPJCC and the MTQ control centres.

3.3.1 Expected results

The system should result in fewer accidents and therefore greater user safety. It should also reduce waiting time following an incident and, therefore, total trip time, resulting in a reduction in fuel consumption.

These three aspects were evaluated in dollar terms on the basis of a set of hypotheses for each technique and each section of corridor. Each case evaluated thus has a range of benefits. The results given here correspond to the most conservative hypotheses for peak periods on working days.

The bridge traffic management system will generate savings amounting to $1.0 million annually, that is, $600 000 due to the reduction in accidents and $423 000 in fuel saved. If the time saved is evaluated at one dollar an hour for motorists, representing 90 percent of the traffic, and $22 an hour for truckers, representing 10 percent of the traffic, $395 000 are saved, for a total of about $1.4 million.

Even though the economic argument is a powerful one, there are other very important benefits, in terms of quality, that are more easily perceived, such as better management of the Champlain bridge, user satisfaction with smoothly flowing traffic and reliable information on traffic conditions, and less pollution.

3.3.2 Cost of system and implementation

The capital investment for implementing the management system on the bridge is $2.6 million, including $2.2 million for equipment and $400 000 for engineering works and start-up operations.

If the system is implemented simultaneously in both corridors, there will be no additional costs. However, the techniques for the Bonaventure/Champlain bridge corridor can be carried out at a time determined by the SPJCC. In either case, it will require four years to execute all the work.

3.3.3 Conclusion

It must be understood that the implementation of this system will not increase the capacity of the bridge or solve all the congestion problems. However, it will result in an improvement in traffic flow, making traffic conditions more tolerable for the user. For an investment of $2.6 million, the system will generate annual savings of $1.4 million owing to the reduction in accidents and the time and fuel saved.

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Appendix A

CURRENT AND PROJECTED WORK IN THE BONAVENTURE/CHAMPLAIN BRIDGE CORRIDOR

TRANSLATION

The Jacques Cartier and
Champlain Bridges Incorporated
1000 de Sérigny
Suite 630
Longueuil, Quebec
J4K 5B1
Tel: (514) 651-8771

File No: 92-109-1-1
91-4/2

April 25, 1988

Government of Quebec
Department of Transport
255 Crémazie Blvd. East
Montreal, Quebec
H2M 1L5

Att: Jean-Claude Larrivée, Eng.
Engineering Branch

Subject: **Road Safety Program**
Champlain Bridge – Bonaventure Autoroute

Dear Sir:

As requested at our meeting of April 21, 1988, this is to provide you with a list of projects to be carried out during the 1988-89 fiscal year on the Champlain Bridge and Bonaventure Autoroute under the safety program.

- Installation of chevron markers on dangerous curves.
- Installation of anti-skid pavement on the Atwater and Bonaventure curves.
- Installation of lane use control signals on the Champlain Bridge.
- Installation of closed-circuit cameras on the Champlain Bridge.

We also intend to install variable message signs on the Atwater curve depending on the results of the trial we are currently conducting on the Jacques Cartier Bridge (Craig curve).

We trust that this information will be useful. Please feel free to contact us if you require any further details.

Yours truly,

(signed)
Michel L. Lesage, Eng.
General Manager

cc: O. Galella
A. McDougall

Appendix B

LIST OF TECHNICAL REPORTS PREPARED IN THE COURSE OF THIS STUDY

Rapport de l'étape 1, Évaluation des problèmes de circulation, A-25/Métropolitaine/Décarie/Ville-Marie, March 1987, 230 p.

Rapport de missions techniques sur les systèmes opérationnels Canada-Europe, May 1987.

Rapport de l'étape 2, Élaboration de stratégies de gestion de circulation, A-25/Métropolitaine/Décarie/Ville-Marie, August 1987, 95 p.

Rapport de l'étape 1 de l'avenant no. 1, Évaluation des problèmes de circulation, Bonaventure/pont Champlain, October 1987, 70 p.

Rapport des étapes 3 & 4, Mise au point et évaluation des variantes de systèmes, A-25/Métropolitaine/Décarie/Ville-Marie/Bonaventure/pont Champlain, January 1988, 121 p., Appendices, 169 p.

Rapport de l'étape 5, Mise au point d'un plan d'implantation, A-25/Métropolitaine/Décarie/Ville-Marie/Bonaventure/pont Champlain, February 1988, 55 p.

Système de gestion de la circulation autoroutière — Région métropolitaine, March 1988, 18 p.

These documents may be consulted at the library of either the ministère des Transports du Québec or Transport Canada:

Centre de documentation
Transports Québec
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Contact: Mr. Donald Blais

Transportation Development Centre
Transport Canada
Guy Favreau Complex
200 René Lévesque Blvd. West
West Tower, Suite 601
Montreal, Quebec
H2Z 1X4

Contact: Mr. George Ekins