ATLANTIC

A Thematic Long-Term Approach to Networking for the Telematics & the ITS Community

A Partnership of ITS Communities in Europe and North America

SYNOPSIS
and Highlights of
DISCUSSION PAPER

NETWORK MONITORING AND TRAFFIC MANAGEMENT & CONTROL: STATE OF THE ART AND STATE OF THE PRACTICE IN CANADA

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In collaboration with Participating Partners and Sponsors

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Preface

ATLANTIC (A Thematic Long-term Approach to Networking for the Telematics and ITS Community) is an international cooperative undertaking that aims to foster information exchange and policy debate related to the application and development of intelligent transport systems (ITS). ATLANTIC originated as a project sponsored by the European Union under the 5th Research Framework with self-sustaining partners in Canada and the United States. ATLANTIC is organized into 8 work groups focused on different topics related to telematics and ITS. This document is the product of one of the Canadian work groups to benchmark and assess the state of ITS practice and research and development in Canada.

This document a summary or a synopsis of the full Work-Group 1.2 paper focused on network monitoring and integrated traffic control and management practice and research in Canada. It also includes emergency service systems as related to incident detection and diagnosis, as well as road weather and environment detection and information dissemination systems.

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The ATLANTIC Canada network node is sponsored by Transport Canada, Ministry of Transportation Ontario and Ministère des Transports du Québec and jointly managed by the ITS Centre and Testbed, University of Toronto and the Centre de recherché sur les transports, Université de Montréal. The core team providing overall leadership for ATLANTIC Canada includes Professor Baher Abdulhai (Toronto), Professor Teodor Gabriel Crainic (Montréal) and Dr. William Johnson (Ottawa).

The Canadian Work Group 1.2, Network Monitoring and Traffic Management & Control: State of the Art and State of the Practice in Canada, is jointly managed by Dr. Baher Abdulhai (leader) and Lina Kattan (rapporteur) of the University of Toronto. They provided the intellectual leadership and writing skills to assemble and document this discussion paper with inputs and contributions from a network of Work Group members. The names of Work Group 1.2 members and contributors appear in Annex A.

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Work Group 1.2:

Network Monitoring and Traffic Management and Control

Scope and Outline:

This document a summary or a synopsis of the full Work-Group 1.2 paper focused on network monitoring and integrated traffic control and management practice and research in Canada. It also includes emergency service systems as related to incident detection and diagnosis, as well as road weather and environment detection and information dissemination systems. Therefore, the objective of the full paper which is summarized in this synopsis is to identify the state-of-the practice as well as the state-of-the-art of ITS activities related to this theme in Canada in Canada and to assist in identifying opportunities and priorities for future R&D programs. At attempt is also made to compare activities in Canada to the international community in a non-exhaustive fashion, i.e. focusing only on what could be called "clearly critical and missing". The paper contents and discussions consider i) Systems & Technology, ii) Models and iii) Policy. For readers interested in details, this synopsis is insufficient and they are referred to the full paper.

In this effort, we divide Canada into three regions, namely: the province of Ontario, the Province of Quebec and the rest of Canada. The Work Group conducted a survey of various Network Monitoring and Traffic Management and Control practices in the Canadian provinces showing selected examples of such practices based on publicly available information. It also reviewed available information on the related state-of-the-art research conducted in Canadian Universities and research centers.

The discussion paper is organized in two parts: Part I describes the state of the practices while part II describes the state of the art. International comparisons are briefly introduced at the end. Chapter 1 provides a general overview of the scope of the discussion paper, the nature and structure of the subject area and the types of sub-themes that will be explored. In Part I, Chapters 2, 3 and 4 review practices in respectively the Provinces of Ontario, Quebec and then the rest of Canada. Chapter 5 identifies the existing related research and development programs. Finally, comparisons, conclusions and recommendations are presented in Chapter 6. Although details are provided in the full paper, this synopsis provides a quick glance through the essentials, i.e. an executive summary.

Introduction

ITS provides monitoring, detection, response, control and administration functions in support of traffic management and control. The monitoring function covers traffic conditions, road conditions, as well as weather and environmental conditions. Traffic monitoring focuses on flow characteristics (speed, volume and occupancy), incidents, and vehicles at certain locations, such as traffic signals, interchange points on highways or at-grade rail crossings. Response capabilities include responding to emergency and hazardous material incidents and management of both planned and unexpected events. Control functions include traffic signals, ramp metering, traffic diversion, lane control and speed control.

Network Monitoring and Traffic Management and Control are crucial components needed for the success of any ITS sub-system. They contribute to alleviating traffic congestion and increasing safety by:

- Providing accurate and timely delay and road condition information to motorists;
- Allowing for the prompt detection of freeway incidents, road surface conditions and network emissions and subsequently the removal of vehicle breakdowns, snow and ice; and
- Effectively managing peak hour traffic flow through innovative traffic street and freeway control devices.

Analysis Structure

Work Group 1.2 discussion paper reviews all the above issues ranging from system architecture issues to integrated information and control strategies and techniques for network monitoring and emergency service systems. For information grouping and management, the discussion paper focuses on these three themes, namely, (i) Network Monitoring, (ii) Detection and Diagnosis and (iii) Traffic Management and Control.

Under each theme, discussion is further subdivided into sub-themes focusing on "Systems and Technologies", "Models" and "Policies". Information related to the above themes and sub-themes have been collected, summarized and discussed in an attempt to assess the Canadian state of development, opportunities for improvement, priorities for research and benchmark comparisons with ATLANTIC partners.

Figures 1.a & 1.b illustrate the framework, themes and sub-themes covered by WG1.2.

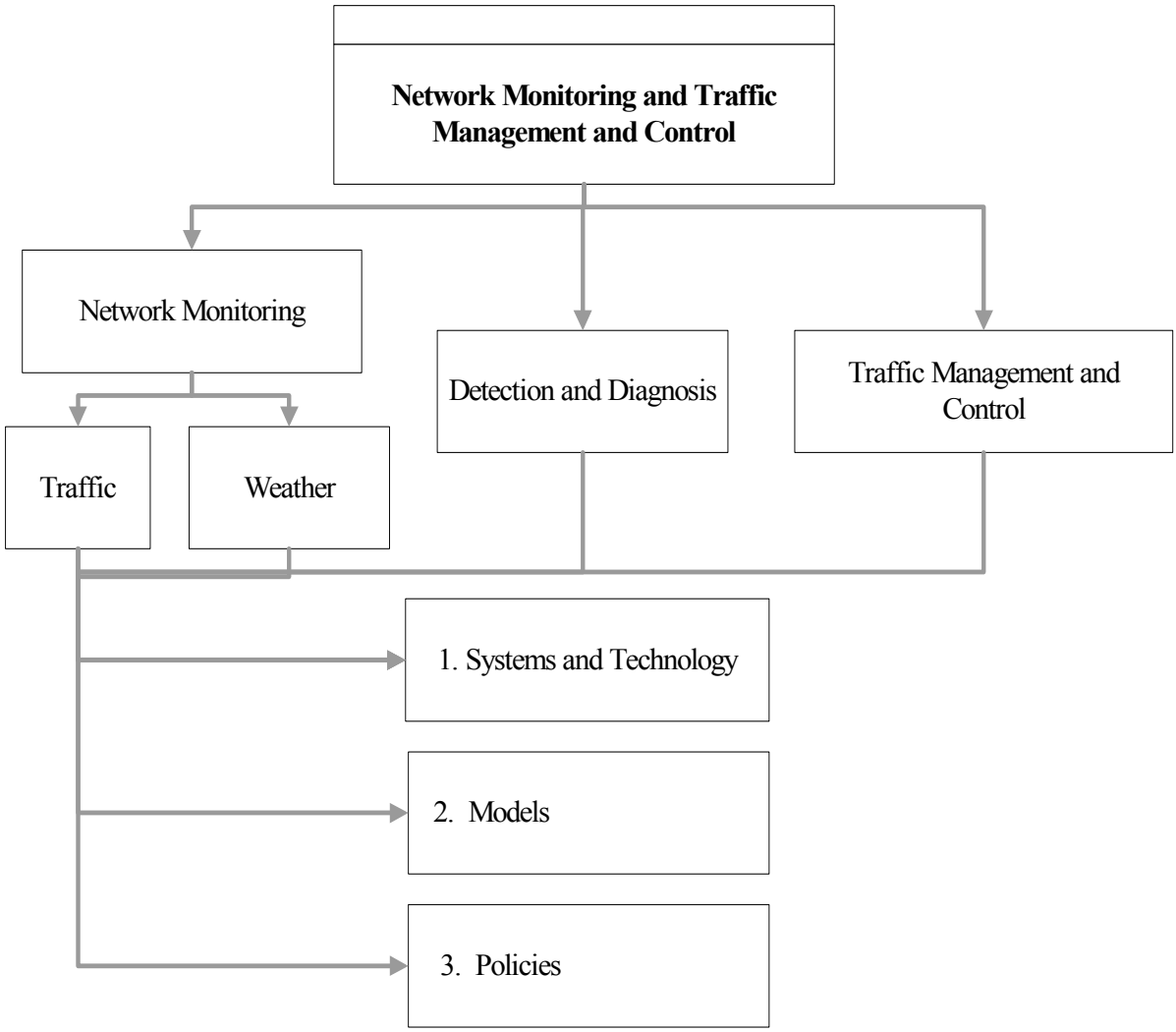
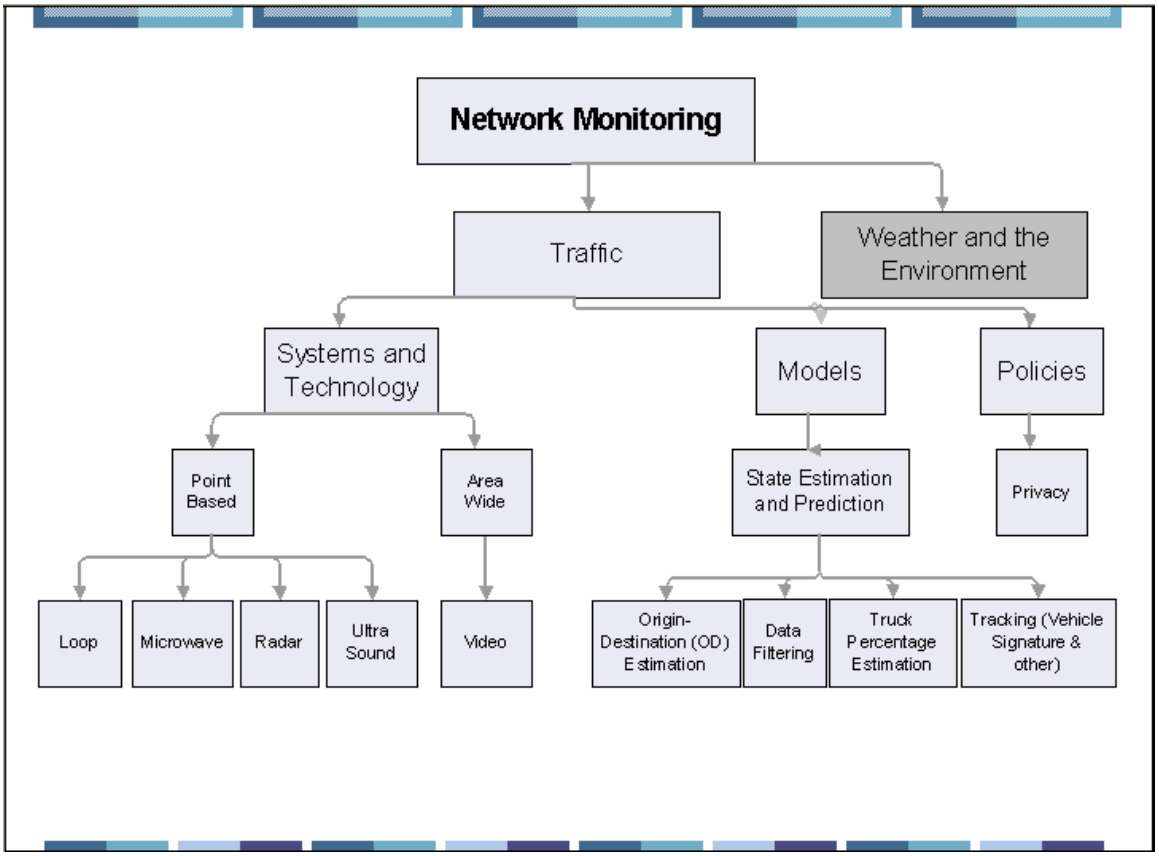


Figure 1.a Network Monitoring and Traffic Management and Control



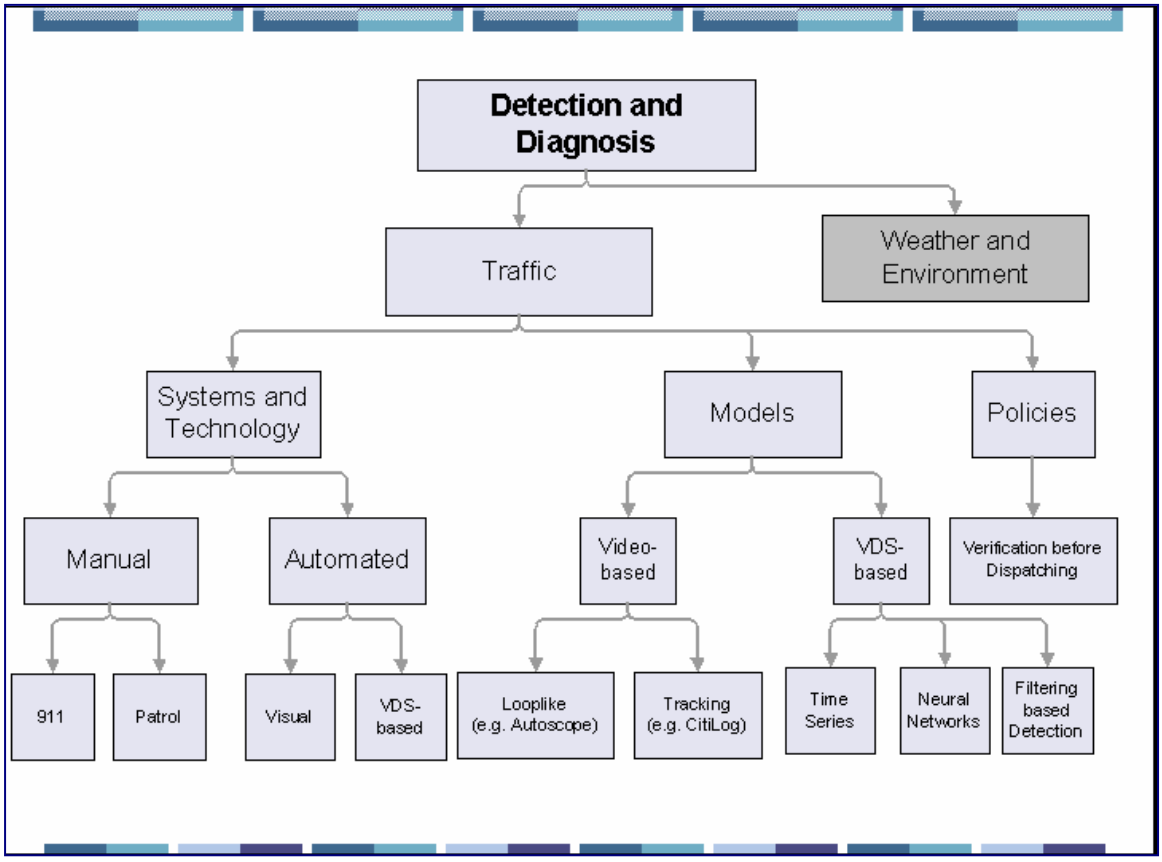
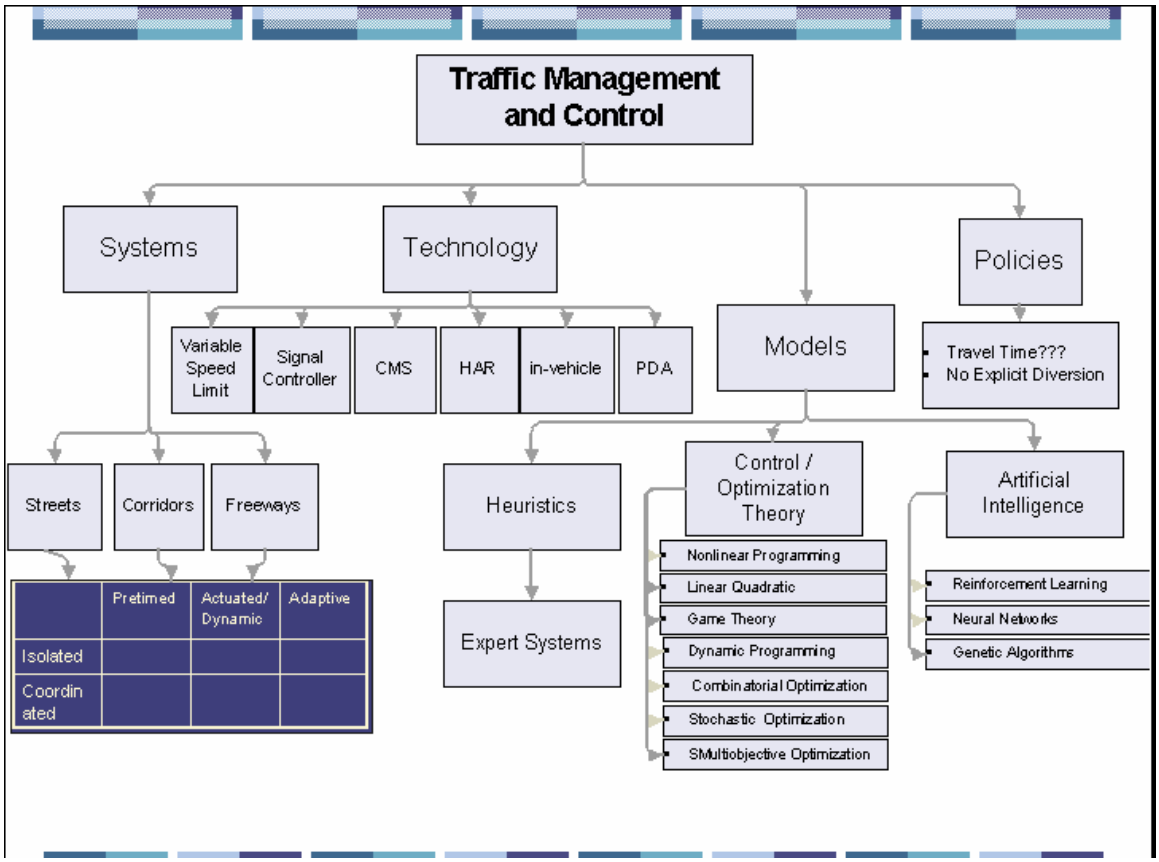


Figure 1.b. Themes and sub-themes of WG1.2 (Part I)



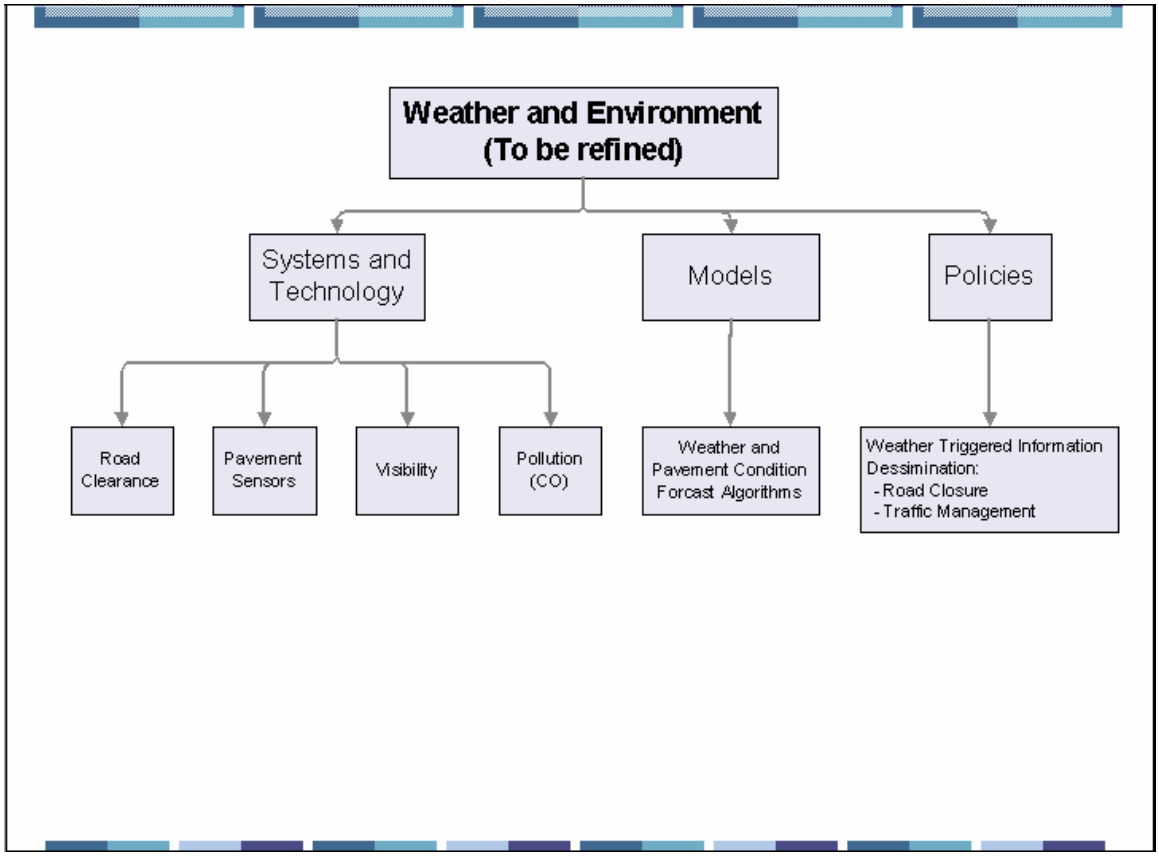


Figure 1.b Themes and sub-themes of WG1.2 (Part II)

Summary of the State of the Practice in Canada

Part I of the paper reviewed the state-of-the practice in the province of Ontario, Province of Quebec and the rest of Canada. The figures below highlight, for Ontario and Quebec, the systems and technologies, models and policies that are adopted in each. The highlighted parts of the figures summarize the adopted technology or systems, in contrast with the shaded parts, whereby such technologies or system are absent. Table 1 provides a side-by-side comparison of the three regions. Extensive details are provided in the full paper.

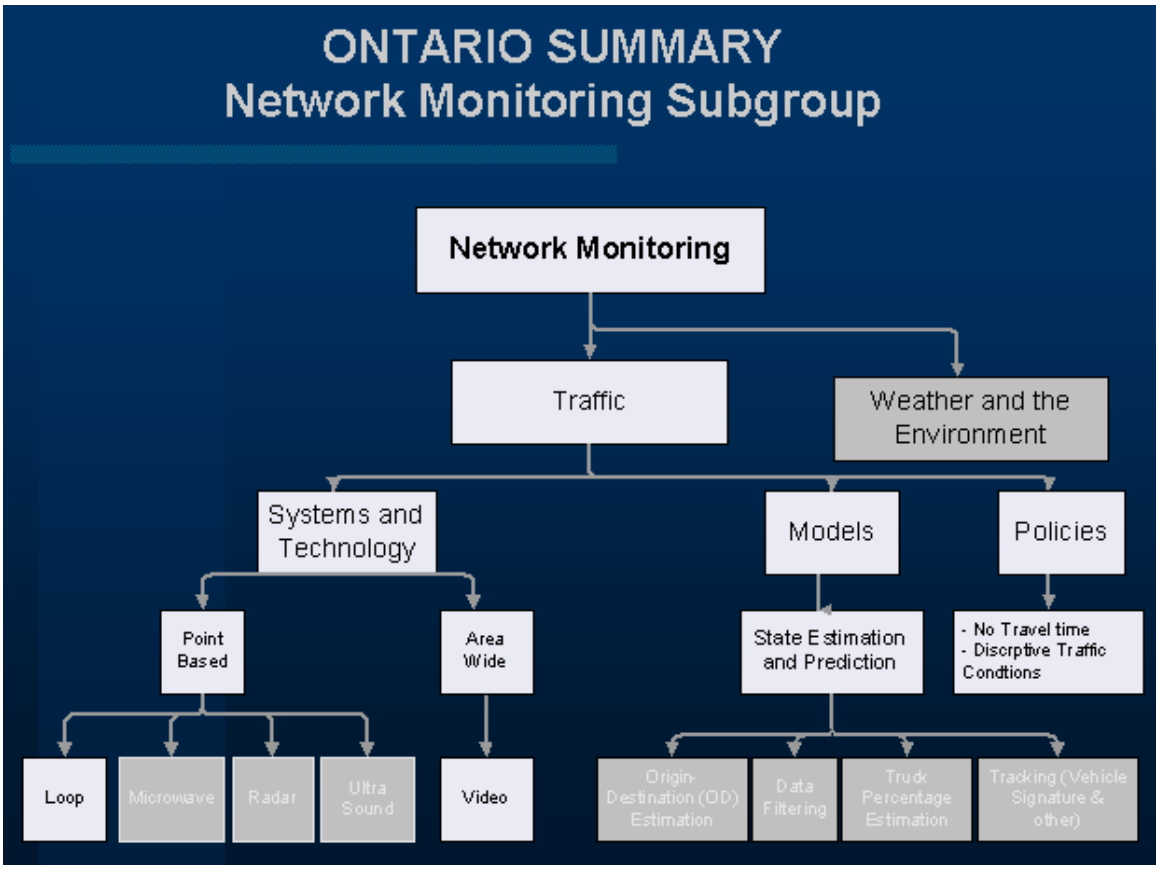


Figure 2 Ontario Summary: Network Monitoring Subgroup

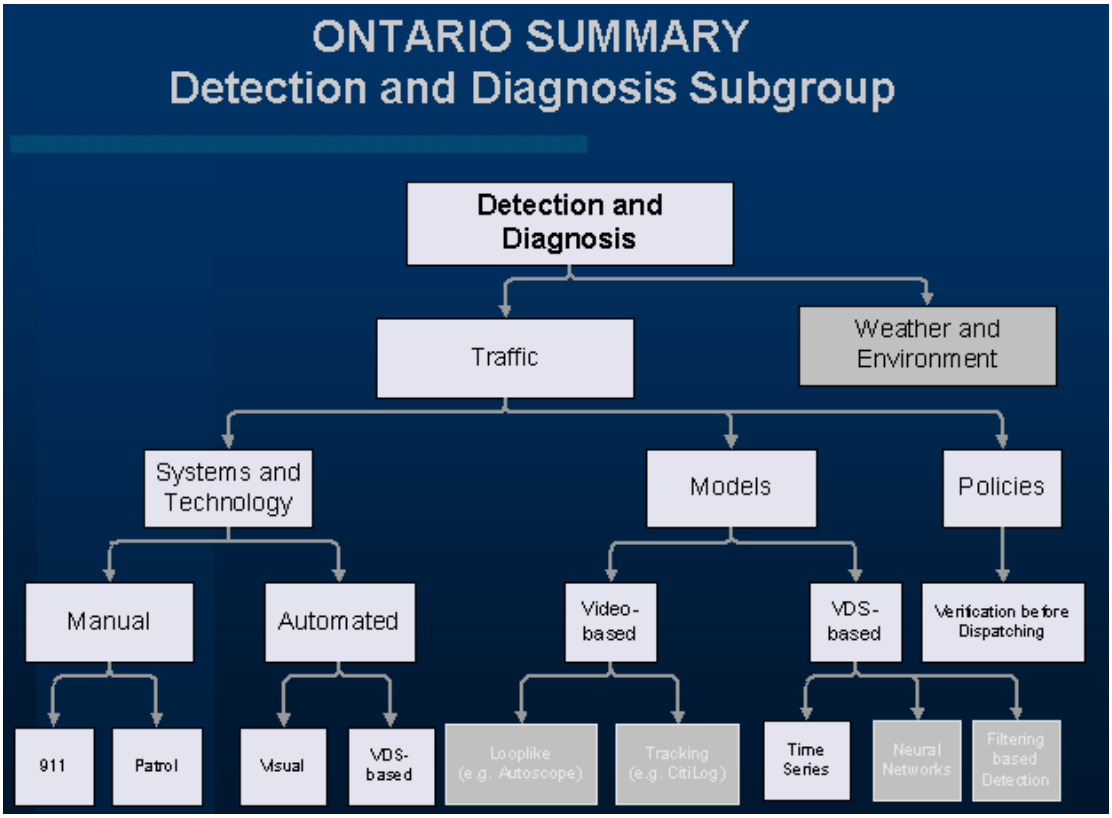


Figure 3 Ontario Summary: Detection and Diagnosis Subgroup

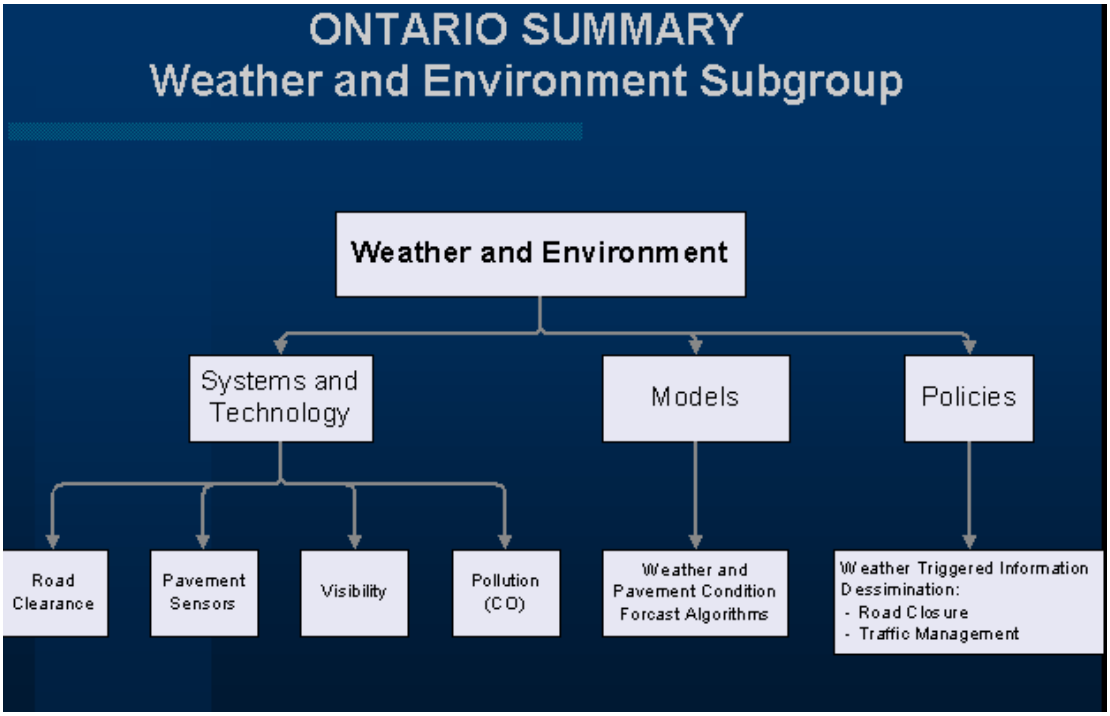


Figure 4 Ontario Summary: Weather and Environment Subgroup

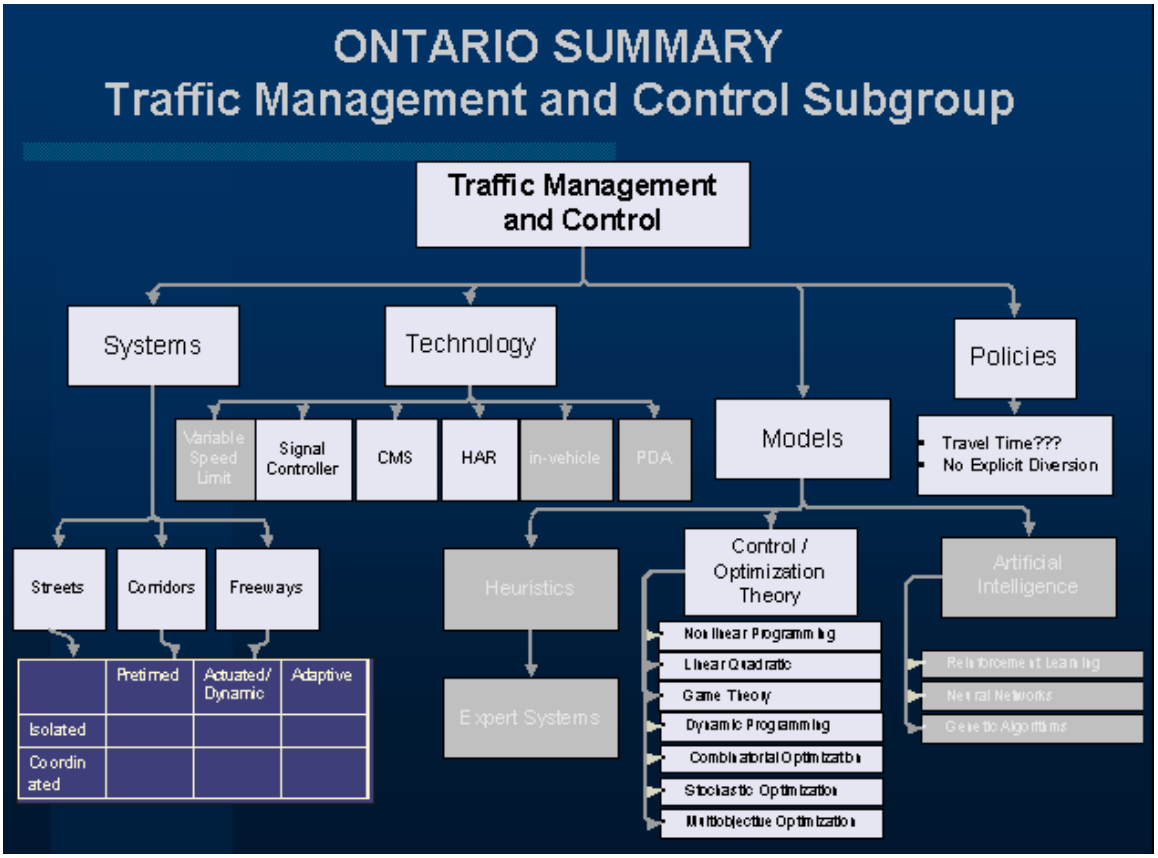


Figure 5 Ontario Summary: Traffic Management and Control Subgroup

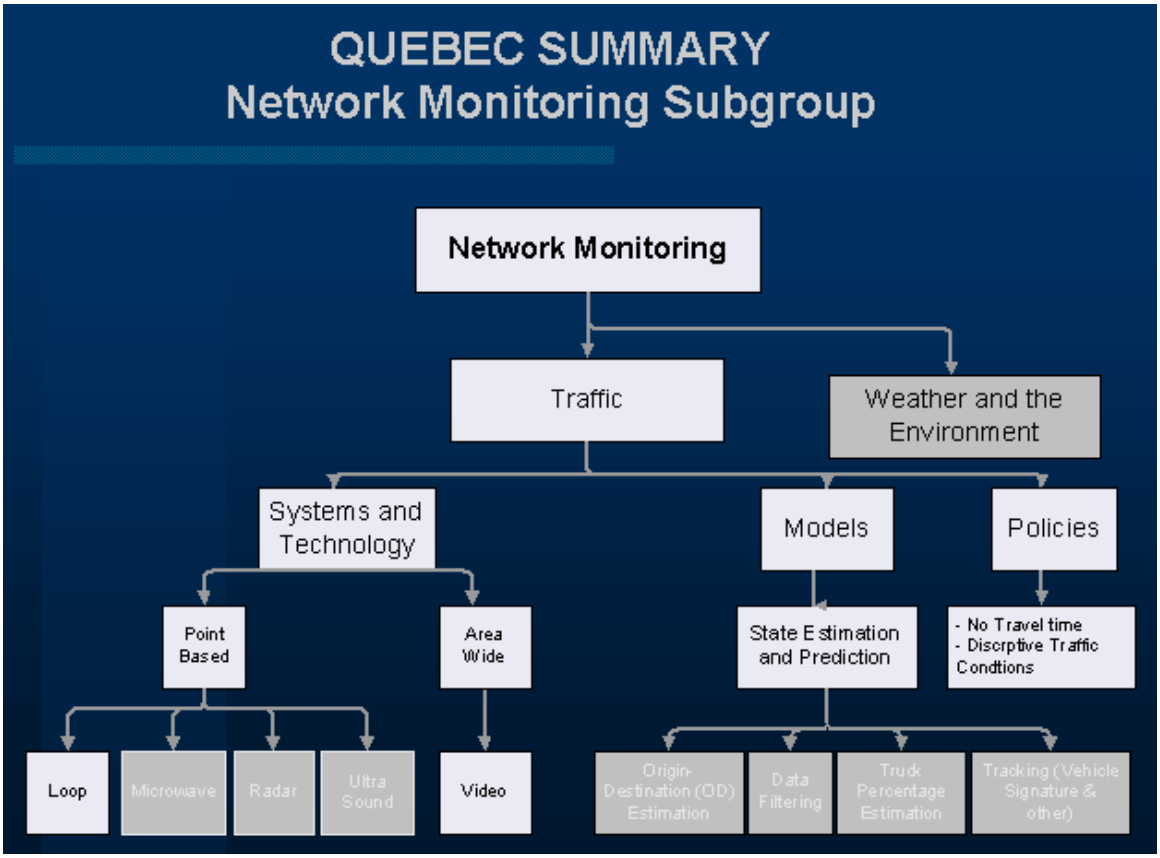


Figure 6 Quebec Summary: Network Monitoring Subgroup

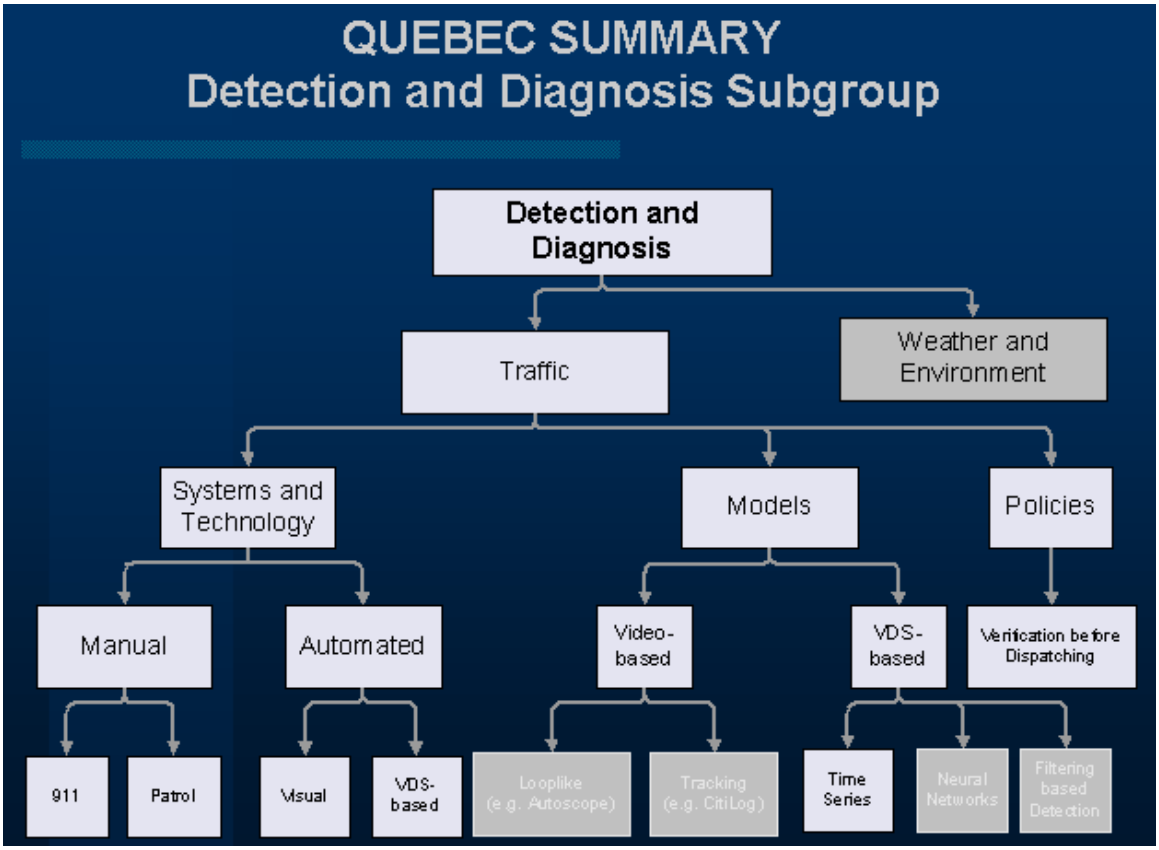


Figure 7 Quebec Summary: Detection and Diagnosis Subgroup

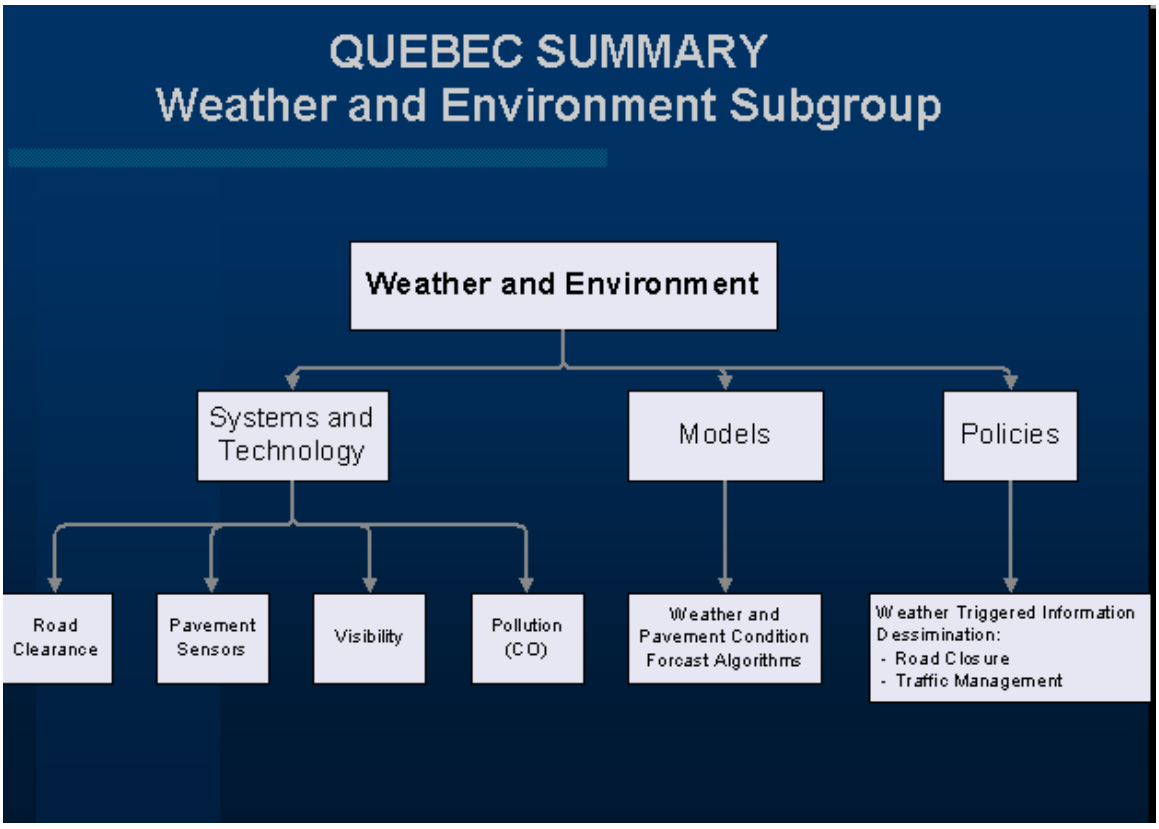


Figure 8 Quebec Summary: Weather and Environment Subgroup

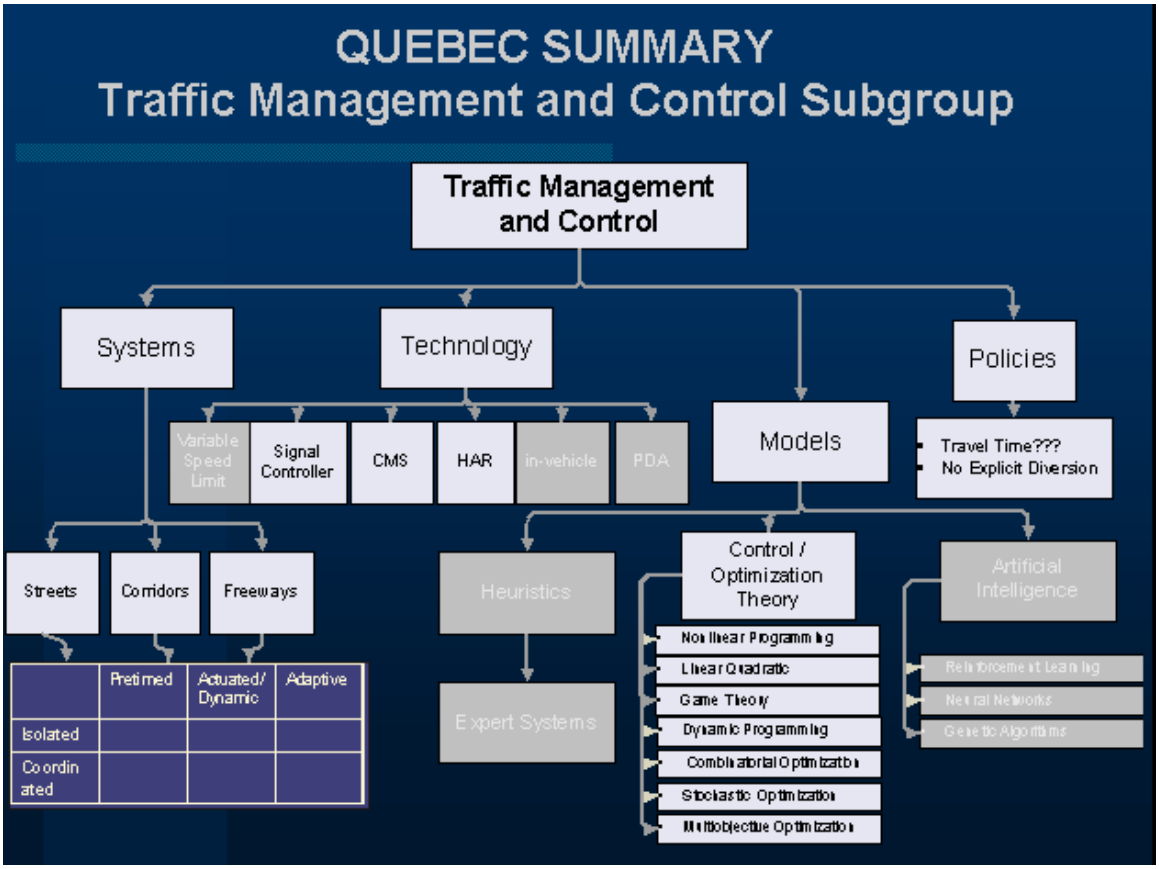


Figure 9 Quebec Summary: Traffic Management and Control Subgroup

Table 1: Overall Summary of the State-of-the-practice in Canada

				Ontario	Quebec	Rest of Canada
Network Monitoring	**Systems and Technologies**	Point Based	Loop	X	X	X
			Microwave			
			Radar	X	X	
			Ultrasound			
		Area Wide	Video	X	X	X
	Models	State Estimation and Prediction	Origin-Destination Estimation			
			Data Filtering			
			Truck Percentage Estimation			
			Tracking Vehicle Signature			
	Policies		No travel time	X	X	X
			Information on speed	X	X	X
			Description of Traffic Throughput	X	X	X
Detection and Diagnosis	**Systems and Technologies**	Manual	911 service	X	X	X
			Patrol	X	X	X
		Automated	VDS based	X	X	X
			Video Based			X
	Models		Video-based			X
			VDS-based	X	X	X
	Policies		Accident Verification before Dispatching	X	X	X
Weather and the Environment	**Systems and Technologies**	Road Clearance		X	X	X
		Pavement Sensors		X	X	X
		Visibility		X	X	X
		Pollution		X	X	X
	Models	Weather and Pavement Forecast Algorithms		X	X	X
	Policies	Weather Triggered Information Dissemination	Road Closure	X	X	X
			Traffic Management	X	X	X
ntrol and Management	**Systems**	Streets	Isolated, Coordinated / Pretimed, Actuated, Adaptive	X	X	X
		Corridors	Isolated, Coordinated / Pretimed, Actuated, Adaptive	X	X	X
		Freeways	Isolated, Coordinated / Pretimed, Actuated, Adaptive	X	X	X
	Technologies	Variable Speed Limit			X	X
		Signal Controller		X	X	X
		CMS		X	X	X
		HAR		X	X	X
		In-vehicle				
		PDA				
		Heuristics	Expert Systems			

WG1.2 State-of-the-Art in Canada

Introduction

This section summarizes the state-of-the-art of Canadian research in the area of network monitoring and traffic management and control.

Research efforts in the area of network monitoring focus on improving the information extracted from surveillance equipment, such as traffic detectors and CCTV, as well as probe vehicles and cellular phones. The collected data is further analyzed to model real-time network state estimation, such as traffic demand, link travel times and their variability, link densities, route travel time data and queue length.

Research subjects addressing detection and diagnosis sub-group include: enhancing existing capabilities of incident detection algorithms, developing incident prediction models, as well as management schemes and routing for site clearance after incident occurrence.

Research efforts involving weather and the environment include identifying the most useful data for road maintenance purposes, and issues related to road weather information systems.

Finally, research subjects in the area of traffic management and control include travel-demand management, congestion management, freeway control as well as traffic signal control.

Network Monitoring

The ability to estimate the status of current traffic congestion of a road network is of significant importance for many Intelligent Transportation Systems (ITS) applications including advanced traveler information system (ATIS), as well as advanced traffic management systems (ATMS). The state of the art research described below attempts to extract valuable information from various existing systems and technologies to estimate and predict, in real time, the status of transportation network. The following research topics have been identified at Canadian universities. An abstract of each project is provided in the full paper:

1. Spatio-Temporal Inductance Pattern Recognition for Vehicle Re-Identification - University of Toronto
2. Road Traffic Condition Acquisition via Mobile Phone Location Reference - University of Waterloo
   An Adaptive Model for Real-time Estimation of Overflow Queues on Congested Arterials - University of Waterloo
3. Modeling and Estimation of Origin-Destination Travel Time in Urban Traffic Networks - University of Waterloo
4. Modeling and Estimation of Travel Time Variability - University of Waterloo
5. Mobile Active-Vision Traffic Surveillance in Urban Networks – University of Toronto
6. State Estimation: OD Estimation – University of Toronto
7. Shortest Path Routing in Dynamic and Stochastic Networks - University of Waterloo

Detection and Diagnosis

Research in Incident Detection and Diagnosis tries to enhance existing capabilities to identify incidents, formulate response actions, and support initiation and ongoing co-ordination of those response actions. The following section lists such research efforts in Canadian Universities. Abstracts are provided in the full paper.

1. Accident Frequency Prediction Model – University of Toronto
2. Real-Time Crash Prediction Model for the Application to Crash Prevention in Freeway Traffic – University of Waterloo
3. GAID: Genetic Adaptive Incident Detection – University of Toronto
4. Automatic Freeway Incident Detection using Travel Time Data from AVI Equipped Vehicles - University of Waterloo
5. Automatic Incident Detection Algorithms and Incident Management Schemes – University of Montreal
6. Real-Time Prediction of Incident Delay – University of Waterloo
7. Development of an Accident Risk Prediction Approach for Dynamic Route Guidance - University of Toronto

Weather and the Environment

Major Road Weather research in Canada focuses on the following:

- Meteorological Service of Canada (MSC) Pavement model;
- Forecasting systems;

The following is list of identified research in the area. Abstracts are provided in the full paper.

1. The METRo Pavement Model
2. Monster Computer Powers Advanced Weather Forecasting – University of British Columbia

Traffic Management and Control

Traffic congestion is a major problem in urban areas, requiring tremendous efforts to minimize its detrimental impact on the environment, the economy and society. Specific examples of research topics in the area of traffic management and control include, congestion management (CMS or HOV), and traffic signal control as listed below with further details in the full paper.

1. Seamless Multi-Jurisdictional Traffic Corridor Control using Reinforcement Learning – University of Toronto
2. Adaptive Traffic Signal Control – University of Toronto
3. Adaptive Ramp Metering – University of Toronto
4. Microscopic Operational Analysis of HOV Lane Options for Three Major Expressways in Toronto – University of Toronto
5. Accident Risk Assessment Using Microsimulation for Dynamic Route Guidance – University of Toronto

   Genetic Algorithm-Based Combinatorial Parametric Optimization for Traffic Microscopic Simulation Models Calibration – University of Toronto
6. A Parallel Computing Approach To Fast Calibration of Large Scale Microsimulation Networks – University of Toronto
7. Galapagos: A Development Platform for Distributed Parallel Genetic Algorithms for Computationally Demanding ITS Optimization Problems – University of Toronto

Comparisons with Other ATLANTIC Partners and Priorities for Canada

Extensive surveying of International ITS state of the practice and state of the art is beyond the scope of this investigation. However, we attempt to identify the very clear differences between Canada and the international ATLANTIC partners, primarily to identify where we fall relatively short. This would contribute to the process of identifying research and deployment priorities for Canada.

Despite the significant Canadian ITS deployment and research achievements in the area of Network Monitoring and Traffic Management and Control, many deployment and research efforts are still modest as compared to the US and European counterpart. For instance, Canada uses relatively few advanced traffic management systems as compared to US. This includes the use of variable message signs, ramp metering, CCTV, vehicle probes, parking guidance systems as well as congestion management are of limited practice in Canada as compared to specifically Europe and also to the US.

As for the state of the art side, the area of Dynamic Traffic Assignment research seems to be a focus in the US and Europe but relatively silent in Canada. Research efforts in this area are limited in Canada and addressing this research topic is becoming increasingly relevant as ITS components are adopted by operating agencies and gaining market penetration.

The full report outlines specific examples from the US, Europe and as far as Japan, primarily to attract the attention of Canadian stakeholders to international practices not fully exploited in Canada.

Conclusion and Recommendation

Canada has good strengths in ITS as discussed through the various applications mentioned in the paper. These include Network Monitoring, Detection and Diagnosis, Weather and Environment Monitoring and Traffic Control and Management. These systems are being used to enhance road user convenience, efficiency and safety on urban and rural roads in the Canadian Provinces.

However, there are still significant practices and research and development needs to meet the growing demands of people and economy in Canada. These can be summarized as such:

- On the state-of-the-practice side:
    - In the area of Network Monitoring, ITS in Canada would benefit more form the use of Probe Vehicles (vehicles that can tracked by GPS or similar) for network monitoring. Information from probe vehicles can either supplement of replace traditional surveillance techniques that rely on government maintained infrastructure such loop detector and similar technologies.

  - In the area of advanced Traffic Control and Management systems, Canada need more intensive application of Ramp Metering to manage more efficiently its freeway systems. In addition, Canada should further explore the possibility of integrating freeway and surface street control (i.e. integrated corridor control). Canada can also benefit from the European experience in the area of congestion pricing as well as parking guidance to alleviate the congestion from its major city centers. This is not to advocate congestion pricing. It merits further investigation however.

- On the state-of-the-art side:
  The Canadian research in the area of transportation management needs involvement in the area of Dynamic Traffic Assignment. This research effort is, as illustrated in this report, relatively very under-explored in the Canadian Universities and research centers as compared to US and especially Europe. Addressing this research topic is becoming increasingly urgent as ITS is gaining market penetration in Canada.

Apart from the ATLANTIC partners, it is important to note that ITS in Canada can also benefit tremendously from the Japanese ITS experience specially in the areas of in-vehicle navigation systems, parking guidance, as well as pedestrian support systems. It is notable that the use of route guidance in Japan is years ahead of the rest of the world.

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