Centre de recherche sur les transports

ATLANTIC

A Thematic Long-term Approach to Networking for the Telematics and ITS Community

A Partnership of ITS Communities in Europe and North America

SYNOPSIS

And Highlights of

DISCUSSION PAPER

INTELLIGENT VEHICLE & INTELLIGENT VEHICLE-HIGHWAY SYSTEMS

Prepared by

Work Group 2.2
Leader: Dr. Denis Gingras, Université de Sherbrooke

Rapporteur: William Johnson, Consultant, Ottawa
Research Assistant: Mathieu St.-Pierre, Université de Sherbrooke

IN COLLABORATION WITH PARTICIPATING PARTNERS AND SPONSORS

April 2004

Canada Québec Ontario

(Blank page)

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 □ractice and research and development in Canada.

This Synopsis is based on the Discussion Paper prepared by the Canadian ATLANTIC Work Group 2.2 Intelligent Vehicle and Intelligent Vehicle-Highway Systems. The documentation of projects referred to in the Synopsis can be found in the Discussion Paper posted on the Canadian ATLANTIC website at : www.crt.umontreal.ca/atlantic/ .

European Commission Directorate-General
Information Society

Herman Bertrand
ARTTIC in Brussels
Tel: + 32 2 672 33 39
Email: hb@arttic.be

Siegfried Rupprecht
Rupprecht Consult
Tel: +49 221968 130
Email: s.rupprecht@rupprecht-consult.de

Richard Harris
Ian Catling Consultancy
Tel +44 1737 552225
Email : rh@catling.com

Professor Teodor Gabriel Crainic
École des sciences de la gestion
Université du Québec à Montréal
Centre de recherche sur les transports
Université de Montréal
Tel : +1 514 343-7143
Email : theo@crt.umontreal.ca

William Johnson
Consultant, Ottawa
Tel: +1 613 797-1489
E-mail: johnswf@attglobal.net

Isabelle Dussutour
POLIS
Tel. +32 2 282 84 67
E-mail : polis@polis-online.org

Dr. John Miles
Ankerbold International Ltd.
Tel +44 118 975 1566
Email: jcm@Ankerbold.co.uk

Steve Morello
ISIS Consultants
Tel: +33 4 78 71 89 55
Email: s.morello@isis.tm.fr

Dr. Baher Abdulhai
ITS Centre and Testbed
University of Toronto
Tel: +1 416 946-5036
Email: baher@ecf.utoronto.ca

Professor Chelsea White III
School of Industrial & Systems Eng.
Georgia Institute of Technology
Atlanta, GA
USA 30332-0205
Tel : +1 404 894 2307
Email : cwhite@isye.gatech.edu

Professor Kan Chen
2420 Skyfarm Drive
Hillsborough CA
USA 94010
Tel: +1 650 375-8890
Email: kan@kanchen.com

(Blank page)

ACKNOWLEDGEMENTS

The ATLANTIC Canada network acknowledges the leadership and contributions provided by its partners in Europe and the United States. The principal partners include Dr. John Miles (United Kingdom), Steve Morello (France), Ian Catling (United Kingdom), Isabelle Dussutour (POLIS), Siegried Rupprecht (Germany), Professor Chelsea White (USA) and Professor Kan Chen (USA).

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 2.2 Intelligent Vehicles and Intelligent Vehicle-Highway Systems is jointly managed by Dr. Denis Gingras, Université de Sherbrooke (leader) and William Johnson, Consultant, Ottawa (rapporteur). 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 2.2 members and contributors appear in Annex A. Special recognition is extended to Mathieu St.-Pierre, Research Assistant, Université de Sherbrooke for his extensive contribution.

The Work Group 2.2 leader and rapporteur can be contacted at:

Denis Gingras, Dr. Ing. (leader)
Directeur général
IMSI-Institut des matériaux et systèmes intelligents
Professeur titulaire
Génie électrique
Université de Sherbrooke
D6-1004, Pavillon Marie-Victorin
2500 Boulevard Université
Sherbrooke, Québec, Canada J1K 2R1
Tel : (819) 821-7110
Fax. :(819) 821-8028
Courriel : denis.gingras@imsi.usherb.ca
Site internet IMSI : www.imsi.usherb.ca
Site internet personnel : http ://pages.infinit.net/dgingras

William Johnson, Sc.D., Consultant (rapporteur)
Transport Research, Education & Development Services
58-280 McClellan Road
Ottawa, Ontario, Canada K2H 8P8
Tel : (613) 797-1489
Fax : (613) 820-1831
E-mail : johnswf@attglobal.net

(Blank page)

TABLE OF CONTENTS

(Blank page)

1 EXECUTIVE ABSTRACT

This Synopsis is a brief report on the research activity of the Canadian ATLANTIC Work Group 2.2 (see Annex A for active members). The major undertaking was to compile an inventory of research and development projects related to Intelligent Vehicles and Intelligent Vehicle-Highway systems in Canada and elsewhere (see Appendix A). This serves as the basis to begin a benchmark exercise to compare Canadian efforts in this field against progress in other countries. It is intended to pursue this activity in a future workshop in Canada. Another undertaking by members of Work Group 2.2 was to participate in an international ATLANTIC forum led by the U.S. partners to identify areas of consensus on key issues and areas for future research and documented in a companion report.

2 BACKGROUND

The ATLANTIC Thematic Network was initiated in May 2001 as a project under the European Commission's 5th Framework for Research. A condition of E.C. funding for the project was that it have self-funded partners in North America. The Canadian partners, jointly lead by the ITS Centre and Testbed at the University of Toronto and the Centre for Research on Transport at Université de Momtréal, secured sponsorship for the network activites in Canada from Transport Canada, Ministry of Transportation Ontario and Ministère des Transports du Québec. The Canadian ATLANTIC network was officially launched in January 2003 after a period of development starting in July 2001.

The purpose of ATLANTIC is to bring together experts and professionals in fields related to intelligent transportation systems (ITS) to benchmark ITS research and development in Europe and North America. This is conducted through the activities of 8 work groups that collectively encompass the major inter-related elements of transportation systems, i.e. the driver, vehicle and roadway. The 8 elements, grouped into 3 theme areas, are as follows (see www.atlan-tic.net for further information) :

- 1.0 Integrated Transport
  - 1.1 - Traffic and Travel Information Systems
  - 1.2 - Network Monitoring and Traffic Management and Control
  - 1.3 - Urban Public Transit R&D in Canada
- 2.0 Technologies and Services
  - 2.1 - Intermodal Freight Information, Pre-clearance & Logistics
  - 2.2 - Intelligent Vehicles and Intelligent Vehicle-Highway Systems
  - 2.3 - Electronic Road User Charging & Integration with Payment Systems
- 3.0 Assessment and Evaluation
  - 3.1 - ITS User Acceptance and Impact Assessment
  - 3.2 - Human Machine Interface & User Friendly ITS : Human Factors & ITS

AUTO21 is a new Network of Centres of Excellence in Canada that was created to help position Canada as a leader in automotive research and development. It consists of more than 200 researchers in 28 Canadian universities and more than 120 industry partners.

AUTO21 was launched in May 2001 and has 6 theme areas in which research and development projects are funded (see www.auto21.ca for further information) :

A : Health, Safety and Injury Prevention
B : Societal Issues and the Automobile of the 21st Century
C : Materials and Manufacturing
D : Powertrains, Fuels and Emissions
E : Design Processes
F : Intelligent Systems and Sensors.

The AUTO21 theme area F : Intelligent Systems and Sensors is closely related to the ATLANTIC theme topic Intelligent Vehicles and Intelligent-Highway Systems (Work Group 2.2). The two networks in Canada have established an effective link between them through Dr. Denis Gingras of Université de Sherbrooke who is the leader of AUTO21 Theme F and leader of the Canadian ATLANTIC Work Group 2.2, both related to the area of intelligent vehicle research. This has the potential to greatly expand the network of interested professionals to collaborate together in Canada in this emerging field.

3 SCOPE OF WORK GROUP 2.2

The Work Group 2.2 for Intelligent Vehicles and Intelligent Vehicle-Highway Systems is focused on intelligent in-vehicle systems and vehicle-to-roadside communication systems that link to the broader field of intelligent transportation systems. The main emphasis in Work Group 2.2 in Canada has been on collecting information about current projects in Canada and comparable projects in Europe and the U.S. to benchmark the status of ITS research and development in Canada. This activity is the subject matter of this report.

The U.S. partners in ATLANTIC led the development of a discussion paper entitled "ATLANTIC Vehicle-Highway Systems Forum: Final Report" by Richard Bishop and Dr. Mark Brackstone dated November 2002. The international members of this Work Group, including Canadians, met to review and discuss the topic at an ATLANTIC workshop in Washington D.C. in January 2002. It also included responding to two surveys in 2002 that provided input to the discussion paper authored by the U.S. partners.

The leader and rapporteur of Work Group 2.2 met informally with academics and students associated with the AUTO21 Theme F at the 2003 AUTO21 Scientific Conference in June 2003 in Niagara-on-the-Lake, Ontario. This was a get-acquainted meeting at which professional and project interests were exchanged between the two networks. A second meeting is planned at the 2004 AUTO21 Scientific Conference in Montreal, Quebec in June 2004. At that time, it is proposed to have a more formal exchange based on the Discussion Paper prepared by Work Group 2.2.

4 OVERVIEW OF THEMES AND SUBTOPICS

The research and development of intelligent vehicles is emerging as a field of wide interest to the automotive industry and its suppliers because of the potential to enhance the quality and attractiveness of their products for consumers. This includes enhanced comfort, safety, reduced operating costs, more convenience for the driver to plan and make trips, and reduced environmental impacts. The key technologies used to achieve these enhancements are sensors (to detect and monitor real-world conditions), communications channels (to transmit data to processing points), and computers to analyze data and produce information for intelligent decision-making. These technologies provide the means to implement better information and control services to improve the operating performance of the vehicle, the vehicle-highway system and the broader transportation regulatory and supply environment.

The operation of intelligent systems requires the use of communication channels to connect the components of specific systems. These communication channels exist within a vehicle and between the vehicle and the roadside infrastructure. One scheme for classifying these data streams was proposed by Ronald Miller of Ford's e-Technology Research program at the ITS America Annual Meeting 2002. It defines three streams of information flows centred on three primary elements: the vehicle, the driver and the passengers, and the decision-making associated with each element. These three information streams are discussed with examples in the following subsections.

<u>Vehicle Monitoring</u>

Vehicle monitoring is performed at several levels. There is monitoring by the driver of the vehicle operations while in motion; there is monitoring by the driver and maintenance personnel of the vehicle condition with or without motion; and monitoring of the vehicle's location in space and time. Automation of these monitoring functions can relieve the human operators of the monotonous task of monitoring systems that are mainly operating in steady state equilibrium while facilitating rapid response to changes in operating conditions that require taking actions that will improve system performance. This applies to both real time operations as well as static condition monitoring.

- Vehicle systems to sense, report and process data on the status and performance of vehicle components and sub-systems enable informed decisions to be made to optimize functional effectiveness and operational efficiency in vehicle systems, including real time operating systems and static maintenance schedules over the longer term.

Vehicle location monitoring can be used by an agent, such as the owner or a regulatory agency, to follow the movement of a vehicle through a network or along a roadway. In this case, the external agent can use the vehicle's location coordinates to make decisions that require the driver to change course and follow certain routes or to avoid certain impediments along the way.

- Vehicle location monitoring is used to inform dispatchers of the location of a vehicle to facilitate routing and scheduling decisions, or to enable the timely dispatch of emergency vehicles in case of an accident or incident, or to inform authorities of vehicle location in case it is stolen or missing.

Driver Aids

Driver aids involve information to better inform the driver in making decisions that concern routing and scheduling of trips and to make the driving task easier, safer and more convenient.

- Information concerning the road network including up-to-date maps is an essential tool for finding one's way in unfamiliar territory. This information can be partly stored on-board the vehicle in map databases and updated at intervals by means of manual updating or downloading data in real time using roadside to vehicle communications services from a central location.
- Information on immediate road conditions including construction zones and surface conditions (ice, snow) is usually transmitted to the driver by means of static signs at the roadside. These are placed in positions so that the driver can read them visually while passing. However, if the driver misses the sign, either through error or inattention, the information is not available to act upon. By communicating this information from the roadside to the driver using telecommunication technologies, the driver can make a more positive recognition of the information (in a language of the driver's choice) and act on it accordingly.
- Information concerning real time traffic, weather and environmental conditions can assist the driver to avoid conditions that are unsafe or impose discomfort during the trip.
- Communications services to facilitate payment of road user charges automatically can relieve the driver of the necessity to stop or slow down to pay tolls or parking fees.

Passenger Services

Passenger services include communication systems that enhance the traveller's comfort and convenience during the trip. These services can include systems that communicate via a vehicle-to-roadside communications link (e.g. dedicated short range communications) or a capability to communicate between travellers and an agent in the external environment (e.g. cellular telephone). The am/fm radio is an example of a technology that provides entertainment for travellers but is limited to one-way communication into the vehicle. Modern technology enables communications both into and out of the moving vehicle.

- Passenger communication services enable the occupants of a vehicle to obtain services such as access to the Internet or downloading of music and movie files or to pay for these services while the vehicle is in motion or stopped.
- Passenger communication services such as cellular telephone enable travelers to communicate with others in the broader external environment.

- Cargo monitoring is a service for freight that requires constant monitoring during transit for reasons of safety and security (Dangerous goods) or to preserve value (e.g. constant temperature) while in transit.

These categories are discussed in the next section and R&D projects identified in this research are used to compare the state of the art of intelligent vehicle and intelligent vehicle-highway research in Canada with other countries.

5 DISCUSSION OF SUBTOPICS

5.1 CONTROL AND MONITORING OF VEHICLE BEHAVIOR

5.1.1 STAKEHOLDERS

- Drivers who will benefit from a safer, more reliable, easier to drive and more comfortable vehicle.
- Automotive manufacturers
- Insurance companies
- Government agencies
- OEM

5.1.2 MAIN THREADS

Active Suspension System

Suspension systems have a major effect on the handling characteristics of a vehicle. Active suspension system resolves the traditional conflict between road holding, load carrying and passenger comfort by letting the driver the option to select the mode of the suspension depending on the intended use of the car. Moreover, the active suspension can counteract heave, roll and pitch. This control is achieved by pairing a microprocessor with four shock absorbers that have a continuously variable (and controllable) damping coefficient. On occasion, these dampers are paired with pneumatic springs to provide ride height/levelling control.

Advanced braking system

Advanced braking systems replace or improve the conventional mechanically controlled brake systems. The goal is to augment the stability and efficiency of braking operations.

Active noise control

Acoustically, vehicles present a challenging environment. Driver speech is mixed with ambient noise and reverberation. In-vehicle noise sources are various and varying. The in-vehicle acoustic environment varies with road surface, vehicle speed, acceleration, weather, window position, HVAC status, entertainment system status, presence of passengers and even vehicle shape and finishing details. The character of the ambient sound is the same for most vehicles but general level differences exist between 300-2000 Hz. As example, in larger, spacious vehicles, low frequency noises (under 250-300 Hz) are significant.

Advanced thermal control

The technological innovation of thermal comfort in the passenger vehicle compartment continues to evolve with the advancement of computer technology. The control of discharge air temperature, fan speed, and air outlets are now electronically controlled. The next level of sophistication is to control the thermal system adaptively according to the preference of each passenger and the current temperature sensed inside the vehicle.

Electronic

Electronic components are increasingly used in the automotive industry. Most of the functional parts of common vehicles require electronics components. This includes the control of the engine, the dashboard instrumentations, braking system, thermal system, etc… In high-end cars, even more sophisticated systems requiring electronic components are available such as advanced driver assistance systems, infotronic systems, navigation systems, etc. The communication between the different electronic components requires complex electrical architectures using multiple networks with different protocols.

Diagnostic

The diagnostic operation helps in identifying failure of vehicle parts by monitoring their performances electronically. Diagnostic improves system safety, information on function availability and system service. Usually, there are three levels of diagnostic :

1 - ***Fault detection*** : Provide an indication of an abnormal event in the system, which may result in a system failure.

2 - ***Fault isolation*** : Determine the exact location of the fault within the system. An alerts may be sent to the driver if the fault happened in a critical location.

3 - ***Fault identification*** : Determine of the root cause and magnitude of the fault within the system.

5.2 DRIVING ASSISTANCE AND AUTOMATION

5.2.1 STAKEHOLDERS

- Government
- Car insurance companies (ADAS)
- Medical emergency centre (Crash notification system)
- Traffic management agency (Advanced cruise control)

5.2.2 MAIN THREADS

Driver Cognitive Load system

With the electronic systems entering into the car, the driver is becoming overloaded with information coming from different sources like embedded or portable phone, Internet, navigation system, and driver assistance systems. It becomes necessary to have a system that monitors the cognitive load of the driver and manages the information sent to the driver according to a priority policy. The information directly relate to the driving of the car should be prioritize over the information not important to drive such as phone calls.

Advanced Automatic Crash Notification

Critical crash data on qualified crashes may result in improved response time to the crash scene with the appropriate resources, as well as one-step routing to the correct emergency care facility. These advances are made possible through the use of an embedded telematics system and crash detectors.

A **c**ruise control system controls the speed of the vehicle automatically. Advanced cruise control systems adapt the speed of the vehicle depending on the presence or absence of a vehicle ahead.

Advanced Driver Assistance System (ADAS)

Advanced driver assistance systems use electronic technologies to facilitate the driving task by providing warning or assistance to the driver. These systems are grouped into two principal clusters - the INTERVENTION cluster and the INFORMATION / WARNING cluster. The INTERVENTION cluster includes systems that control automatically some behaviours of the vehicle such as lateral control and longitudinal control. The INFORMATION / WARNING cluster warn the driver against potential danger like slow-moving vehicle in a curve which cannot be seen at a secure distance by the driver.

Automation

Automation means that the vehicle can be controlled automatically without any human intervention.

Collision avoidance system

Collision avoidance systems must be able to detect potentially dangerous physical entities and applied suitable actions to avoid or mitigate an impact. Suitable actions may include activating the braking system, controlling the steering of the car or deploying in-car occupant safety protection measures such as safety belt pre-deployment tension adjustment.

Vision

The safe driving of a car depends heavily on vision. This is why so many accidents happen at night or when the visibility is reduced by weather conditions such as fog. The vision of a driver can be improved by systems that give information on the environment around the vehicle that can't be seen or hardly seen by human eyes.

5.3 VEHICLE GUIDANCE, NAVIGATION AND TELEMATICS

5.3.1 STAKEHOLDERS

- Consumers
- Information providers (traffic reports, digital maps, points of interest, weather, news, etc…)
- Automotive OEMs
- Telematics Service Providers
- Wireless Carriers
- Telematics Equipment Manufacturers
- Fleet manager
- Call Centers

5.3.2 MAIN THREADS

Wireless Communication

Wireless communication is a very important enabling technology for navigation, telematics and infotronic applications.

Infotronic Systems

The combination of computers and electronics has transformed our home and work environments, but in the automobile the application of this powerful technology combination is still evolving. The race is on to develop in-vehicle computing systems that provide infotainment, edutainment and entertainment to the occupants.

Navigation

A navigation system is composed of a digital map database, a positioning module, a route planning module, a route guidance module, a user's interface with speech capability and a communication module. The digital map database is usually store on CD-ROM and is updated normally 2 times a year. The positioning module is composed of various sensors to determine the position of the vehicle accurately and continuously. The route-planning module calculates an optimal route to a chosen destination. The route guidance module indicates the direction to the driver along the planned route. A user's interface displays information of the road network surrounding the vehicle and the vehicle's position on the road network. The communication module is used to receive useful information relevant to the route-planning module such as traffic conditions and weather conditions. A navigation system can also give the location of various points of interest near the vehicle such as gas stations, restaurants, emergency centres, etc.

Interface

Spoken language technologies, including speech recognition, natural language understanding, dialogue management, language generation and speech synthesis, can be important elements of driver interaction systems. They appear to offer the promise of a natural, hands-free, eyes-on-the-road way to interact with systems on and off the vehicle, especially systems that are rich in features and flexibility.

6 OVERVIEW OF ACTIVE PROJECTS

This research has compiled a inventory of 46 ITS research and development projects related to intelligent vehicles and intelligent vehicle-highway systems currently underway in Canada, the United States, Europe and Japan. A brief documentation of each of these projects is included in Appendix A of the full Discussion Paper for Work Group 2.2. In this Synopsis, only descriptions of the 4 Canadian projects are included in Appendix A. These projects are representative of the types of projects of interest to this research.

The 46 projects are listed in Table 1 categorized by country and ITS category. There are 4 projects in Canada, 14 in the United States, 23 in Europe and 5 in Japan. Viewed another way, there are 15 Vehicle Monitor projects, 19 Driver Aid projects and 12 Passenger Service projects. Although the projects are placed in only one category, individual projects may have attributes relevant to more than one category. Evidently, Canada has fewer projects underway than in any of the large automotive-intensive industrial economies of the world. Three of the Canadian projects are sponsored by AUTO21.

The details of all projects can be obtained by referring to the descriptions in Appendix A of the Discussion Paper.

7 DISCUSSION OF ISSUES

The inventory of R&D projects is a start and indicative of the scope and scale of the work going on intelligent vehicles and vehicle-highway systems in various countries. The projects reported in Canada are relatively new since they are sponsored by AUTO21 that only started in 2001. Also, the projects in Canada are largely centred on university based teams. While industrial partners are mentioned by the Canadian projects, there is no indication of the level of contribution from the industrial partners.

The model used to categorize the projects requires some explanation. The complexity of the intelligent vehicle and vehicle-highway systems makes any system of categorization difficult to implement. There is always much overlap between categories.

It is also apparent that, with so much work underway in the other industrial economies, it would be prudent for Canada to try to participate in joint projects with non-Canadian partners. This would help to avoid duplication and to find a wider market for the outputs of Canadian research and development in the global automotive industry.

The importance of in-vehicle passenger services is that they present commercial opportunities that can be exploited to put the communication channels in place that can then be used for vehicle monitoring and driver aids at marginal additional costs. The following discussion, taken from a description of one of the projects in Appendix A and is reproduced here to emphasize the essence of the current telematics debate.

<u>Telematics Applications Analysis</u>

Reference: Schumacher, R. W., Lind, R. C., Yen, H., Welk, D. and Gidwani, S. (2002) "MultiMedia Entertainment: Vehicle Technology and Service Business Trends", SAE Convergence, Detroit.

“Presently, very few suppliers of telematics services are making an operating profit in 2002. Yet, just a few years ago market and equity analysts were forecasting a $50B market for telematics by the end of the decade with profits for service providers right around the corner. Thus far, consumers around the world have not demonstrated a great demand for entry-level telematics services that provide safety/security and a live call center. This is a new business model and consumers have not found sufficient value in such a rarely used service to pay $20 or more per month. Going forward, service providers are evaluating other, more advanced services, hoping to discover the “killer application” that will drive everyday use of telematics services and provide sufficient value to consumers to drive at least hundreds of dollars per year of subscription or pay per use services. The chart below shows the services on a consumer value-added versus technical complexity tableau.

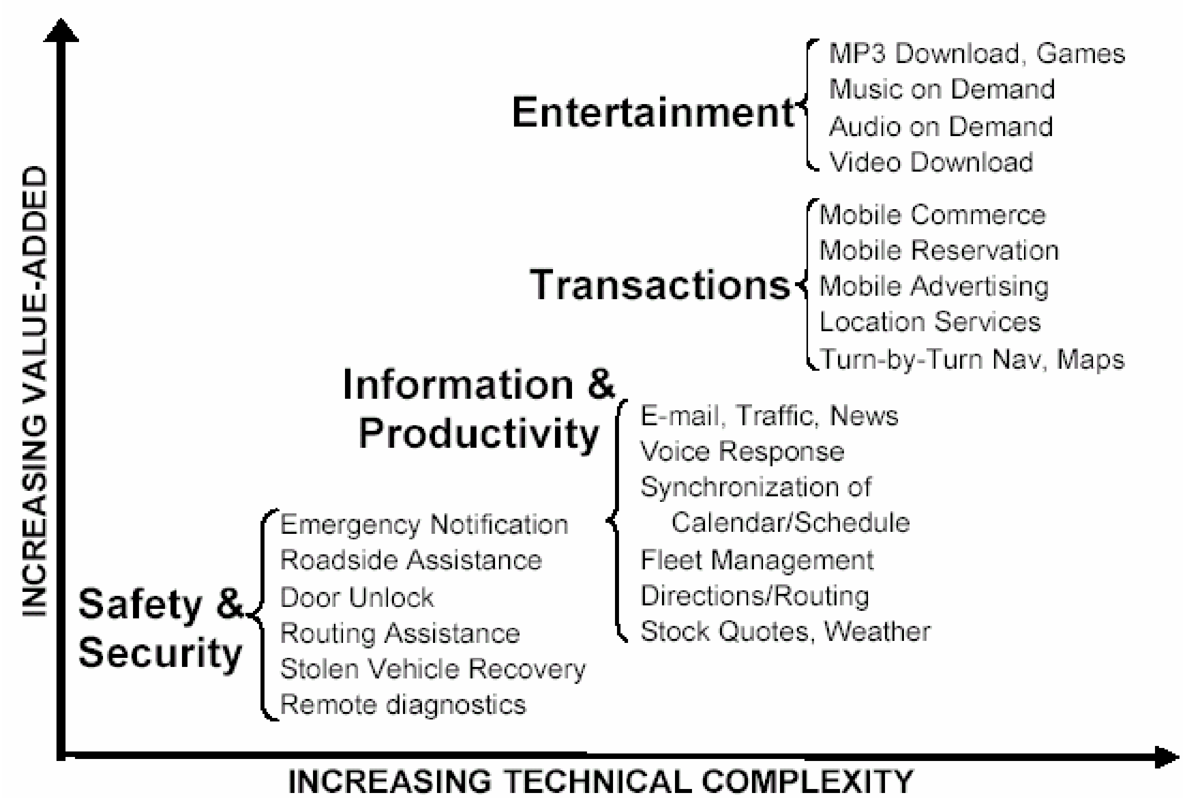


Chart - Telematics Service Classifications Source : (Schumacher 2002)

The most advanced business is entertainment services. Here consumers are already purchasing on a subscription for services such as XM and Sirius satellite broadcast transmitting near CD-quality digital music and talk radio. In the near future, advanced wireless infrastructure such as 802.11 local area networks (LAN), high bandwidth satellite, and digital TV broadcasting will provide sufficient bandwidth to download high value digitally compressed entertainment media on demand in a pay-per-use model. Examples might include music, movies, and game software sold over a broadband internet link to the consumer's home multimedia PC and then transferred to a hard disk drive in the homeowner's vehicle through an 802.11 LAN system. The 802.11 LAN could also be accessible in public places such as parking lots and gas stations. This type of business model for wirelessly distributing entertainment media is significantly more efficient than today's retail business."

8 SUMMARY AND CONCLUSIONS

Several concepts are emerging in making automobile smarter:

- Networked vehicle : both intra and extra-vehicular communications. Cars will be linked to infrastructures, service centers and among themselves

- Total awareness : various sensors are becoming available and more efficient, radar, IR, intelligent vision system will allow to analyze in real-time the immediate vicinity of a vehicle and help automating its behavior in hazardous situations or warn the driver of immediate danger this lead to Automated Driver Assistance Systems (ADAS) :

ADAS will naturally appear in some years when all its essential constituents will be already available in vehicles (eg. navigation, human-machine interface, sensors and computing modules). These modules need first to be introduced gradually and individually into vehicles before fully operational ADAS be available.

- Big cultural changes: automotive manufacturer, road infrastructures constructors and managers as well as other manufacturer sectors (eg. telecommunications, computing, storage etc) need to cooperate and work together. Standards and manufacturing process automation will become a major challenge in this area.

Intelligence brought into the vehicle must bring simplicity and ease of use to the passengers and driver (driver will one day become optional).

Smarter vehicle will also revolutionize traffic management system as well as the vehicle servicing and maintenance chain.

China shall not be overlooked. In 1999, less than 2% of automotive R&D in China was devoted to electronics. Today, it is over 20%. China produced over 4 millions vehicle in the first 11 months of 2003 and it is steadily increasing.

Canada's future in the automotive sector lies more in the development of smart distributed high tech industries (telecom, navigation, computing, AI) adapted to future automotive needs rather than focusing solely in attracting OEM assembly plants on Canadian soils but controlled by foreign companies.

Automating a vehicle can be dangerous if the technology integration is not done wisely. Long standing testing and certification will be required to insure safety to passengers, to the other vehicles and to the pedestrians.

REFERENCES

Bishop, Richard, Brackstone, Mark (2002), "ATLANTIC Vehicle-Highway Systems Forum Final Report", ATLANTIC International Thematic Network, November 2002

Gößmann, E., Wille, F.-M., König, R. and Guddat, U. (2002) "Collaborative Product Creation Driving the MOST Cooperation", SAE Convergence, Detroit.

Hayashi, R., Kajino, Y. and Arias, C. C. (2002) "Advanced Thermal Comfort in the Passenger Vehicle Compartment", SAE Convergence, Detroit.

Hein, C. M. and Rillings, J. H. (2002) "Spoken Dialogue Technologies for Drivers", SAE Convergence, Detroit.

Malhotra, A. P. (2002) "Enabling Technology's Promise – Collaborative Development of Common Requirements for Mobile Information and Entertainment Systems", SAE Convergence, Detroit.

Merker, T., Girres, G. and Thriemer, O. (2002) "Active Body Control (ABC) The DaimlerChrysler Active Suspension and Damping System", SAE Convergence, Detroit.

Millstein, S. (2002) "vRM (vehicle Relationship Management)", SAE Convergence, Detroit.

Reilhac, P. and Bavoux, B. (2002) "Vehicle E/E Architecture: A New Paradigm for Collaborative Product Creation? A Case Study", SAE Convergence, Detroit.

Santoro, K. (2002) "Java Telematics Technology - Building and Leveraging a Market Ecosystem", SAE Convergence, Detroit.

Schumacher, R. W., Lind, R. C., Yen, H., Welk, D. and Gidwani, S. (2002) "MultiMedia Entertainment: Vehicle Technology and Service Business Trends", SAE Convergence, Detroit.

Severinsky, A., Louckes, T., Templin, R. and Frederiksen, F. (2002) "Electronics as the Cornerstone of Future Fuel-efficient and Clean Vehicles", SAE Convergence, Detroit.

Acebrón, F. and Marco, J. M. (2003) "Automotive Navigation Systems in Spain: State of the art, Evolution and Dynamic Navigation Experiences." 10 th ITS World Congress, Madrid.

Blosseville, J. M., Hoc, J. M., Riat, J. C., Wautier, D., Bourdonnaye, A. d. l., Artur, R., Tournié, E., Narduzzi, C. and Gerbenne, E. (2003) "French Contribution To The Functional Analysis Of 4 Key Active Safety Functions (ARCOS Project)", 10 th ITS World Congress, Madrid.

Ishida, S., Tanaka, J., Kondo, S. and Shingyoji, M. (2003) "The method of a driver assistance system and analysis of a driver’s behavior", 10 th ITS World Congress, Madrid.

Marchi, M., Guichon, D., Ehrlich, J., Jarri, P., Dominois, D., Salesse, L. and Leverger, C. (2003) "LAVIA, The French ISA Project : main issues and first results on technical tests", 10 th ITS world congress, Madrid.

Minderhoud, M. M. and Hansen, I. A. (2003) "Simulations of Externally Controlled Adaptive Cruise Control Headway Setting", 10th ITS World Congress, Madrid.

Pandazis, J.-C. (2003) "The challenge to interface driver assistance systems with map and positioning data", 10 th ITS World Congress, Madrid.

Takahama, T., Kimura, T., Iwasaki, E. and Naitou, G. (2003) "Robust Vehicle Detection for Collision Avoidance Systems by Using a Lidar Sensor and a Vision Sensor", 10 th ITS World Congress, Madrid.

Wees, K. v. (2003) "Liability And Insurance Aspects Of Advanced Driver Assistance Systems; Barriers Or Incentives?" 10 th ITS World Congress, Madrid.

Yoshiteru, I., Masuo, K., Hiroshi, K., Masaya, Y. and Tomohiro, Y. (2003) "An Examination Of Advanced Cruise-Assist Highway Systems (AHS) Safety And Reliability", 10 th ITS World Congress, Madrid.

Achenbach, W. (2002) "Safety Concepts in x-by-wire-Systems", SAE Convergence 2002, Detroit.

Bekiaris, E., Amditis, A., Polychronopoulos, A., Nikolaou, S., Dangelmaier, M., Marberger, C. and Thomas, J. (2003) "E-Safety Architecture Of A Personalized Driver Monitoring And Warning System : The AWAKE Approach", 10 th World Congress on Intelligent Transportation and Systems, Madrid.

Frank, R. (2002) "Towards the Intelligent Power Network Randy", SAE Convergence 2002, Detroit.

Hautiere, N. and Aubert, D. (2003) "Driving Assistance : Automatic Fog Detection And Measure Of The Visibility Distance", 10 th World Conference on Intelligent Transportation and Systems, Madrid.

Kolodko, J. and Vlacic, L. (2003) "Cooperative Autonomous Driving at the Inteligent Control Systems Laboratory", IEEE Intelligent Transportation Systems Council Newsletter**,** p. 6-10.

Lilli, F., Damiani, S. and Gutiérrez-Lanza, S. (2003) "GALLANT Pilot Project Galileo for safety road application", 10 th World Conference on Intelligent Transportation and Systems, Madrid.

Oyaide, A., Willhoeft, V., Shooter, C. and Heenan, A. (2003) "Lane And Road Detection Using Video And Laserscanner Data", 10 th World Conference on Intelligent Transportation and Systems, Madrid.

Rajnak, A. and Ramnefors, M. (2002) "The Volcano Communication Concept", SAE Convergence 2002, Detroit.

Ségarra, G. (2003) "Distributed, Integrated Environment For Cars Telematics Configuration Management(DIECOM IST Project)", 10 th ITS World Congress, Madrid.

Weidner, T. and Hahn, W. (2003) "Algorithms For Fusion Of FAR Infrared And Visual Night -Time Images With Scope To An Automotive Application", 10 th ITS World Congress, Madrid.

Butler, D. (2002) "Launching Advanced Automatic Crash Notification (AACN): A New Generation of Emergency Response", SAE Convergence 2002, Detroit.

D’Avello, B. and Bosch, J. V. (2002) "Portable and Embedded Wireless Devices as Conduit for Telematics Applications", SAE Convergence 2002, Madrid.

DeVries, P., Chrysochoos, M. and Kumthekar, S. (2002) "The Mobile Wireless Ether – Finding Its Way Into the Automobile", SAE Convergence 2002, Detroit.

Grill, D. and Tacke, S. (2002) "System Architecture and Applications of Vehicle Condition Monitoring", Detroit, SAE Convergence 2002.

Knoll, P. M. (2002) "A NIR Based System for Night Vision Improvement", SAE Convergence 2002, Detroit.

Lages, U. and Schulz, R. (2003) "Obstacle Detection by Multi-Layer Laserscanner for Collision Mitigation", 10 th ITS World Congress, Madrid.

Mateos, M., Robin, P., Sauvage, S., Joloboff, V., Madhusudan, G., Bennani, Y., Dague, P. and Bourgeois, L. (2002) "Environment for Evolutionary Automotive Diagnosis", SAE Convergence 2002, Detroit.

Ogawa, T. and Morozumi, H. (2002) "Diagnostics Trends for Automotive Electronic Systems", SAE Convergence 2002, Detroit.

Pompei, F. J., Sharon, T., Buckley, S. J. and Kemp, J. (2002) "An Automobile-Integrated System for Assessing and Reacting to Driver Cognitive Load", SAE Convergence 2002, Detroit.

Waldeck, W. R. (2002) "Diagnostic Protocol Challenges in a Global Environment", SAE Convergence 2002, Detroit.

Bock, T., Feather, K., Holfelder, W. and Lundberg, J. (2002) "Internet-Based Infotronic Systems Technologies and Markets", SAE Convergence 2002, Detroit.

Kun, A. L., Miller, W. T. and Lenharth, W. H. (2003) "Project54 : Standardizing Electronic Device Integration in Police Cruisers", p. 10-13.

Würtenberger, M. (2002) "Business and Technical Impacts of Open and Proprietary Architectures on Infotronic Systems", SAE Convergence 2002, Detroit.

TABLE 1 – R&D Projects by Country & ITS Category

Country	ITS Category	Project
Canada	Vehicle Monitor	- AUTO21 Project FIN – Interior Noise Environment of Automobiles
	Driver Aid	- AUTO21 - Project FCD (Collaborative Driving System)
	Passenger Communications	- AUTO21 Project FII - Construction of an integrated navigation information infrastructure - VICTOR
United States	Vehicle Monitor	- Hyperdrive technology - Vehicle relationship management - Ford's Diagnostic Systems
	Driver Aid	- The Chrysler 300M IT-Edition research vehicle - Crash Notification System Overview - Crash Avoidance Metrics Partnership - Advanced Cruise-Assist Highway Systems
	Passenger Communications	- Wireless communication for in-vehicle telematics system - Wireless Personal Area Network Overview - The Dodge Super8 Hemi - Java Telematics Technology middleware - Telematics Applications Analysis - The Project54, electronic devices integration in police cruiser - Speech Dialog System Overview
Europe	Vehicle Monitor	- DaimlerChrysler's ABC system - BMW's DynamicDrive - Hydractive Suspension - DaimlerChrysler's Brake-by-wire - Smart electric/electronic architecture - The RESEDA project - Vehicle relationship management - Telematics infrastructure for testing and maintenance - The MOST Cooperation

	Driver Aid	- The AWAKE project - The GALLANT project, combining Galileo and ADAS - ADASIS (ADAS Interface Specifications) - The ARCOS project, speeding up ADAS deployment - LAVIA, an intelligent speed adaptation system - Centralized Distance Control - The AUTOTAXI project - Cooperation activities between autonomous vehicles - Automatic Emergency Braking system - Atmospheric Visibility Distance Sensor - FIR-Camera based Night Vision
	Passenger Communications	- Open infotronic system - The DIECoM project - On-board Dynamic Navigation Systems
Japan	Vehicle Monitor	- Tri-zone Neural Network Control System - On-Board Diagnostic (OBD) system
	Driver Aid	- The Honda Intelligent Driver Support System - Camera augmented collision avoidance system - Advanced Cruise-Assist Highway Systems
	Passenger Communications	

ANNEX A – Participants in Work Group 2.2

Denis Gingras, Dr. ing. (leader)
Directeur général
IMSI-Institut des matériaux et systèmes intelligents
Professeur titulaire
Génie électrique
Université de Sherbrooke, Quebec

William Johnson (rapporteur interim)
Consultant
Ottawa Ontario

Mathieu St.-Pierre
Research Assistant & Student
Université de Sherbrooke, Quebec

ATLANTIC Workshop Washington D.C. January 17, 2002

Dr. Jim White
Road Safety Directorate
Transport Canada
Ottawa, Ontario

AUTO21–ATLANTIC Discussions at 2003 AUTO21 Scientific Conference

Denis Gingras, op. cit.
William Johnson, op. cit.

Shengrui Wang, Ph.D.
Professeur, Dépt. de mathématiques et d'informatique
Université de Sherbrooke

François Michaud, Ph.D., ing.
Professeur agrégé, Dépt. de génie électrique et de génie informatique
Université de Sherbrooke

Patrice Masson, ing., Ph.D.
Professeur adjoint, Dépt. génie mécanique
Université de Sherbrooke

Brahim Chaib-draa, Ph.D., ing.
Professeur titulaire, Dépt. d'informatique et de génie logiciel
Université de Sherbrooke

Yunlong Sheng, D. ès Sc. Phy.
Professeur, Centre d'optique, phononique et laser
Dépt. de physique, Université de Laval, Québec QC

H.K. Kwan, PhD, Peng
Professor, Dept. Of Electrical and Computer Engineering
University of Windsor

Elizabeth Cannon, Peng
Professor, Dept. Of Geomatics Engineering
University of Calgary

M. Parameswaran, Ph.D.
Director, Institute of Micromachine and Microfabrication Research
Professor, School of Engineering Science
Simon Fraser University, Burnaby B.C.

Zhen Mei, Ph.D.
Principal, Analytics & Modelling
Manifold Data Mining Inc., Toronto ON

Sylvain Nadeau, P.Eng.
NVH Specialist, Aerodynamics Product Engineering
Siemens VDO Automotive Inc., London ON

APPENDIX A - R&D Project Summaries

Vehicle Monitor - Active noise control

AUTO21 Project FIN – Interior Noise Environment of Automobiles

Collaborators :

- Université de Sherbrooke, Canada
- McMaster University, Canada
- McGill University, Canada
- Simon Fraser University, Canada
- University of Windsor, Canada
- Xilinx, Canada
- Sensor, Canada
- Siemens, Canada
- Soft db, Canada

Summary :

This project strives to alleviate automobile interior noises generated by two sources which pose unresolved problems :

- The **airborne noise** produced by the interior climate system (ICS) which is transmitted directly to the interior via the circulating air ducts, including circulating fans, compressor and evaporator of air conditioners, and duct flow noise; the noise from the radiator fan will also be investigated;
- The structure-borne road noise, which contributes significant levels of low frequency noise, especially at high speed.

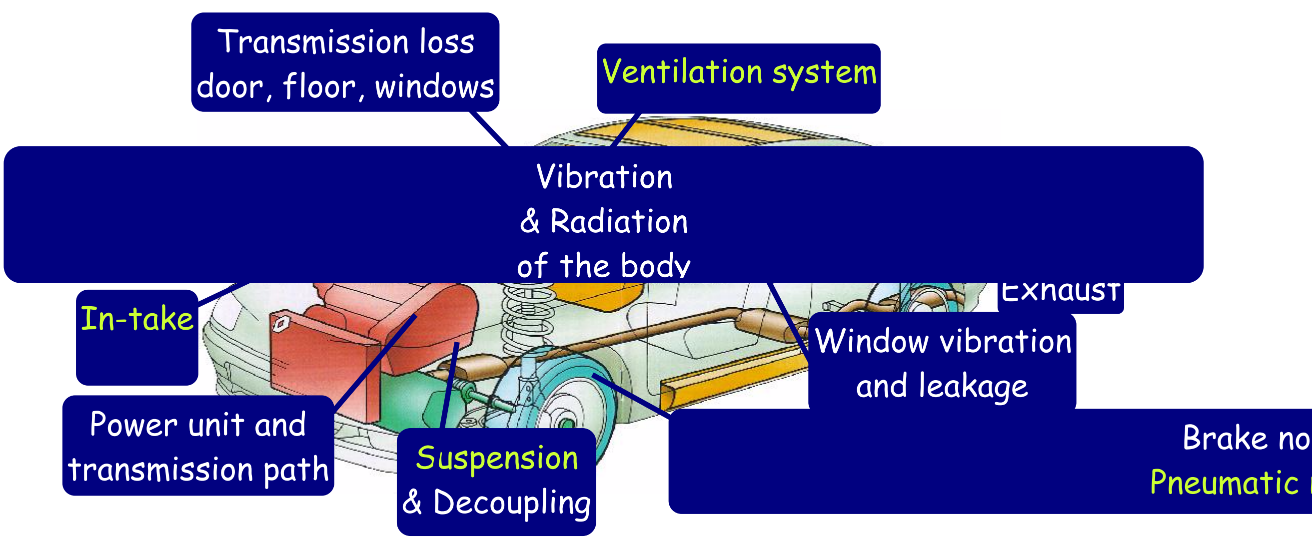


Figure 1.1 Acoustic Noise Sources

Driver Aids

AUTO21 - Project FCD (Collaborative Driving System)

Collaborator :

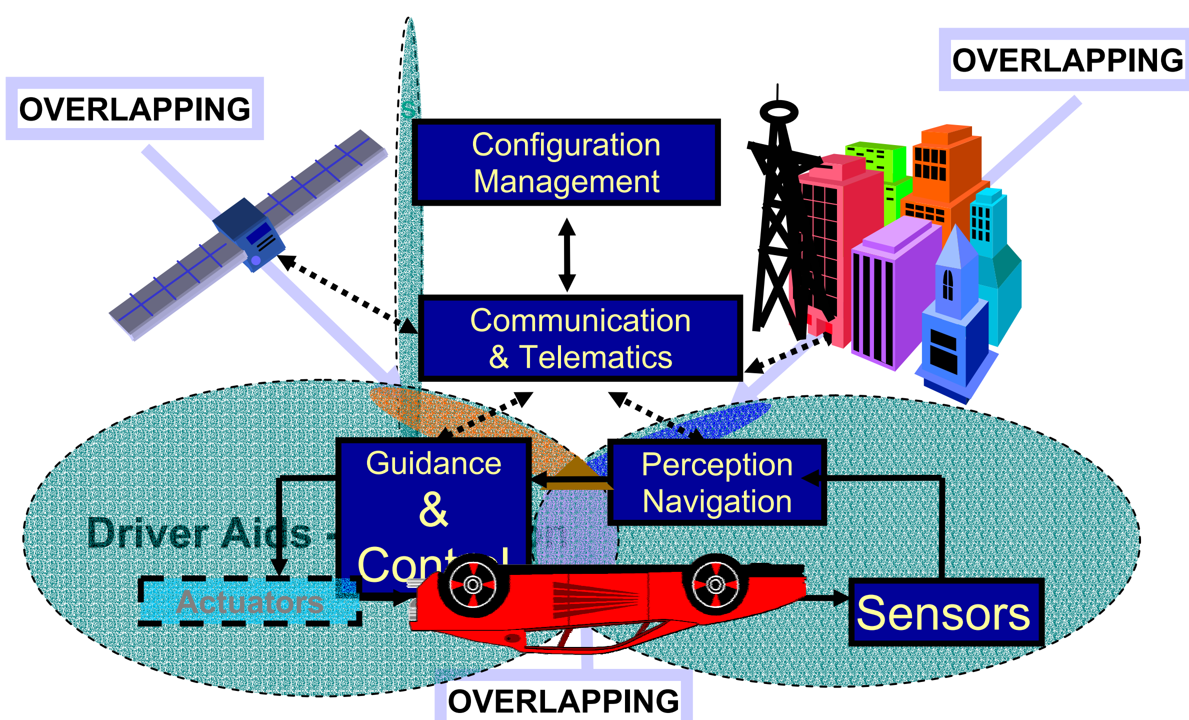
Université de Sherbrooke, Canada
University of Calgary, Canada
Université de Laval, Canada

Summary :

A Collaborative Driving System has been developed to automate the driving task on selected highway. Basically, the vehicles equipped with sensors, wireless communication devices and advanced control systems will follow automatically the vehicle in front of them. The vehicle at the front of a line composed of automated vehicles is normally driven by a qualified employee. The different parts of the system are shown in 0.

1. **Intelligent Sensors for Vehicle Perception & Navigation**
2. **Guidance & Control**
3. **Communication and Coordination Architecture**

Figure 1.2 Architecture of the Collaborative Driving System



Driver Aids

AUTO21 Project FII - Construction of an integrated navigation information infrastructure

Collaborators :

- University of Calgary
- Université de Sherbrooke
- Université de Laval
- Daimler Chrysler Canada Inc.
- AUG Signal
- Bell
- Manifold Data Mining Inc.
- Corimédia
- Natural Resources Canada
- Geomatic Canada

Goal of the project :

Design and develop an integrated information system as part of a global navigation infrastructure :

- To assist navigation
- To enhance on-board systems for safe driving
- To provide information to improve access to location-based information

Research subjects :

1) Augmenting the availability and accuracy of an estimated position with High Sensitivity GPS and Map Matching.

Map-matching techniques with vehicle movement modeling

- Better accuracy added to HSGPS which has a better availability but poor accuracy
- Combines HSGPS with Road network domain

Simulated GPS blockages and multipath in Urban Canyons

2) Applications in Traffic Monitoring and Control

- Real-time traffic simulations
- Real-time data from GPS
- Better traffic management and control

4) Runtimeieval of information contained in a database

5) Improving the performance of the positioning module

A positioning module includes a cluster of sensors which measure the kinematics, the attitude and the position of the vehicle and a fusion method which computes an optimal estimate of the vehicle's position based on the measurements. The goal is to analyse known existing fusion methods and new ones to improve the performance of the positioning module.

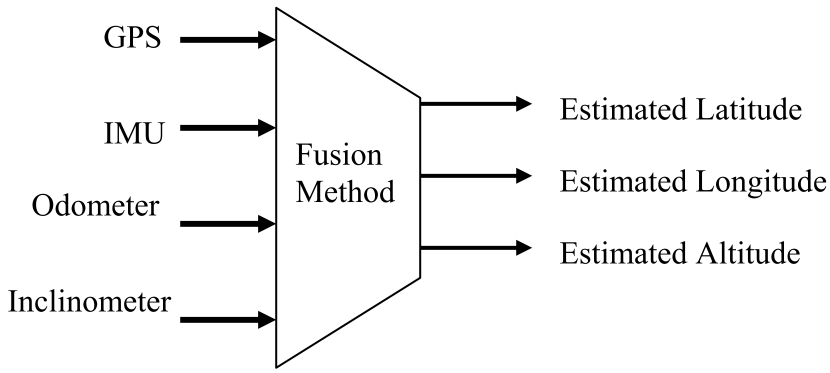


Figure 1.2 Basic scheme of a Positioning Module

Passenger Services

VICTOR

Collaborator :

Tetra Technologies, Canada

Reference :

Plan Mars 2001

Summary :

VICTOR is a system used for the management of a fleet of commercial vehicles. The system includes an on-board computer, a communication system and a management system software. With the enlargement of frontiers, new transportation rules and just-in-time distribution, fleet management systems are rapidly gaining popularity by providing fast access to accurate information on the vehicles composing the fleet. The on-board system collects data from the motor, various sensors, a GPS, an optical reader and the driver inputs. The driver inputs include daily activities, important messages and information on goods delivered and collected. At the fleet management center, system software allows the storage, classification and display of data collected by on-board systems and the creation of useful reports for the fleet dispatchers, the repairmen, the administrators or the customer service center. The data communication between the fleet management center, the different fleet company's departments and the vehicle are handle by an information gateway based on the Internet protocols.