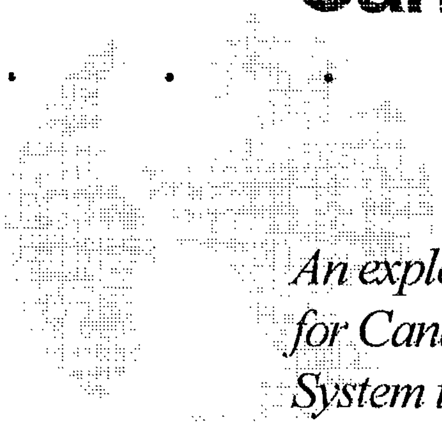
Strategy for Developing an ITS Industrial Base in Canada



An exploration of global opportunities for Canadian Intelligent Transportation System technology suppliers.

Strategy for Developing an ITS Industrial Base in Canada

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17: Abstract:

The report begins with an overview of the purpose of this strategic study and an analysis of the current ITS global environment from the perspective of the current state-of-the-art of ITS technologies as well as the activities of various key governments and organizations throughout the world. Four subsequent chapters build a global picture of the ITS market from the standpoints of "ITS demographics", market estimates, market accessibility issues, and an analysis of the competitive environment. These discussions focus primarily on the North American, European and Japanese markets, but also attempt to address some broader geographic scope through overviews of selected emerging industrial country markets in Latin and South America, as well as in Asia and the Pacific Rim. A Canadian ITS technology supplier perspective is then developed and compared to the world marketplace. Opportunities for Canadian industry are identified and national, multi-sector strategies and action plans for helping industry to take advantage of these are set out.

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17: Résumé

Le rapport début avec un survol de l'objectif du project ainsi qu'une analyse de l'environnement actuel du domaine des systèmes intélligents de transport (SIT). Les quatres chapitres suivants visent le marché global pour les SIT de diverse points de vue: la démographie des SIT; les prévisions du marché; l'accessibilité du marché; et une analyse de l'environnement competitif. Ces discussions traitent d'abord les marché Nord Americain, Européen, at Japonais. Ensuite, les discussions s'étendent sur d'autres régions: les Amériques Latin and Sud, ainsi que l'Asie.

Une perspective sur les fournisseurs des technologies des SIT au Canada suit, ainsi qu'une discussion de ceux-ci vis-à-vis les besoins du marché. Les opportunités globales pour l'industrie Canadien en SIT sont identifiées et des stratégies nationales ainsi que des plans-d'action pour appuyer l'industrie Canadien en SIT sont présentées.

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The contents of this report reflect the views of the authors and not necessarily the official views or opinions of the Aerospace and Defence Branch of Industry Canada or the Research and Development Directorate of Transport Canada.

Report Context

This report is one of a series of reports produced under the joint Industry Canada / Transport Canada study into: "Strategy for the Development of an ITS Industrial Base in Canada". It builds on these other reports and should be read in conjunction with them. The other reports in the series, most of which are available from Industry Canada, include:

- Assessment of Communication Needs and Standards for ITS (A. Waltho Engineering)
- Assessment of Geographic Information Technologies for ITS (Intergraph Canada Ltd.)
- Assessment of Positioning and Navigation Technologies for ITS (IDI Ltd.)
- Assessment of Sensor Technologies for ITS (IBI Group)
- Assessment of Display Technologies for ITS (IBI Group)
- Assessment of System Integration and Intelligent Software for ITS (IBI Group)
- Assessment of FM Sub-Carrier Broadcast Technology Applications for ITS (Lapp-Hancock Associates Ltd. and L-P Tardif & Associates)
- Benefit-Cost Assessment of ITS Implementation in Canada: IBI Group, SNC-Lavalin, Parvianen & Associates, A. Waltho Engineering, Richard Zavergiu)
- Assessment of the Demand, Markets and Commercial Development of the Global ITS Industry (SRI Consulting)
- Strategy for Developing an ITS Industrial Base in Canada (Delphi Systems Inc.)
- Survey and Assessment of Canadian involvement in ISO/TC-204 Standards for Transportation Information and Control Systems (E.R. Case & Associates)
- Intelligent Transportation Systems Applications for Improving Transportation for Elderly and Disabled Travelers. (A working paper by Transport Canada for Industry Canada)
- Application of ITS/Advanced Train Control Systems Technologies at Highway-Rail Level Crossings. (Prepared for Transportation Association of Canada by L.P. Tardiff & Associates, Parvianinen & Associates, and CANAC International Inc.)

For information on any of these projects, please contact:

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Extensive consultations were held with individuals and groups from government, industry and the private sector in the course of carrying out this work. These consultations were invaluable in helping to shape this document. Many people helped in this respect, including:

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Greg Bates	Department of Foreign Affairs and International Trade
Colin Rayman	Ministry of Transportation of Ontario
Melville Walker	CRAD, Department of National Defence

In addition to the above, over 30 ITS Canadian technology suppliers participated in our industry survey and numerous informal discussions were held with stakeholders in other government agencies and private sector groups in the course of our research. Space limitations do now allow us to thank all of these people individually, but their help and contributions are gratefully acknowledged.

Finally, we would be remiss if we did not mention the valuable contributions of the members of our research team:

Jennifer Buckley	Research Associate, Delphi Systems Inc.
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Executive Summary

Strategy for Developing an ITS Industrial Base in Canada

ES 1.0 Introduction: A Changing Transportation Context

> *New Technologies present both new opportunities and new challenges. When these technologies have far-reaching impacts, society cannot afford to allow itself to be driven by either the technology or the marketplace without attempting to channel the consequent changes in directions that produce the best possible results for all parties.*

J. Robinson & R. Ridley
A Strategic Plan for the Development of IVHS in Canada

Intelligent Transportation Systems (ITS) are a group of technologies that are changing the way in which we build, design, manage and operate our road transportation systems. Through these changes they promise to bring important benefits to society, both at the transportation level and at the level of building an industrial base necessary to develop and implement these technologies.

This study is about building an industry and the jobs that go with it. It is about mining an existing rich and well established high technology capability in this country to put in place an ITS industrial base that can participate in a new, technologically dynamic, and rapidly growing marketplace that is global in scope. This study is NOT about what government alone must do. It is about what all stakeholders in the potential ITS market - government, the private sector and academia - must do in partnership to ensure that Canada takes its place in this potentially lucrative global market.

ES 2.0 Goals and Objectives

The overall goal of this study was to facilitate the entry of Canadian companies into the ITS marketplace. We've approached this by providing fundamental intelligence about: our own industry capabilities; who we are competing against; technical areas where we have the best chance to be successful; and ways and means that we should exploit to achieve our goal.

The study focus is industrial. Its intent is to find ways to build our national ITS industrial base in this country. Its product is a set of recommended actions and directions for Canadian ITS stakeholders - including industry, government and academia. These actions are aimed at creating a solid and well-focused national partnership to ensure that Canadian industry plays a significant role in the global ITS marketplace, and that Canada reaps the jobs and growth in its high technology industries that flow therefrom.

ES 3.0 ITS Products and Terminology

New science and technology domains spawn new lexicons. Numerous dialects exist in the ITS world and for convenience we have settled on the ITS America categories of ITS user service bundles and user services as our primary technology descriptors.

ITS Nomenclature Map

User Services	*User Service Bundle*
• Enroute driver information • Route guidance • Traveler services information • Traffic control • Incident management • Emissions testing and mitigation	*Travel and transportation management*
• Electronic payment services	*Electronic payment*
• Public transportation management • Enroute transit information • Personalized public transit • Public travel security	*Public transportation operations*
• CV electronic clearance • Automated safety inspections • On-board safety monitoring • CV administrative processes • HAZMAT response • Freight mobility	*Commercial vehicle operations*
• Demand management • Pre-trip travel information • Ride-matching/reservations	*Travel demand management*
• Emergency notification • Emergency vehicle management	*Emergency management*
• Longitudinal. Collision avoid. • Lateral collision avoidance • Intersection collision avoid. • Vision enhancement • Safety readiness • Pre-crash restraint deployment • Automated highway system • Railway crossings	*Advanced vehicle control and safety systems*

Our overall study was focused on these ITS products and the technologies which enabled them. The latter come from a wide variety of companies not traditionally associated with ITS, or even necessarily transportation. The enabling technology sectors of interest to us were: Geomatics; Displays; Sensors; Positioning and Navigation Systems; Communications; and System Integration and Intelligent software suppliers.

ES 4.0 Global ITS Product Maturity

It is clear that there is a marked differentiation of ITS applications and their related user services in terms of their "readiness" for the marketplace. In the course of our work we looked closely at the various ITS products to assess their state of readiness as expressed by a measure which we termed Technology Maturity.

In so doing, we were able to distinguish a clear pattern of probable product deployment into three distinct groups: near term, medium term, and long term. While we did not attempt to attach specific years to each of these groups, we generally regarded near term as within 5 years; medium term as between 5 and 10 years; and long term as beyond 10 years.

The table below summarizes our general findings in this respect.

Technology Maturity Summary Table

Near Term Products (0 to 5 years)	Medium Term Products (5 to 10 years)	Long Term Products (beyond 10 years)
Commercial Vehicle Operations • Commercial vehicle clearance • Freight mobility • CV administrative processes • HAZMAT response • On-board safety monitoring	*Transportation Management* • Traffic control • Incident management • Emissions testing/mitigation • Route guidance	*Advanced Vehicle Safety* • Collision avoidance • Automated highway system • Vision enhancement • Safety readiness • Restraint deployment • Railway crossings
Public Transportation Operations • Public transportation management • Public travel security	*Travel demand management* • Ride matching/reservations	*Transportation Management* • Enroute driver information
Emergency Management • Emergency notification	*Public Transportation Oper.* • Enroute transit information	*Public Transportation Oper.* • Personalized public transit
Electronic Payment • Electronic toll collection		
Travel Demand Management • Pre-trip travel information		

The results of the analysis make sense. Technologies which we know are already being deployed do appear where they ought to. Freight distribution and logistics applications; automatic vehicle location and tracking technologies for use with both public transit and fleet management; and driver access and information for commercial vehicles and public transit fleets are all technologies that are actively being deployed due to market pull. Emergency notification and electronic toll collection are in a similar situation. These are key focus areas for ITS activity today.

At the other extreme, integrated traffic management systems (including dynamic multi-modal coordinated traveller information systems); safety status monitoring technologies; and automatic vehicle control applications are all ITS products which are currently in a technology push situation and for which the future is still uncertain.

A number of key technology issues which will affect the implementation of ITS technologies emerge from this analysis. Several are ubiquitous and appear against most, or all of the application areas. These were borne in mind in building our strategic program and related action plans for Canadian initiatives in the ITS area.

- Standards and interoperability are fundamental issues affecting ITS technology market penetration.
- Institutional constraints in the form of government budget cutbacks have a direct impact on the likelihood of ITS technology deployments.
- Technologies which are advancing the fastest in ITS are those which have developed proven performance records - usually through showcase or demonstration projects.
- Communications technologies will play a key role in the deployment potential of most ITS technology areas.
- ITS technologies which provide immediate "bottom-line" payback to users are those which are moving most quickly into deployment. Commercial vehicle and electronic tolling applications are good examples.
- User acceptance is a key to successful ITS technology deployments.

ES 5.0 International Efforts in ITS

Japan, Europe and the United States clearly lead the development and deployment of ITS technologies. All have had major ITS programs in place for some time - the Japanese since the late 1970's, the Europeans since the mid 1980's, and the US since about 1990. Governments, in partnership with the private sector have literally spent billions of dollars on R&D, demonstration projects, and now deployment. They are building strong industrial foundations from a combination of diversified defence and high technology industries.

From their experience, it is clear that there is no one mechanism that can be prescribed for a country that wants to develop its ITS capabilities. In most cases, the mechanisms that will work depend to a significant extent on the constitutional structure of the country and the traditional mechanisms that have been put in place to foster cooperation in the past.

In Europe, the contintental cooperation required has been fostered to a significant degree by the European Union effort, the ERTICO organization, and cooperative structures already in place. In Japan, the tradition of managed competition run through such agencies as MITI, has allowed that country to advance the development of its technologies in a structured and managed fashion, minimizing waste, and exploiting the strengths of the Japanese technology industry.

The United States has used the 1992 Intermodal Surface Transportation Efficiency Act (ISTEA) as the cornerstone of its ITS efforts from a financial standpoint. However, the creation of the Intelligent Transportation Society of America (ITS America) as a body which could bring together all of the parties interested in ITS to discuss, exchange information, and provide advice to the federal government on technical and policy issues has strengthened the ability of the various communities to work together.

The mechanisms differ from country to country, however the key ingredients are the same wherever ITS is moving ahead quickly:

- There is a national coordinating (not dictating) mechanism whose primary aim is to protect and promote national interests both domestically and abroad. This mechanism is usually an office (or offices) of the central government in some form: US DOT in the United States; MITI in association with other critical ministries in Japan; the European Commission Directorates on that continent.

- All sectors are involved: public, private, and academia. Government and private sector cooperation are seen as essential. Partnerships are the key to successful ITS development and deployment and both financial risks and benefits have to be shared in the longer term. The way to achieving such partnerships is often smoothed through some form of independent (or quasi-independent) group or society such as: ITS America (US), ERTICO (ITS Europe), ITS Focus (Great Britain), VERTIS (Japan).

- Catalytic funding from central government is available and is crucial to helping gain partnership involvement from other stakeholders.

- There is a heavy emphasis on demonstration projects - re-iterating the need for ITS to prove its worth through the demonstration of benefits but also providing a vital "showcase" function to allow domestic industries to demonstrate their abilities. This showcasing function is important not only from a "proof of benefit" point of view, but also from the standpoint of marketing domestic capabilities internationally.

- International cooperation and coordination are seen as keys to opening new market opportunities for national industries . Participation in such efforts - particularly in relevant standards setting activities is seen by all participants as being critical to protecting national industry interests and helping to ensure that ITS develops as a global marketplace. Shaping standards is closely related to helping to shape the marketplace.

ES 6.0 The ITS World Market

A number of key observations can be made regarding the world marketplace for ITS technologies.

- The ITS marketplace is still dynamic in terms of both growth and change. Projecting potential future market sizes on a general world basis is difficult at best, but by any standard - given the ubiquity of the need for transportation and the use of the automobile in both industrialized and emerging industrial countries, the market is very large.

- The technology market areas which are forecast to progress the most quickly are:

  ◊ Commercial vehicle operations in North America
  ◊ ATMS applications combined with ATIS in Japan, and ATMS applications oriented to traffic signal system adaptive control and coordination in Europe.
  ◊ Electronic toll collection, which, although limited in ultimate size, is undergoing a dramatic market pull in North America. Similar interest

appears to exist in emerging industrialized countries, although this was not included as part of our forecasts.

- A substantial market in the electronic tolling, CVO and ATMS areas appears to exist in emerging industrial countries. Our research indicates that it is being very actively pursued by international firms, as well as national organizations such as ITS America in partnership with FHWA on behalf of their national-level ITS technology suppliers.

The table below summarizes priority ITS user service markets by region.

ITS Priority User Service Markets by Region

Region	Major Thrusts	Initial Applications (near to mid-term)	Secondary Applications (longer term)
North America	• Commercial vehicle ops. • Electronic payment • Emergency management	• Freight mobility • CV electronic clearance • CV admin. processes • Electronic payment services • Emergency notification • Emergency veh. managm't	• Automated safety inspections • On-board safety monitoring • HAZMAT response • Route guidance • Public transportation management
Europe	• Transportation management • Electronic payment	• Traffic control • Route guidance • Traveler services information • Electronic payment services	• Incident management • Enroute driver information • Freight mobility • CV electronic clearance
Japan	• Transportation management • Travel demand management	• Traffic control • Enroute driver information • Route guidance • Incident management • Pre-trip travel information	• Traveler services information • Demand management
Other industrialized countries	• Transportation management • Electronic payment • Commercial vehicle ops.	• Electronic payment services • Traffic control • Freight mobility • CV electronic clearance • CV admin. processes	• Route guidance
Pacific rim	• Electronic payment • Transportation management	• Electronic payment services • Traffic control • Incident management	• Demand management • Pre-trip travel information • Route guidance • Freight mobility
Mexico and Latin America	• Electronic payment • Transportation management	• Electronic payment services • Traffic control	• Demand management • Freight mobility

Summaries of the world market ITS forecasts are provided on the page following. To simplify the presentation of these figures, we have grouped the application areas into five primary categories as follows:

- ATMS: corresponding approximately to the Travel and Transportation Management User Service Bundle.
- ETC: corresponding to the Electronic Payment Services bundle.

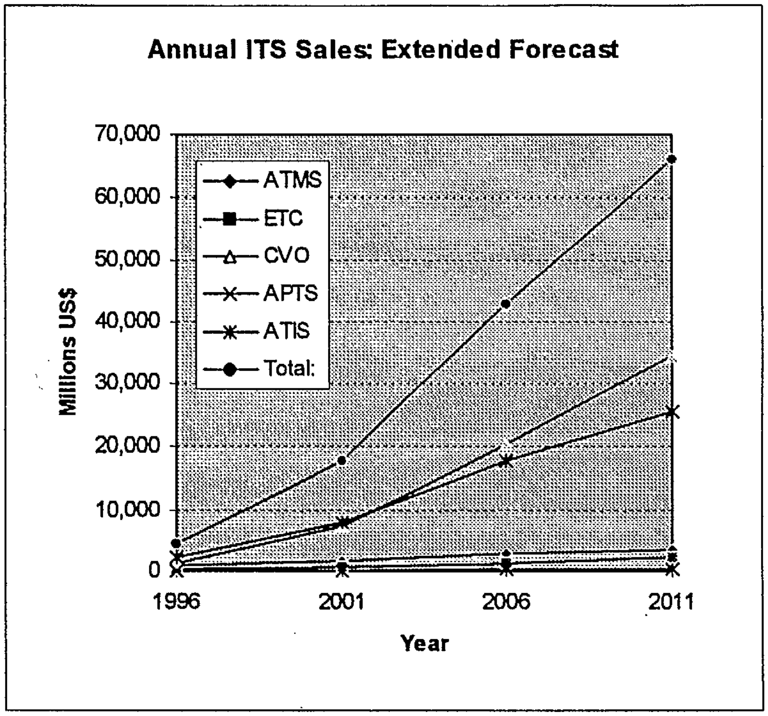
- CVO: corresponding to the Commercial Vehicle Operations bundle.
- APTS: corresponding to the Public Transportation Operations bundle.
- ATIS: corresponding approximately to the traveler information system components of the Travel Demand Management and Transportation Management bundles.

We did not attempt to forecast any markets for Advanced Vehicle Control and Safety Systems - because of the great uncertainties that are still associated with the direction in which these products will evolve.

The extended world ITS market forecasts summarized in the table below are referred to as such by virtue of the fact that they were developed from the core forecasts produced by SRI Consulting for North America, Europe and Japan. These base estimates were extended to include market estimates for other industrialized countries, the emerging industrial nations of both the Pacific Rim and Latin America/South America, as well as the unique markets of India and China.

Extended World ITS Market Forecast

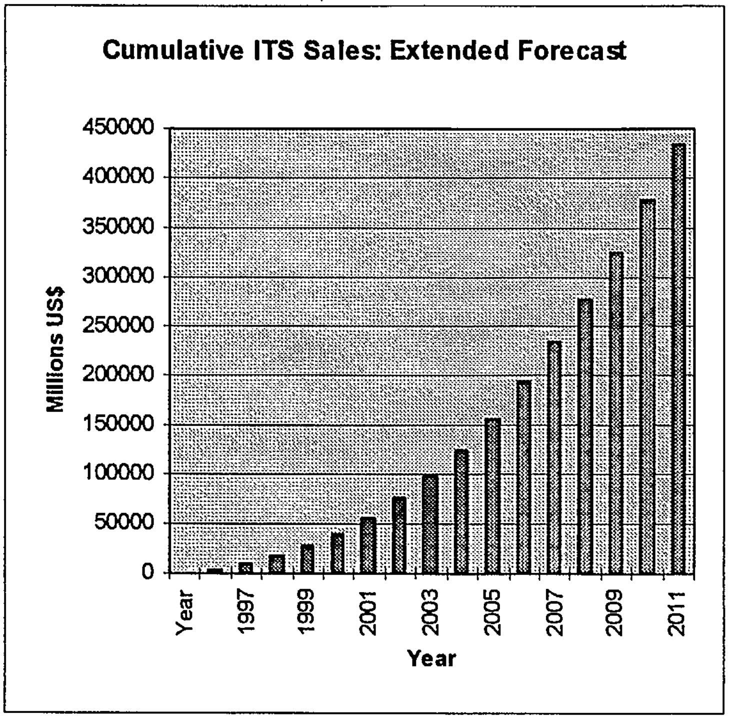
	1996	2001	2006	2011
	Millions of US$			
ATMS	997	1,640	2,735	3,472
ETC	205	776	1,428	2,113
CVO	1,143	7,348	20,311	34,635
APTS	59	136	385	408
ATIS	2,130	8,069	17,815	25,454
Total:	4,534	17,969	42,673	66,081



By the year 2011, annual sales of ITS technologies at the world level are forecast to reach over $66 billion per year. It's important to note that this very substantive sum includes both equipment and services. The latter in many cases may be provided by non-traditional transportation industries - in particular the communications sector - primarily because so many of the technologies related to in-vehicle services obviously rely on this sector. It's also important to note that it is exactly the types of service which rely on communications - services that provide real-time, quick-response information - that are valued most highly in the marketplace by both commercial and private client sectors alike. We estimate that this service-side market could represent over US$22 billion per year.

Projecting a cumulative market based on these forecasts indicates that cumulative ITS sales worldwide between 1996 and 2011 may reach over US$434 billion. The graph below summarizes this cumulative sales pattern.

Extended World ITS Cumulative Market Forecast
1996 - 2011



ES 7.0 The Canadian Context

Analysis of Canadian activities and particularly industry capabilities as they relate to ITS showed a picture of a small but well respected base industry already active in ITS with a substantial potential for significant future development in conjunction with enabling technology providers not currently active in the ITS marketplace. A number of observations were made:

- Canadian governments are active in ITS at all levels, although financial constraints mitigate against extensive programs. Nonetheless, Canada - and in particular the Province of Ontario was in the forefront of ATMS development with the COMPASS system, and is now responsible for a world's first all electronically tolled highway in the form of Highway 407 which is scheduled to open in the winter of 1996/97.

- Unfortunately, although this activity exists, there is little formal coordination between jurisdictions - other than that which has existed through ITS Canada. This low level of activity makes it difficult to develop showcase products for our industry capabilities. The significant role played by ITS America in that country suggests that current efforts underway to restructure and reinforce ITS Canada as a primary vehicle for national level coordination and information sharing between both the public and private sectors, are well justified.

- Canada does have some world-leading companies in the ITS area. These tend to be concentrated in the ITS areas with the most dramatic market pull: Commercial vehicle operations, electronic tolling, advanced passenger transportation systems. In the longer term we have solid expertise in the ATIS area - one of the largest long-term markets.

- Canada has world-leading capabilities in communications, and in particular in a number of sectors directly related to ITS. Market opportunities for both technology and service markets are excellent in this critical area that underlies all ITS technologies.

- Canada has strengths in all of the key enabling technology areas: GIS, displays, sensors, system integration and software, and positioning and navigation technologies. Nevertheless, some of our technologies are becoming dated and R&D funding to continue development is almost nonexistent. Partnership funding programs should be considered for this purpose.

- There is a distinct need for a national-level government office to coordinate and work with Canadian ITS industries in a number of key areas.

- Canada must participate in ITS standards setting activities in all areas including communications, or risk finding our industry shut out of the market.

- Proprietary attitudes in some government offices with respect to map data ownership and associated royalty charges has stifled industry development. Other departments have demonstrated excellent ability to work with industry. The latter example must prevail throughout.

- Key communications technologies should be pursued and developed in Canada in support of ITS. One suggested emphasis area is high data rate FM sub-carrier broadcasting.

- Industry is active and committed. The market is export oriented.

ES 8.0 The Potential Canadian Share

The analysis of Canadian industry capabilities leaves little doubt about the relevance of our active and latent industrial strengths. Our primary strengths in CVO and Electronic payment sectors tie exactly into the fastest moving areas of the ITS market. Our ATMS skills link strongly to that ITS bundle which, while secondary in the North American market, is forecast to move quickly in overseas markets, particularly in the emerging industrialized countries. Our secondary strengths in the Public Transportation - while playing to a relatively smaller portion of the market - are building on an already very strong worldwide installed market base - thus enhancing our ability to further capture market share.

To help better understand the match between our capabilities and the world marketplace, the table below matches forecast priority ITS market area developments with our capability areas by highlighting in bold italic those user services in which we are recognized as having significant strengths.

At the user service level, not all user services have been included as Canadian strength areas in recognition of the coarseness of the "bundle-level" capability measure and the known focused nature of some of our strengths.

Canadian Capabilities and the World Market
(Canadian technology strength areas shown in **bold** type)

Region	Major Thrusts	Initial Applications (near to mid-term)	Secondary Applications (longer term)
North America	• ***Commercial vehicle ops.*** • ***Electronic payment*** • ***Emergency management***	• ***Freight mobility*** • ***CV electronic clearance*** • ***CV admin. processes*** • ***Electronic payment services*** • Emergency notification • Emergency veh. managm't	• Automated safety inspections • On-board safety monitoring • HAZMAT response • Route guidance • ***Public transportation management***
Europe	• ***Transportation management*** • ***Electronic payment***	• Traffic control • Route guidance • Traveler services information • ***Electronic payment services***	• Incident management • Enroute driver information • ***Freight mobility*** • ***CV electronic clearance***
Japan	• ***Transportation management*** • Travel demand management	• Traffic control • Enroute driver information • Route guidance • Incident management • Pre-trip travel information	• Traveler services information • Demand management
Other industrialized countries	• ***Transportation management*** • ***Electronic payment*** • ***Commercial vehicle ops.***	• ***Electronic payment services*** • Traffic control • ***Freight mobility*** • ***CV electronic clearance*** • ***CV admin. processes***	• Route guidance
Pacific rim	• ***Electronic payment*** • ***Transportation management***	• ***Electronic payment services*** • ***Traffic control*** • ***Incident management***	• Demand management • Pre-trip travel information • Route guidance • ***Freight mobility***
Mexico and Latin America	• ***Electronic payment*** • ***Transportation management***	• ***Electronic payment services*** • ***Traffic control***	• Demand management • ***Freight mobility***

The following observations are made regarding this and related analyses.

- North America - in the form of the US market - is a key area. The potential is there, and the match of market to skillset is close. We know the market. Alliances already exist. Intergovernmental cooperation and mechanisms for working together are in place. Cross-border government/industry partnerships have worked well in the past, and the environment, although very competitive, is well known.

- Emerging industrialized countries in the Pacific Rim and Mexico/Latin American regions are a second prime market for our ITS technology providers. Once again, market needs in the form of ETC, traffic management and freight mobility map exactly to Canadian capabilities. This area must be a high priority. This same perspective applies to China and India, although the likely slower pace of development of that market should be recognized.

- Other industrialized countries are likely to offer a third excellent match to our skillsets. Canadian skillsets and company scales play well to this market. Culturally, we are often more suited to these areas than other, larger offshore competitors because we are less of a threat and more of a partner.

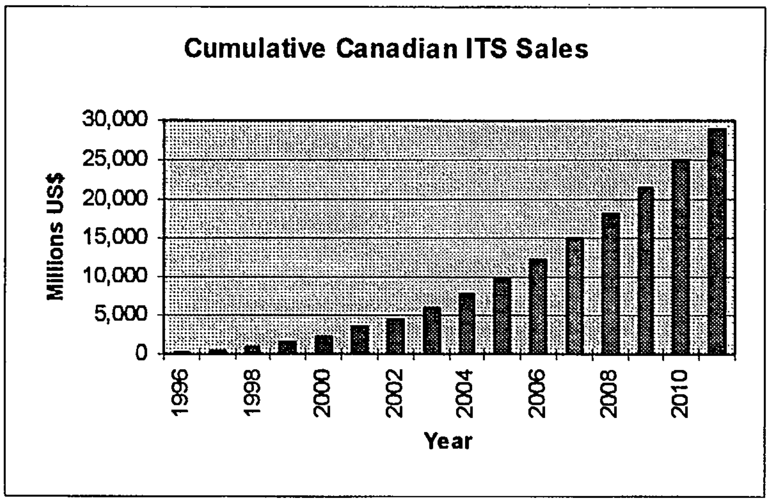
- Europe could offer a potential market, but European business practices, and culture often mitigate against offshore companies except in very niche areas, or where technology alliances are completely complementary. In some areas, such as Public Transit management we are already in place and competing. We recognize this, and cite it as an example of excellent niche marketing practice. Alliance and niche marketing should form the basis for our market efforts here, but they should probably take a back seat to the primary areas.

- While Japanese markets are impressive in some ITS areas, they match poorly with our current strengths. In addition, this market is often tightly closed to offshore industry except possibly for component supply in niche technological areas. Japan should be regarded as a tertiary market.

The table and figure below summarize the quantitative forecasts of Canadian market share. These figures should be read with caution, and readers interested in knowing more about the underlying assumptions should refer to the full final report for this project.

Projected Canadian ITS Market Shares

	1996	2001	2006	2011
	Millions of US$			
ATMS	63	117	210	278
ETC	43	164	320	477
CVO	114	735	2,031	3,464
APTS	6	14	39	41
ATIS	21	161	356	509
Total:	248	1,191	2,956	4,768



ES 9.0 Our Strategic Philosophy

> *Anyone who is practically acquainted with scientific work is aware that those who refuse to go beyond fact rarely get as far as fact.*
>
> *Thomas Henry Huxley*

Anyone who has worked in business forecasting is familiar with the act of going beyond fact. Investors do it every day. But in the world of government - with constrained budgets and the increasing restlessness of taxpayers - taking risks is something that is getting harder and harder to do.

If the primary reality of the ITS world is about taking risks, then its immediate second is about sharing them. Our fundamental philosophy in developing our strategies turns around the concept of partnership and cooperation among stakeholders. ***Partnership, shared risks and shared benefits have been the cornerstone of global ITS progress to date and provide the primary basis for our strategic approach.***

Our focus is the ITS technology industry - not the transportation service sector. ***Our primary goal is to create high value employment opportunities for Canadians*** by helping the Canadian ITS industry to establish a strong presence in the global marketplace. ***Our orientation is export.*** This is where the real ITS marketplace is, and this is how real wealth is created in a country - by selling to people outside domestic borders. By virtue of Canada's small population, low densities and terribly constrained government economic circumstances, the domestic ITS market will provide an arena for minor showcase opportunities, little more.

Our market is global, so our competition is as well. We regard market profile and intelligence to be fundamental to our strategic approach. Technology is what ITS is all about, hence a ***strong intelligence capability that focuses on the enabling technologies***, and not the transportation application itself, is crucial. ***Participation in helping to shape those technologies through standards setting activities is crucial.*** Standards shape the marketplace and can be direct instruments of market access control. They cannot be left to others to determine.

The ITS world is marked by rapid change in products, applications and enabling technologies. Other national governments are investing literally billions of dollars <u>in partnership with industry</u> in major ITS technology development and demonstration programs. Most are using national technology resources such as their government research laboratories to further help develop their capabilities. Our own national efforts must attempt to emulate this approach insofar as our constrained circumstances will allow. Focus, based on solid technology intelligence, will be critical to such programs.

Finally, someone has to bring this all together and provide coordination and leadership. This is an industry building activity. It is national in scope. It's potential is substantial. It's about creating jobs. It has to be a government function and in our strategy two key federal agencies are identified as having significant roles: Industry Canada and Transport Canada. Many other federal agencies such as NSERC, IRAP, Geomatics Canada, various government laboratories (NRC, Communications Research Centre, various defence research establishments etc...) will also have important roles to play.

Four strategic axes of activity are recommended: Market development; Technology Intelligence; Industry development; and Standards setting participation. The actions within these axes will build on the use of existing programs and resources within government. Establishment of an ITS desk within Industry Canada is strongly recommended. In addition, Transport Canada must play a key role in the Standards setting process as well as in the funding (through its Transportation Development Centre) of ITS-oriented research and development in support of industry. Cooperation and coordination between these two key federal agencies is essential.

ES 10.0 Key Observations and Recommendations

Radical changes in technologies which underlie fundamental elements of societal structure inevitably lead to dramatic industrial echoes. These are rare events and represent significant opportunities for those that are ready to take advantage of them. This is the case with Intelligent Transportation Systems. As Koji Kobayashi wrote in his introduction to the Club of Rome publication Information Technology and Civilization:

> *Let us not ask what the future holds in store. It is ours to build.*

The following observations and recommendations are geared to achieving this goal.

ES 10.1 Observations:

ES 10.1.1 General

1. Intelligent Transportation Systems represent a new paradigm in the transportation field. With that new paradigm comes the opportunity to develop the industry base to deploy and serve its technologies.

ES 10.1.2 The Global Marketplace

1. The potential global ITS marketplace is very large. Annual sales could reach almost US$ 19 billion by 2001, US$ 43 billion by 2006, and US$ 66 billion by 2011. Cumulative sales between 1996 and 2011 could exceed US$ 430 billion.

2. Key ITS technology areas which are technologically mature and subject to strong market pull include commercial vehicle operations, electronic toll collection, emergency management and public transportation management. In Japan, advanced traffic management and advanced traveler information systems are moving quickly ahead.

3. Canadian capabilities match these key ITS technology markets extremely well. We have strong and proven skillsets in commercial vehicle operations, electronic payment systems, and public transportation management. Our secondary skillsets in advanced transportation management systems are also well recognized.

ES 10.1.3 Canadian Opportunities

1. Canadian ITS industries could see global annual market sales of over US$ 1.2 billion by 2001, US$ 2.9 billion by 2006, and US$ 4.7 billion by 2011. Canada's cumulative share of global sales between 1996 and 2011 could exceed $US28 billion. This is virtually a 100% export market.

2. The US is a key market area for Canadian ITS technology suppliers. We are well established and recognized there, have a proven track record, and successful alliances in place that help our market penetration.

3. Emerging industrialized countries in the Pacific Rim and Mexico/Latin America are a second major market area for Canadian ITS suppliers - in this case for ETC, ATMS and CVO technologies: all areas of Canadian technology strength.

4. Other already industrialized countries could offer a good potential market, since they generally have characteristics similar to those of the US or Europe and will probably have ITS technology needs that focus on CVO, ETC and public transit applications to begin with. All of these are areas of Canadian strength.

5. Although undetermined in size, niche ITS applications for elderly and handicapped transportation are seen as excellent candidates for Canadian technology suppliers. We have strong skillsets and proven track records in developing these technologies. The demographics of populations in industrialized countries suggest that this market is rapidly increasing in size and could be very lucrative in the next two decades.

ES 10.1.4 Other Market Observations

1. Europe is seen as a secondary market - primarily because of differing technology priorities, but also because of impediments to market entry.

2. The Japanese market is probably closed to Canadian industries except as a minor component supplier of niche technologies.

3. Domestic ITS markets will be very limited in the future - primarily because of the very constrained financial conditions under which most provincial governments are operating. Domestic marketing efforts should be oriented to developing showcase opportunities that can be used as marketing tools for Canadian industries. The highway 407 electronic toll road is a good example of such an application, although it is much larger than any that are expected to proceed in the future.

ES 10.1.5 The Canadian Context

1. Lack of showcase projects is making Canadian industry progress difficult offshore, although we do have world-leading companies in CVO, ETC and APTS technologies.

2. Canadian strengths in communications are world leading. Strong opportunities exist in this area.

3. Canada has good strengths in all of the key enabling technology areas for ITS: GIS, displays, sensors, system integration and software, and positioning and navigation technologies. However some of our technologies are becoming dated. R&D funding is difficult to find and Canadian company positions in some areas will weaken if steps are not taken to help support them,

4. The weakness of our current ITS coordination efforts in Canada has hampered our ability to compete in the world marketplace. A need exists for such a function. It must be ITS technology industry oriented and must bring together both public and private interests. The combination of the two key federal agencies - Industry Canada and Transport Canada - together with the restructured ITS Canada organization could provide a much stronger force for such coordination.

5. Standards are a key to the ITS marketplace. Although we have succeeded in tracking standards activities, and have participated to some degree, a much more proactive position is needed. Most countries are using standards committees and processes to push their own domestic technologies and shape the marketplace. Our absence from these committees could threaten our market position. Transport Canada and Industry Canada must work cooperatively and strongly in the various international standards committees and venues to ensure that our interests are not only protected, but also promoted. Close cooperation with U.S. efforts at standardization for ITS is also critical.

ES 10.2 Recommendations

ES 10.2.1 Leadership Roles

1. A four-axis strategy is recommended to assist in the development of an ITS industrial base in Canada. The strategy should focus on market development, technology intelligence, industry development and standards setting participation.

2. Industry Canada and Transport Canada must take the lead Federal government roles in supporting Canadian ITS efforts in the future in Canada. Working cooperatively together and with the private sector, these two key agencies should strive to implement the four-axis strategy outlined earlier.

3. ITS Canada - the not-for-profit group established to foster ITS industry development and technology deployment - should play a major role in providing a strong interface between government and the ITS technology industry. The group should be invited to work closely with both Industry Canada and Transport Canada in all aspects of the development of the

Canadian ITS industrial base - providing both coordination and advice to the two lead federal ministries.

ES 10.2.2 Implementing the ITS Industry strategy

1. We strongly recommend the establishment of an ITS desk or sector within the current Industry Canada structure. This desk would assume responsibility for implementing portions of the four axis strategy aimed at helping to build our ITS industrial base in this country, with a particular focus on market development (showcasing Canadian capabilities), industry development and technology intelligence, as well as supporting Transport Canada in key standards setting activiy participation. The estimated annual cost for this office is in the order of $595,000.

2. We strongly recommend that Transport Canada take a proactive role in international standard-setting activities for ITS - with a particular focus on close cooperation with US ITS agencies. It should do so in close collaboration with Industry Canada - particularly in respect of communications standards. In addition, Transport Canada should continue its support of industry oriented technology research and development in ITS through its facilities in the Transportation Development Centre (TDC).

3. The new Industry Canada ITS desk must play an important and proactive role in helping Canadian ITS industries to build both domestic and offshore alliances. Offshore alliances in particular are usually essential to penetrating local market areas for technology.

4. Other countries have clearly demonstrated that government/industry partnerships are an essential part of developing a strong ITS industrial base. Any future efforts in Canada must take such an approach. The new Industry Canada ITS desk must foster such partnerships as part of its mandate.

5. Existing federal government departments and sectors with responsibilities for international trade and export assistance will have important roles to play within the scope of their current programs in assisting the Industry Canada ITS office in its marketing and business intelligence efforts. The new Industry Canada ITS desk must actively foster and coordinate such a program as part of its mandate.

6. Existing federal government laboratories and technical installations with expertise and technologies applicable to the ITS field could play important roles in supporting continuing ITS industry product RD&D in this country. These facilities will be expected to assist the Industry Canada ITS desk in its efforts to support domestic ITS industry capabilities within the scope of their normal operating programs. The new Industry Canada ITS desk must promote and facilitate such cooperation and support as part of its mandate.

7. Although new funding for ITS RD&D is not recommended, existing sources of funding, including the new TPC program, but also looking at the NSERC research partnerships and Industrial Chair programs and other funds, all must be encouraged to support Canadian ITS industry efforts within the scope of their normal programs. The new Industry Canada ITS desk should assist industry in realistic efforts to take advantage of these

programs as part of its mandate. In addition, as noted earlier, Transport Canada should continue to promote, foster and fund ITS-related R&D through the Transportation Development Centre (TDC).

8. The Government of Canada crown copyright policies on digital map data should be reviewed and updated to allow greater cost-effective industry access to them. This will help encourage domestic growth in GIS and navigation based ITS application skillsets.

9. High-rate FM subcarrier broadcasting technology should be a high priority for Canadian applications. Related studies have recommended a $2 million field trial of this technology. We strongly support this recommendation.

10. The need for support for technology R&D is an ongoing problem cited by ITS industry participants. Foreign governments have literally spent billions of dollars in partnership with their industries in developing and demonstrating various ITS technologies. Canada must find a way to accomplish the same goal, even if on a much more limited scale. Technical focus will be essential in this respect. ITS Canada - working with both key and supporting federal departments and laboratories - could play an important role in helping to define priorities and thrusts for such efforts.

ES 11.0 The Next Steps

We recommend a number of immediate actions which should flow from this study.

1. A national level conference should be held on building Canada's ITS industrial base. Involving all ITS stakeholders (from government, the private sector and academia), this conference should focus on taking the first steps to building a true government/industry partnership focusing on ITS. The conference should be jointly organized by Industry Canada, Transport Canada and ITS Canada.

2. A national level workshop on communications needs and issues related to ITS standards should be sponsored jointly by Industry Canada, Transport Canada and ITS Canada. Its aim should be to provide all ITS stakeholders with intelligence on standards-related activities in ITS over the past two years as well as to raise awareness in the communications sector with respect to the future communications needs of ITS and their significant market potential.

3. In any event, the information gathered and developed in the course of this project and its numerous supporting and related studies should be made available to all Canadian companies, universities and agencies with interests in ITS. One way to facilitate this task would be to carry it out under the aegis of or in cooperation with ITS Canada.

Table of Contents

NOTE

The report contains extensive tables and figures used to illustrate key elements of the analysis. These have been integrated into the text of the report and must be read in conjunction with that text in order to properly understand the context of the information illustrated or summarized therein. We have deliberately structured the Table of Contents in a very detailed fashion in order to allow readers wishing to find a specific type of information or intelligence to refer to it to easily find the relevant section and proceed to that part of the report where such figures and tables will be found together with the appropriate text. It is essential that figures and tables NOT be read out of context. In order to obviate that possibility, we have deliberately omitted structured lists of tables and figures.

APPENDICES

Chapter 1: Introduction

1.0 A changing transportation context

> *New Technologies present both new opportunities and new challenges. When these technologies have far-reaching impacts, society cannot afford to allow itself to be driven by either the technology or the marketplace without attempting to channel the consequent changes in directions that produce the best possible results for all parties.*

J. Robinson & R. Ridley
A Strategic Plan for the Development of IVHS in Canada (1)

Intelligent Transportation Systems (ITS) are a group of technologies that are changing the way in which we build, design, manage and operate our road transportation systems. Through these changes they promise to bring important benefits to society, both at the transportation level and at the level of building an industrial base necessary to develop and implement these technologies.

This study is about building an industry and the jobs that go with it. It is about mining an existing rich and well established high technology capability in this country to put in place an ITS industrial base that can participate in a new, technologically dynamic, and rapidly growing marketplace that is global in scope. This study is NOT about what government alone must do. It is about what all stakeholders in the potential ITS market - government, the private sector and academia - must do in partnership to ensure that Canada takes its place in this potentially lucrative global market.

1.1 Some technical background

1.1.1 Overview

ITS technologies which allow us to improve the usage and safety of our highway system cannot solve all of our problems, but coupled with demand management techniques and some degree of infrastructure expansion, do appear to provide a practical and available alternative to the traditional way of doing business. The key to ITS is its ability to bring together the road user, the vehicle and the road infrastructure in one communicating system. This integration allows these elements to exchange information in order to allow for better management and use of the resources available.

The principles of ITS have an analog in the military field that is referred to as C^3I - command, control, communications and intelligence. ITS technologies provide these capabilities to the road transport system participants. It is this shift from the provision of a passive road system used by a "remote" and unconnected user, to a single, communicating and carefully controlled system in which all participants have access to information on system conditions, which represents the "Paradigm Shift" that is so often mentioned when people talk about ITS. We are moving from a passive to an interactive road transport system, and it is this ability to provide for interaction that allows the substantive improvements in cost effective use of road resources.

1.1.2 The "Participants" in ITS:

To get a better idea of how ITS is changing the road transport system,and how technologies can be used to accomplish this, it's useful to look at the potential functions of ITS within each of four key components or "participants" in such a system: the road, the user, the vehicle and the communications system.

ITS technologies allow us to do four different types of things with **the vehicle**: locate, identify, assess, and control. The ability to locate a vehicle within a frame of reference (ie. a map) is a key to successful fleet management and to providing in-vehicle navigation and routing advice. The ability to identify a vehicle without stopping or slowing it could allow us to better enforce regulations, charge tolls, price road use, facilitate border crossings, assess weight-distance taxes, track freight or critical cargo movements and other related functions. Being able to assess vehicles without stopping them is essential to cost effective enforcement of both vehicle size and weight regulations and vehicle-oriented safety rules. Finally, enhanced automated control functions on vehicles could help both improve safety and the efficiency of use of our road networks.

ITS can offer two primary functions with respect to **road users**: navigation, and monitoring. Navigation functions can include in-vehicle navigation, route guidance, and even dynamic route guidance in response to changing conditions on a road system. The ability to monitor driver performance and condition in order to detect fatigue, inattention, or other circumstances which might be of concern could help lead to the provision of a safer and more comfortable driver environment.

ITS offers four primary functions with respect to **the road** : monitoring, detection, control and administration. Monitoring functions can apply to such applications as weather and environmental conditions, as well as to traffic conditions. While monitoring however, certain specific occurrences may have to be noticed - hence the detection function of ITS - which might be applied to the detection of the presence (or absence) of vehicles in certain locations (as we do now at traffic signals etc.), or to the detection of an incident such as an accident, or other non-recurring interruption to traffic flow. Control functions refer to the kinds of activities which are now done with traffic signals and other such devices. Finally, road adminstration could be thought of as functions relating to regulatory enforcement or toll/road pricing collection.

Communications is what makes ITS work. The ability to move information around between the three "participants" in the system provides the necessary linkage to allow for the gathering of data which can be processed to become intelligence, and which can then used to determine and take appropriate command and control actions.

Readers interested in additional technical detail on ITS technologies can find more information in the primer bound with this report under Appendix A.

1.2 Why we're interested in ITS: System improvements

Intelligent transportation systems (ITS) represent a group of technologies which are evolving as a result of the need to respond to congestion and safety problems on the world's highway systems. The inital impetus for much of the work in this area has come from the European and Japanese communities, where such problems are demonstrably more severe than in Canada, although in recent years, the United States has also become a leader in the field through its determined efforts to move quickly into the continuing development and implementation of ITS technologies. The primary transportation system benefit of intelligent transportation systems is their ability to allow us to deal with congestion, safety and transportation efficiency concerns in a more cost effective and environmentally sustainable way than the simple expansion of infrastructure.

The concerns that have stimulated activity in ITS elsewhere, are valid in Canada as well. In 1994 alone, there were over 3,200 fatalities and about 245,000 people injured on Canadian roads (2). Estimates by Transport Canada put the total monetary value of these accident losses at over $14 Billion (3). Even a marginal improvement in safety could thus result in a significant dollar saving to society each year. Unfortunately, current statistics suggest that these problem areas are not likely to diminish in intensity in the future. In 1994, Transport Canada found that there were over 17.8 million registered motor vehicles, and more than 19 million drivers in the country (2).

These numbers are expected to continue growing. Predictions from a Transportation Association of Canada study , "Canada's Highways: The Future", (4) forecast increases of almost 30% and 25% respectively in the number of registered passenger vehicles and licensed drivers, by the year 2001. The same study notes that without significant expansion of the highway system by that time, the number of drivers per kilometre of road will rise from 19.2 to over 24, and the number of vehicles (cars and trucks) per kilometre will increase from just under 19 to over 25. Given these circumstances, it appears unlikely that the problems of safety and congestion on our highways are going to go away.

Safety and congestion problems directly impact on the efficiency of our road transportation system. Increased congestion results in slower travel times and increased costs for the movement of both goods and people. Because transportation costs often represent an important component of the cost of a good, the resultant loss of productivity impacts directly on our ability to be competitive in an increasingly aggressive world market. In their report on US ITS market estimates, Frost & Sullivan note:

> *Prevailing economic wisdom maintains that an advanced country will not be able to compete in the 21st Centrury with a dilapidated national infrastructure. Transportation infrastructure is a major component in the economic vitality of any nation.* (5)

In addition, the stop and go traffic conditions associated with severe congestion result in increased energy use and vehicle emissions. Both of these effects run counter to current societal values.

Unfortunately, the traditional response to such problems - that of expanding highway infrastructure to accommodate increasing demand - is no longer a viable option in many cases. Decreased budgets and increasing concern by society with respect to the environmental and social costs of new highway construction or existing road expansion, mitigates against infrastructure expansion as the only means of coping with problems on our highway networks. Intelligent Transportation Systems technologies provide us with at least a part of the solution to this problem.

1.3 Why we're interested in ITS: A growing world market

Obviously the transportation system benefits of ITS interest us - but there is an equally interesting and challenging prospect that is facing us from the standpoint of industrial benefits. ITS technologies are new and evolving. They are a product of high technology, knowledge-based industries in which Canada has proven, world-level capabilities. The potential marketplace is large, and global. Internationally, the process of research, development and demonstration (RDD) in ITS products has seen very substantial levels of investment in Japan, Europe and more recently the United States, as various nations not only try to cope with their transportation problems, but also develop their industry capabilities to market ITS technologies around the world.

The ITS area is still relatively new, and consequently market estimates for various application areas have varied widely. Initial estimates prepared for the ITS America Strategic Plan indicated that cumulative expenditures on ITS technologies and services in the US alone could reach a level of US$220 billion by 2011 (6). Of this amount, over $US170 billion represented consumer-related costs. While the accuracy of this and other market estimates is still being questioned through a succession of market studies, there is one point on which all parties agree: the market is very large and more than justifies the substantial effort being put into RDD by the public and private sectors alike (7). Primary marketplace questions now relate more to the pace of development of individual ITS technology sectors rather than the ultimate market size (8). For Canadian industry to take advantage of this potential market, a national environment must be created which will help to foster domestic capabilities and promote them to the world.

The recent (March, 1994) Transport Canada/Industry Canada study on the development of a Strategic Planning Document for ITS in the country identified industry promotion and fostering actions as one of the seven primary Action Areas of the Strategic Plan. The mission statement for that area was:

> *There is ample evidence that a vital domestic industry for ITS is desirable for several reasons: to generate economic activity for the funding of growth and R&D; to spread knowledge of ITS products; to stimulate end-user demand' and to provide a basis for competing internationally. Action plans in this area must reflect efforts to stimulate the domestic ITS industry.* (1)

This study follows the direction set by this recommendation. Its focus is industrial. Its intent is to find ways to build our national ITS industrial base in this country. Its product is a set of recommended actions and directions for Canadian ITS stakeholders - including industry, government and academia. These actions are aimed at creating a solid and well-focused national partnership to ensure that Canadian industry plays a significant role in the global ITS marketplace, and that Canada reaps the jobs and growth in its high technology industries that flow therefrom.

1.4 Goals and objectives

The overall goal of this study was to facilitate the entry of Canadian companies into the ITS marketplace. We've approached this by providing fundamental intelligence about: our own industry capabilities; who we are competing against; technical areas where we have the best chance to be successful; and ways and means that we should exploit to achieve our goal. This approach was intended to fulfill the objectives of the study as set out in the original terms of reference:

- To undertake an assessment of Canadian industries' capability in ITS technology and systems
- To evaluate threats to Canadian industry from other countries' programs
- To identify opportunities for Canadian industry in providing ITS technologies, services and systems in Canadian and foreign markets

- To identify ways by which Canadian companies can compete successfully in domestic and international markets

1.5 Context and scope

This work was not carried out as an isolated study. It was conceived and executed as part of a larger joint effort by Industry Canada and Transport Canada entitled: "Strategy for the Development of an ITS Industrial Base in Canada". As noted in the introductory pages to this report, we've built much of our effort using related work including a series of technology assessments in the areas of: communications, geographic information systems (GIS) for transportation, positioning and navigation technologies, sensors, display devices, and systems integration and software capabilities. In addition, associated studies in both global ITS market forecasts and the costs and benefits of ITS were also part of our overall input framework. A complete listing of the studies which fell under the strategic development umbrella can be found on page (v) of this report.

From a technology standpoint, although the name Intelligent Transportation Systems implies a multi-modal environment, the ITS marketplace is really still primarily focused on the highway systems. Many experts argue that the original name applied to this group of technologies - Intelligent Vehicle-Highway Systems (IVHS) - is still more applicable than its newer, more encompassing label in reflecting the true nature of ITS activity around the world today. While we touch on intermodal issues in some aspects of our work, we have addressed the ITS marketplace as it is now defined and forecast to develop in the future by its own stakeholders.

In looking ahead at how the industry might develop in the future, we have followed the path set out by most researchers working in this area and recognized the limitations imposed upon what we can reasonably forecast about a rapidly developing and changing technology area. Thus, in examining the likely technology development path we have dealt with two primary time frames: a near term up to three years ahead; and a longer term out to 10years. In reviewing future ITS markets, we have generally followed the model provided by our primary input studies and have not attempted to extend any forecasts beyond a 15 year envelope (a 2011 horizon year).

Finally, in developing our action plans and industry impact statements we have structured our approach in recognition with the primary industry sectors with interests in ITS: Aerospace and Defence; Automotive; Transportation; Information Technologies and Industries; and Communications Development and Planning.

1.6 Our methodology

Our work has been concerned with the development of "intelligence". As such, our efforts - while supplemented with consultations and some degree of information gathering - have focused primarily on the analysis and interpretation of the work of others. The core of our information came from the previously cited studies which fell under the strategic umbrella of this joint Industry Canada / Transport Canada ITS effort. A great deal of supplementary published information was also reviewed.

In sorting through all of this, we have used a "lines of evidence" approach to developing our final picture and recommended actions. By looking at a variety of independent information sources addressing different aspects of ITS global activity we were able to identify coherent technology and marketplace development patterns which provided the basis for our view of the future. We used this to develop what we have termed an "ITS World Market Map".

Applying a similar approach to our Canadian industries in ITS-relevant technology sectors (based on the various technology assessment foundation studies), we were able to develop an analogous Canadian "ITS Capability Map". Looking at the conformal mapping of our ITS capabilities onto the world market allowed us to identify opportunities for Canadian industry. In-depth analysis of the results of this exercise in the context of the current industry structure and ITS context in Canada helped us develop our strategic directions out of which the action plans for Canadian ITS stakeholders were built. Our end result is an emphasis on building a solid partnership environment among all stakeholders to help ensure that Canadian industry can take advantage of this significant global opportunity.

1.7 Report outline

This first chapter has set out the context of our work. The remainder of the report is structured into three main parts: an examination of the current global ITS environment from the standpoint of technologies and current activities; a review of the potential ITS marketplace leading to the development of an ITS World Market Map; and a final section looking at the Canadian industry context and the development of strategies for advancing its position in the world ITS market.

Chapters two and three provide the global overview, with the former examining the current state-of-the art of ITS technologies and their likely evolution over the next ten years and the latter reviewing current ITS activities and investments in three primary geographic areas: North America, Europe and Japan, as well as providing some look at the emerging industrialized countries and of course, Canada's own efforts.

Chapters 4 and 5 help build the technical background for our ITS worldview, and culminate in the presentation in Chapter 6 of the ITS World Market Map. Beginning with a review of ITS demographics in Chapter 4, this section provides an overview of market estimates for ITS technologies in Japan, Europe and North America in Chapter 5. Chapter 6 extends these forecasts and analyses together in the form of the ITS World Market Map which provides a global view of ITS markets through 2011.

The last three chapters - 7 through 10 - provide the analysis of the Canadian context. Chapter 7 looks at Canadian ITS activities and provides a brief synthesis of the results of the Canadian ITS technology assessment work carried out by others. This is used to build the Canadian ITS Industry Relevance Map described in Chapter 8. Chapter 9 builds on this work to provide a strategic framework and action plans intended to direct the implementation of our overall strategy. The final chapter provides a summary of key observations, critical issues and recommendations of the report.

Chapter 2: The Global ITS Environment: I

The Technology

2.0 Chapter overview: The technology

This chapter is intended to provide an outlook on the evolving state of ITS Technology around the world. We suggest that the reader unfamiliar with ITS might want to take a few minutes to read the ITS Primer provided with this report as Appendix A.

Our intent in this chapter is to define where ITS technology is now, and where it seems to be going over the next ten years - on a global basis. We've based much of our review on the published ITS literature and have used the work of the SRI Consulting report on ITS Technology and Application Evaluations (9) as one of our primary foundations. We have supplemented this material with our own discussions with independent experts and our final evaluations remain our own interpretations of the various source documents.

Our view in this chapter is global. We begin with a review of ITS nomenclature in order to set a clear definitional path for our discussions in the remainder of the report. The second and third sections of this chapter deal with the near term and longer term view of the evolution of ITS technologies respectively. A closing section summarizes key issues which we feel could play an important role in the technology evolution process. We deal with Canadian capabilities in ITS technology later in Chapter 9 of this report.

2.1 ITS nomenclature

New science and technology domains inevitably spawn their own extensive vocabularies of technical jargon and acronyms. At their early stages of development, these lexicons are fluid and changing, and this is certainly the case for ITS. Even the term ITS is an evolution from the original Intelligent Vehicle Highway Systems (IVHS) name coined in the late 1980's as the US terminology for what the Europeans called (and still frequently refer to as) Advanced Transport Telematics (ATT).

To confuse matters further, ITS was originally divided into six functional areas, which later became seven "User Service Bundles" comprised of 30 user services. The final reports on the US architecture published in June of 1996 (10) refined this again and defined seven new (but roughly comparable) "Market Package Groups" which were made up of 53 market packages. Other researchers defined their own breakdowns of ITS technologies - such as SRI Consulting's four-sector, 15 application system as used in their technology assessment report (9). We have chosen to use two of these systems in combination:

- the seven user service bundles / 30 user services
- the SRI four-sector / 15 application area system

The table below maps these two systems to one another.

Table 2.1
ITS Nomenclature Map

User Services	*User Service Bundle*	*SRI ITS Sector*	SRI ITS Applications
• Enroute driver information • Route guidance • Traveler services information • Traffic control • Incident management • Emissions testing and mitigation	*Travel and transportation management*	*Traffic management*	• Traffic control • Integrated traffic management systems • Automatic toll collection
• Electronic payment services	*Electronic payment*		
• Public transportation management • Enroute transit information • Personalized public transit • Public travel security	*Public transportation operations*	*Fleet management*	• Automatic vehicle location and tracking • Driver access & information • Passenger transit management • Freight distribution and logistics
• CV electronic clearance • Automated safety inspections • On-board safety monitoring • CV administrative processes • HAZMAT response • Freight mobility	*Commercial vehicle operations*		
• Demand management • Pre-trip travel information • Ride-matching/reservations	*Travel demand management*	*Driver information and trip planning*	• Pre-trip information • In-vehicle navigation • En-route information
• Emergency notification • Emergency vehicle management	*Emergency management*	*Vehicle safety and control*	• Collision avoidance • Hazard warning • Automatic vehicle control • Safety status monitoring • Emergency notification • Other safety applications
• Longitudinal. Collision avoid. • Lateral collision avoidance • Intersection collision avoid. • Vision enhancement • Safety readiness • Pre-crash restraint deployment • Automated highway system • Railway crossings	*Advanced vehicle control and safety systems*		

Alert readers will note that the match between these systems is not identical, however for the purposes of our report, we felt that the differential in definitions between individual user services and application areas (the outermost columns) was unimportant. It is readily evident that certain categories of application area embrace multiple user services.

Also of interest to our study was the way in which various user services or application areas mapped to enabling technologies. For the purposes of this report, we have defined six general categories of enabling technologies and services. This relationship is important, since few companies actually identify themselves purely as ITS technology suppliers. More frequently they are component or subsystem suppliers to system integrators, and it is at this level that we find that the relationship to our conventional industry structures becomes evident.

The table below summarizes the enabling technology categories of interest and their relationships to the thirty user services listed in Table 2.1. Shaded cells indicate technologies that apply to various user service groups

Table 2.2
ITS Enabling Technology Categories

User Service	GIS-T	Software	Displays	Sensors	Navigation	Comm.
Enroute Driver Information	■	■	■		■	■
Route Guidance	■	■	■	■	■	■
Traveller Services information	■	■	■			■
Traffic control	■	■	■	■		■
Incident management	■	■	■	■	■	■
Emmissions testing		■	■	■		■
Demand management	■	■		■		■
Pre-trip travel information	■	■	■		■	■
Ride matching		■	■			■
Public transport management	■	■	■	■	■	■
Enroute transit information	■	■	■	■	■	■
Personalized public transit		■	■	■		■
Public travel security	■	■				■
Electronic payment services		■	■	■		■
CV electronic clearance		■	■	■		■
Automated roadside inspect.		■		■		■
CV Administrative processing	■	■				■
On board safety monitoring		■	■	■		■
HAZMAT incident response	■	■	■		■	■
Freight mobility	■	■	■		■	■
Emergency notification	■	■		■	■	■
Emergency vehicle manage.	■	■	■	■	■	■
Longitudinal col. avoidance		■		■		■
Lateral col. avoidance		■	■	■		■
Intersection col. avoidance		■	■	■		■
Vision enhancement		■	■			■
Safety readiness		■		■		■
Pre-crash restraint deploym't		■		■		■
Automated highway system		■	■	■	■	■
Raiway Crossings		■	■		■	■

Table 2.3 below provides a more complete description of each of the enabling technology areas.

Table 2.3
Enabling Technologies Category Descriptors

Short Name	Complete Descriptor
GIS-T	Geographic information systems / digital maps
Software	Systems integration and intelligent software
Displays	Display technologies
Sensors	Sensor technologies
Navigation	Positioning and navigation technologies
Comm.	Communication technologies

2.2 Technology synthesis: Our approach

2.2.1 Background

Our discussions in this chapter are structured around the SRI Consulting categorization of ITS Sectors and Applications. We have relied on this report as a primary foundation for our global technology assessment because of its uniform global view of the current state-of-the-art of ITS technologies and their relevant application areas, but we have not done so blindly or in isolation. We have also looked carefully at other published literature and held discussions within our own research team as well as with external experts in relevant areas, to ensure that our final analysis and conclusions are realistic.

While the state-of-the-art of the technology is not in itself a determinant of how well various ITS applications will penetrate the marketplace, it is nonetheless a controlling factor. Immature applications which cannot fulfill user expectations at present will not gain acceptance until they can in fact do so. Applications which have clearly demonstrated their utility (such as many fleet management applications for commercial vehicle operations) are already moving ahead swiftly towards widespread user acceptance.

Our primary objective in this section of our analysis was thus to assess the current "level of maturity" of the 15 ITS application areas defined by SRI, and to do so in a clearly understandable and measurable way which could be readily communicated to others. We deal with both near-term (present to 3 years) and mid-term (4 to 10 years) outlooks. Our discussions are largely summary in nature and focus on our own interpretations and specific concerns. Readers wishing more detail on the SRI Consulting evaluations are referred to the ITS Technology and Application Evaluations report (9) prepared by that group.

2.2.2 Technology Signatures: Our evaluation framework

Our evaluation framework used a combination of a much simplified version of Delphi's proprietary Parametric Signature Analysis™ technique and the evaluation criteria used by SRI as a subjective basis for their technology assessments. The SRI evaluation criteria were:

> ***Technology:*** *How developed are the enabling technologies and what are the barriers to further development ?*
>
> ***Efficiency:*** *Can current systems perform to application requirements?*
>
> ***Utility:*** *Does this application provide a reasonably useful contribution to ITS?*
>
> *Reliability: How reliable have the applications proved to be in trials or in use?*
>
> ***Interoperability:*** *Are products interoperable between different applications, infrastructures, or geographic regions?*
>
> ***Cost:*** *Is the cost of supplying a product with a specific technology acceptable as a competing technology in the industry?*
>
> ***Complexity:*** *Is the technology or application too complex for its supposed function?*
>
> ***Standards:*** *What is the status of national and international standards, and is standardization an issue for implementation of applications?*
>
> ***Institutional issues:*** *Are issues of public funding, capitalization, privacy, liability, and licensing likely to affect implementation of an application?*
>
> ***Next generation:*** *What are the next-generation requirements of the application that, if they develop, will enhance the commercialization of an application*
>
> *(11)*

We rated each ITS application area on these criteria using our own quantitative rating scale as summarized in the table below:

Figure 2.4
ITS Technology Evaluation Rating Scale

Score	Criteria Scale	Application Potential
10	Proven	Mandated
7	Significant Advantage	Excellent
5	Advantage	Very Good
3	Minor Advantage	Good
0	Neutral	Fair
-3	Minor Shortfall	Poor
-5	Shortfall	Very Poor
-7	Significant Shortfall	Insufficient
-10	Intractable	Intractable

The use of a quantitative scale allowed us to develop graphical presentations of each technology area potential in the form of a "Technology Signature". While this is a greatly simplified representation of a complex evaluation process, it does help to readily distinguish between various technology areas from the standpoint of their maturity and readiness for the marketplace. In the table above, the Criteria Scale was used to define thresholds for individual technology parameter scores. The Application Potential column was to express the average of the parameter scores for any given technology area as an overall qualitative expression of the general maturity of the application. While not a direct measure of market potential, it is nonetheless a reflection of the speed with which each application area might penetrate the user marketplace - based on technological criteria alone.

2.2.3 How we present the evaluation results

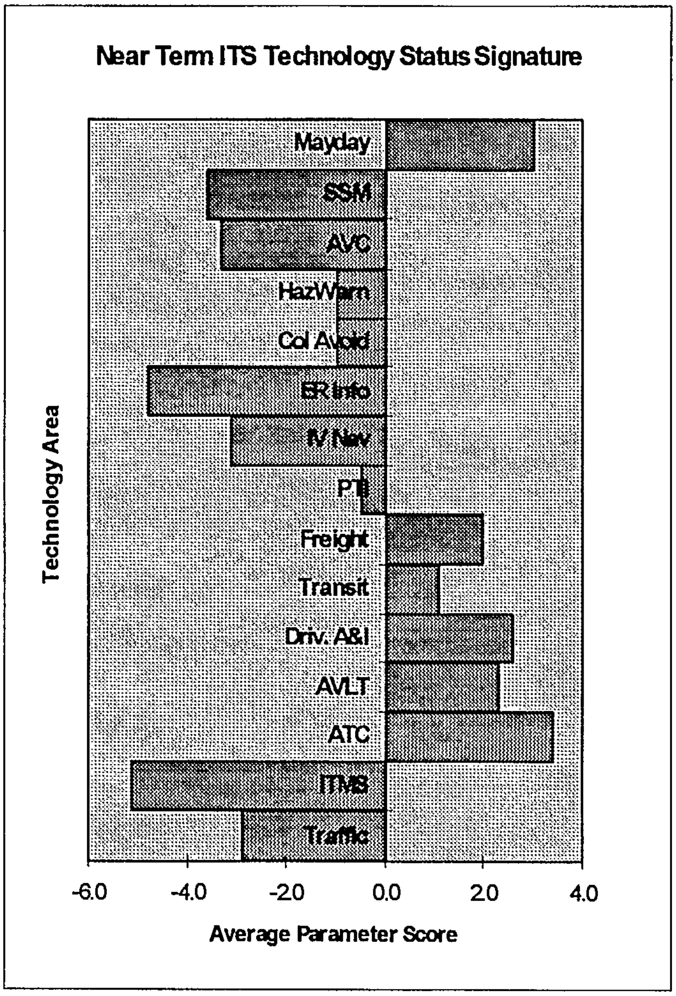
A spreadsheet which provides details of the parameter scores for each application area is provided with this report in Appendix B. As noted above, the results of our evaluation are presented in the form of what we have termed "Technology Signatures". Two types are used:

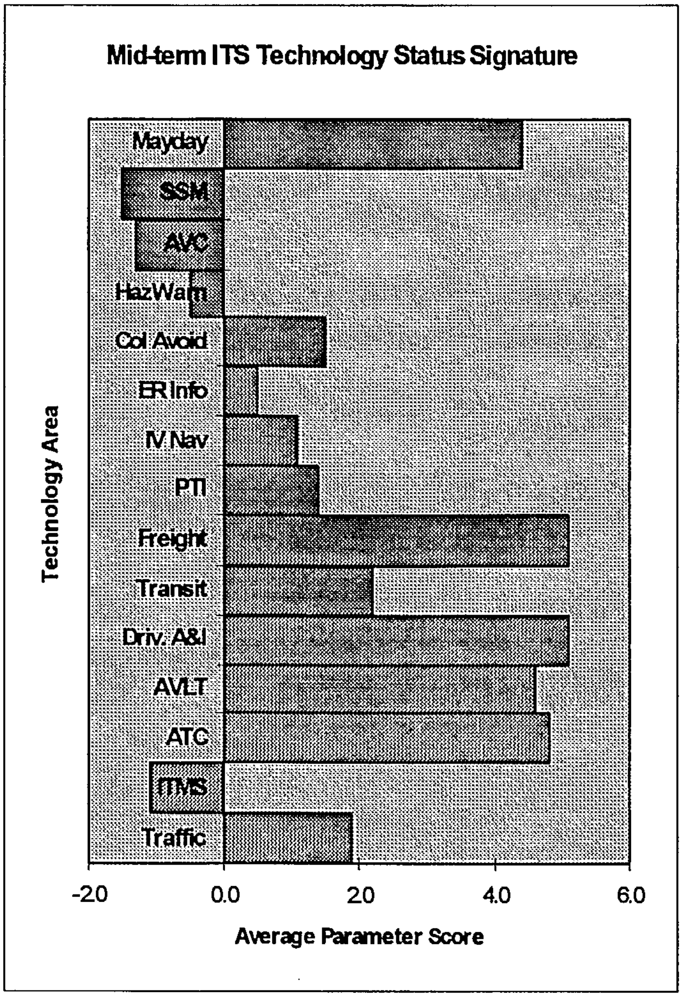
- an overall ITS Technology Signature which summarizes the relative status of each of the 15 ITS application areas (and of course, by extension of each of the 30 user service categories as well) through the simple medium of a comparison of the average of their parameter scores across all 10 of the evaluation criteria.

- Individual application-area Technology Signatures. These are based on the individual criteria ratings, and provide a visual indicator of the areas of strength and weakness of each ITS technology application.

The signatures are presented as horizontal bar graphs whose scale can ranges from -10 at the left edge to +10 at the right. Signatures which are heavily biased to the right are obviously nearer to providing practical solutions to transportation problems than those which reflect greater negative (leftward) bias. For individual technology areas the signatures allow us to appreciate the types of actions needed to bring an application area to the forefront. Weaknesses in interoperability, standards and institutional issues may suggest non-technical impediments to implementation, whereas poor performance on criteria such as efficiency, reliability and utility probably signal a need for greater research and development of the products and services within the area.

2.3 Overall ITS Technology Status





In looking at the overall ITS domain technology signatures for the near (0-3 years) and mid-terms (4-10 years), we begin to get an appreciation for which areas have the most significant potential for advancement over the next decade. Fleet management and Mayday services are obviously already well placed in the near-term and have begun their penetration of both public (transit) and private (commercial fleet) sector markets. Vehicle-related safety applications are still latent, as are in-vehicle technology applications requiring comprehensive system integration and information exchange (i.e. dynamic route guidance, en-route driver information). Advanced traffic management systems - particularly those requiring comprehensive system integration and information exchange also trail in market application potential.

In the mid-term, fleet management applications should mature quickly and begin to evolve into second-generation products. Mayday and safety related technologies are also expected to flourish during this period, and initial advanced vehicle control products, (e.g. adaptive cruise control, forward and adjacent vehicle detection devices), will reach a technological maturity where they will begin to appear as original equipment offerings through major vehicle manufacturers. More advanced vehicle control technologies will still be relatively immature within the forecast period. Consumer acceptance and liability issues may play a role in determining how quickly these areas progress in the future. Autonomous in-vehicle navigation technologies will have continued to mature from their present initial offerings and dynamic route guidance/en route information technologies will be positioned to take advantage of the necessary infrastructure as it comes available in selected locations.

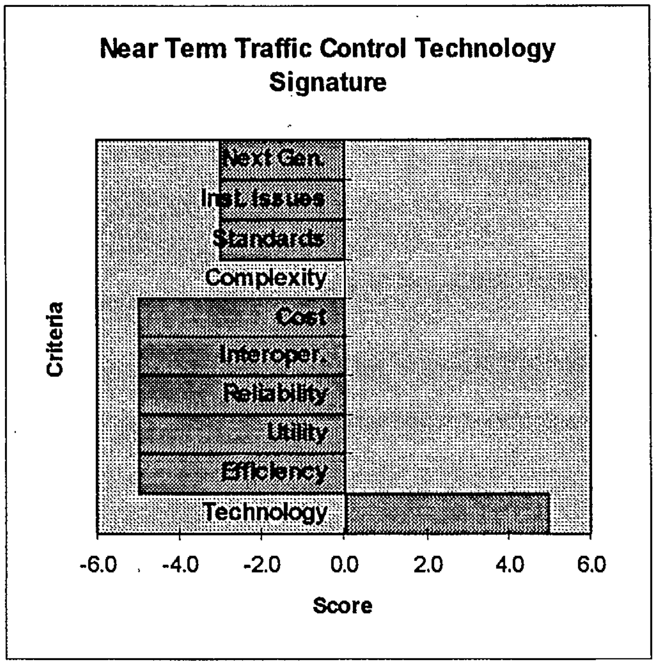
The traffic control area is expected to mature significantly from the standpoint of adaptive traffic control systems. Fully integrated transportation management systems are not expected to progress at the same pace however, primarily because the financially constrained government client base are not currently well positioned to drive this technology area ahead.

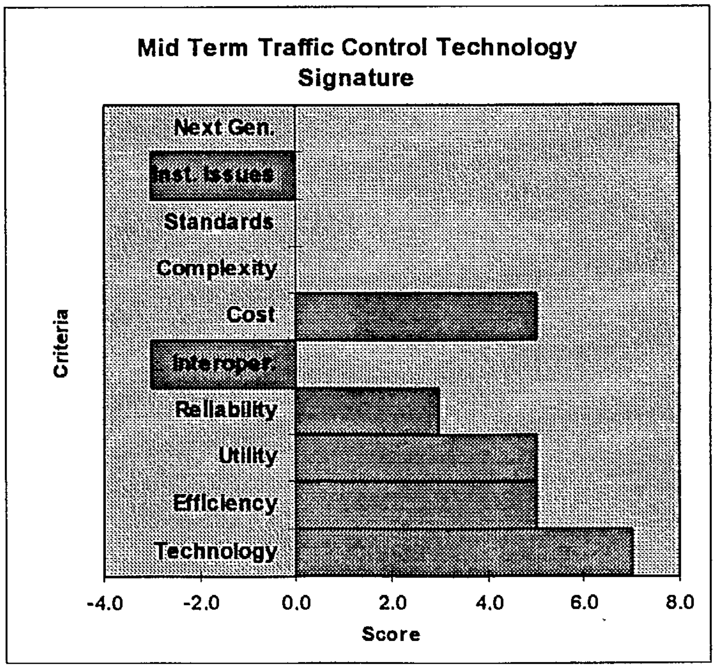
The table below provides a summary of this analysis in terms of the 30 user service areas defined under the current US architecture plan. The table provides a listing of user service areas linked to technology applications with average parameter scores greater than zero in both the near and mid-term. Readers are cautioned to interpret this table with care since not all user services within an ITS application are expected to mature at the same rate. A review of the individual technology area summaries which follows this section provides additional information.

Table 2.5
ITS Technology Evaluation: User Service Summary
(User services linked to application areas with average parameter scores >0)

ITS Application Area	ITS User Services
Near term: 0-3 years	
Mayday (emergency notification)	Emergency notification
Freight distribution and logistics Passenger transit management Driver access and information Automatic vehicle location and tracking	Public transportation management Enroute transit information Personalized public transit Public travel security Commercial vehicle electronic clearance Automated safety inspections On-board safety monitoring Commercial vehicle administrative processes HAZMAT response Freight mobility
Automatic toll collection	Electronic payment services
Mid-term: 4-10 years (in addition to those already noted in 0-3 year period)	
Collision Avoidance	Longitudinal collision avoidance Lateral collision avoidance Intersection collision avoidance Railway crossings
Enroute information In-vehicle navigation Pre-trip information	Demand management Pre-trip travel information Ride-matching & reservations
Traffic control	Traffic control Incident management

2.4 Technology evaluation: Traffic Control Systems





Evaluation:

While adaptive traffic control systems are beginning to make inroads into the marketplace, and the range of systems is proliferating, the strength of this application is primarily technology based. Unfortunately, innate weaknesses related to cost, interoperability and the government funding needed to drive development in this area forward are all factors acting to slow the penetration of these systems into the marketplace. In the mid-term, cost issues are expected to be resolved as the technology matures and competition increases. New sensor technologies which are still very much in the testing and development stage are expected to come into their own. Overall government funding levels will continue to be a strong influence on the ability of this technology to make marketplace headway and although standards issues are generally expected to be resolved in the next three to five years, the interoperability question and the associated ability for neighbouring systems to exchange information and work together is expected to be a continuing problem in the United States.

Related User Services: Traffic Control

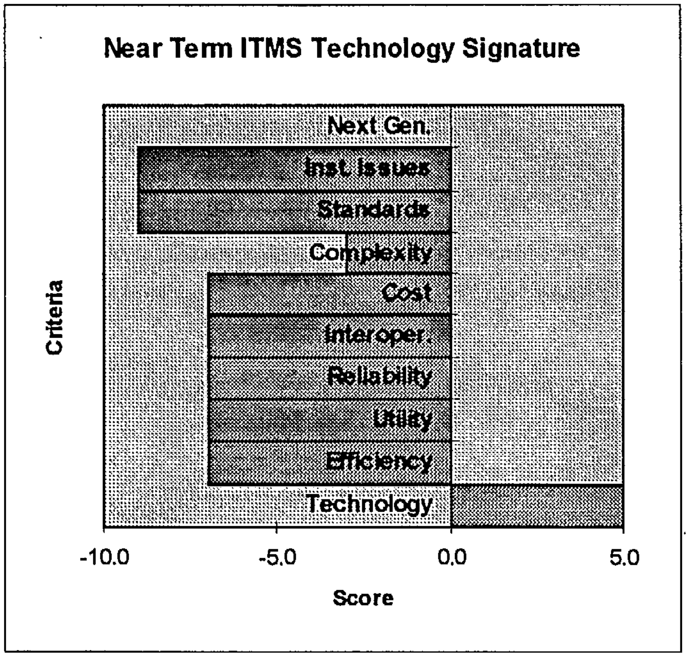
Key Technology Directions:

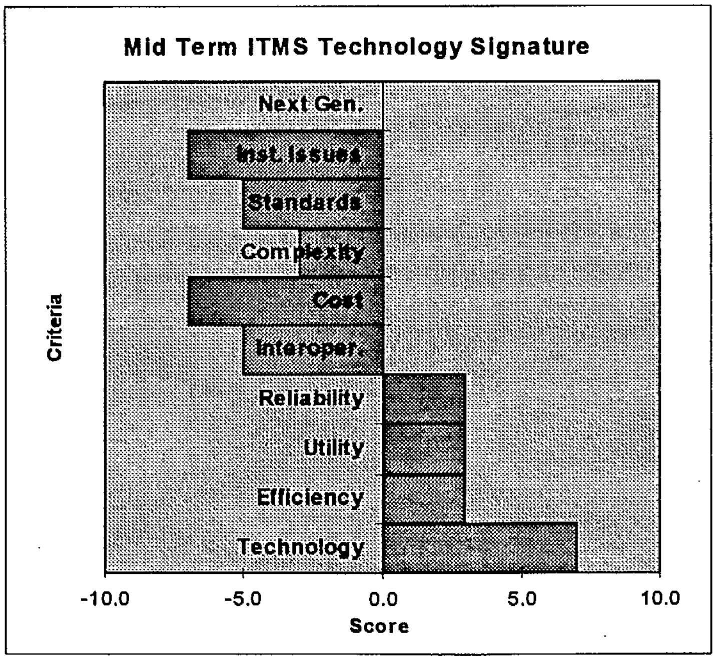
- Sensors: microwave, ultrasonic, infrared, acoustic, video
- Variable message sign (VMS) improvements
- Video image processing for CCTV sensing
- Communications technologies for information dissemination

Critical Implementation Issues:

- Institutional: constrained government budgets
- Interoperability: getting adjacent/overlapping systems to work together

2.5 Technology Evaluation: Integrated Traffic Management Systems





Evaluation:

While technology is a major strength in this technology domain which focuses on centralized and integrated data collection, processing, analysis and dissemination for control and information purposes, major obstacles will inhibit the progress of these applications. Demonstration projects currently exist, but have not provided sufficient demonstration of the reliability, efficiency and utility of these systems. High costs and the dependence of these applications on government investment in infrastructure are a particular drawback. Solutions to longer term issues related to standards and interoperability do not appear on the horizon and will act as a brake on their practical implementation. Cost will also continue to impede successful widespread use of the technologies.

Related User Services: Enroute driver information, dynamic route guidance, traveler services information.

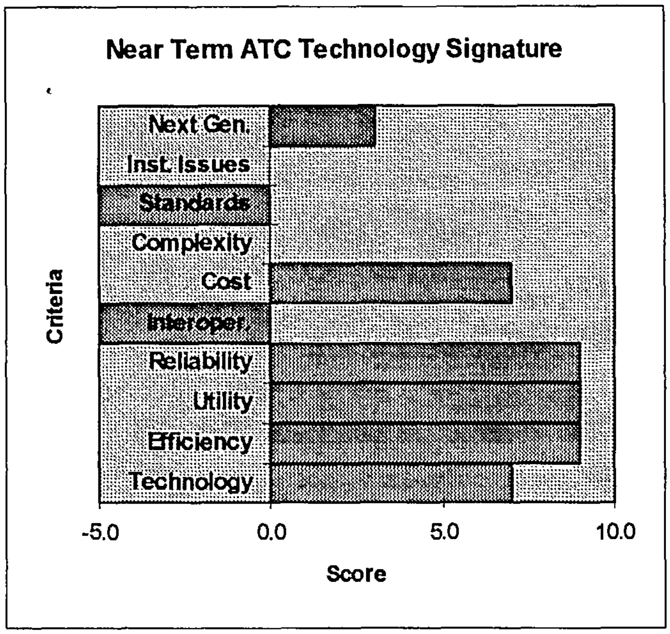
Key Technology Directions:

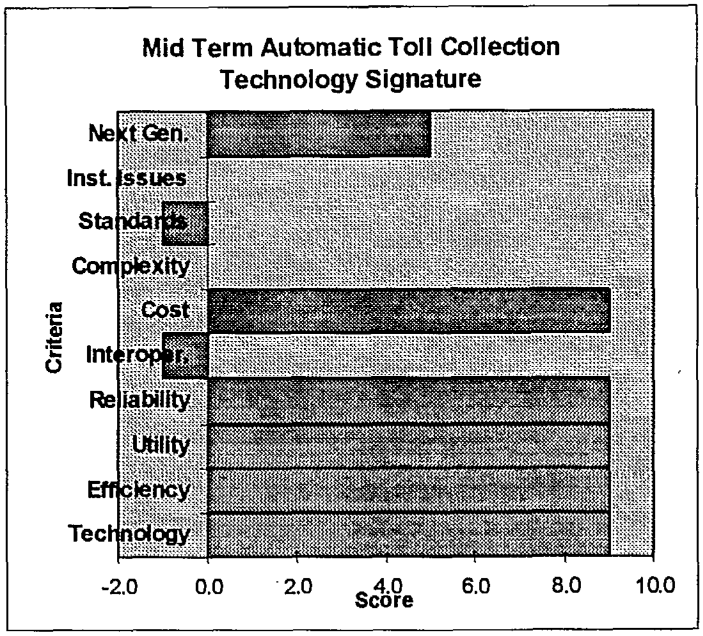
- Improved sensors for real-time traffic data collection
- Data fusion and warehousing solutions
- Artificial intelligence applications for operator decision support
- Communications technologies for information dissemination

Critical Implementation Issues:

- Institutional: constrained government budgets
- Utility: limited information on public need and acceptability
- Interoperability and standards

2.6 Technology evaluation: Automatic toll collection





Evaluation:

Automatic toll collection emerges as one of the most viable current ITS application areas. While interoperability and standards are still an issue, ATC technologies are by and large proven, robust and very cost effective. The technology itself is a major strength of the application, and North American jurisdictions in particular are moving ahead quickly in the planning and implementation of projects in this area. Similar activities are occurring in Europe. The longer term outlook is very positive, with multipurpose integrated electronic payment schemes already being used on a trial basis. Standards and interoperability may still prove somewhat of a problem in the mid-term - particularly in Europe - however this is not expected to slow the penetration of ATC and related electronic payment technologies in the marketplace significantly. Transaction security issues are one weakness of this technology area.

Related User Services: Electronic payment services

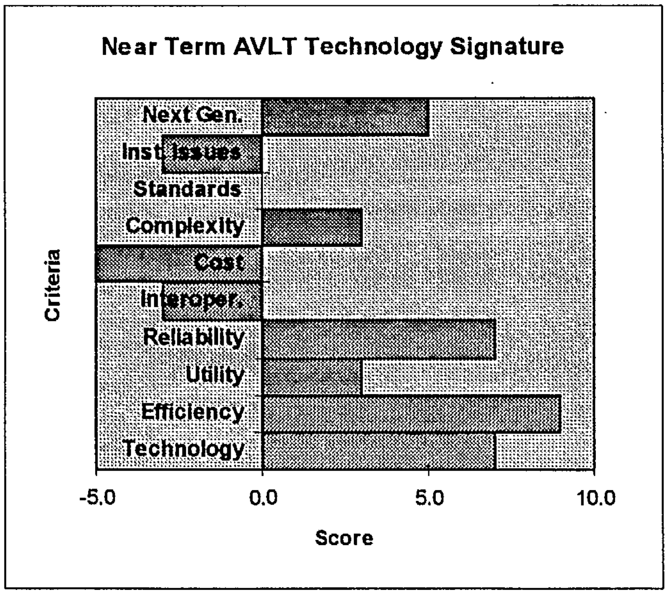
Key Technology Directions:

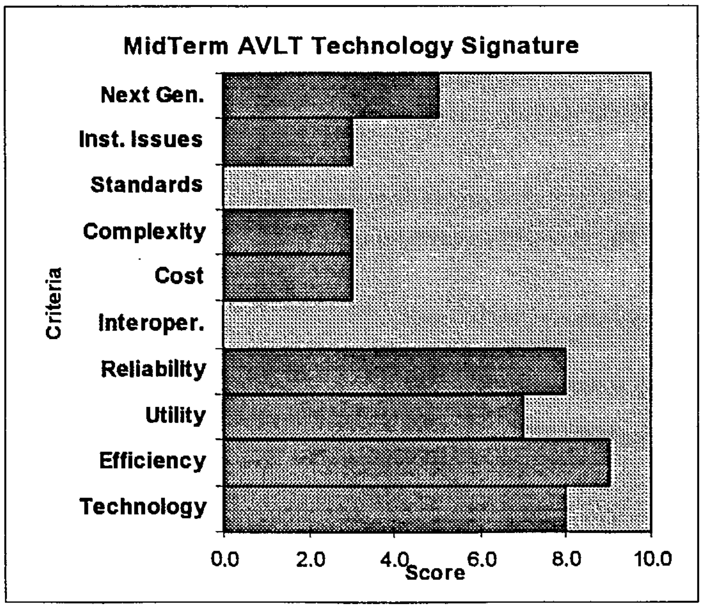
- Transponder technology improvements (multipurpose and interoperability)
- Improved video image processing for enforcement
- Improved transaction security processes

Critical Implementation Issues:

- Standards and interoperability
- Public support for ATC and tolling

2.7 Technology evaluation: Automatic Vehicle Location & Tracking





Evaluation:

Automatic Vehicle Location and Tracking is another technology application that has emerged as a clear leader in the ITS area. Focusing on fleet management, commercial vehicle operations, and regulatory compliance applications for commercial vehicles, the AVLT area's strong technology base, proven cost effectiveness and return on investment, efficiency and reliability have allowed it to make major inroads in the North American marketplace. While cost still poses a problem for small public and private fleet operators, this problem will be resolved in the mid-term. Interoperability and standards still pose problems in North America, however this is expected to be resolved in the mid-term as well. Improved data and voice communication technologies will further enhance the benefits to users of these systems in the mid-term, and it is expected that Europe will follow the North American path in seeing substantial implementation of these systems in that area as well. The Japanese picture is not as clear for commercial vehicles, however the application of these technologies in other fleet applications will see this marketplace build as well in the mid-term. The synergy with Electronic Data Interchange (EDI) for intermodal, border crossing, regulatory compliance and other applications suggests that this application area has substantial long-term potential.

Related User Services: Freight mobility, public transportation management, commercial vehicle (cv) electronic clearance, cv administrative processes, on-board safety monitoring, automated safety inspections.

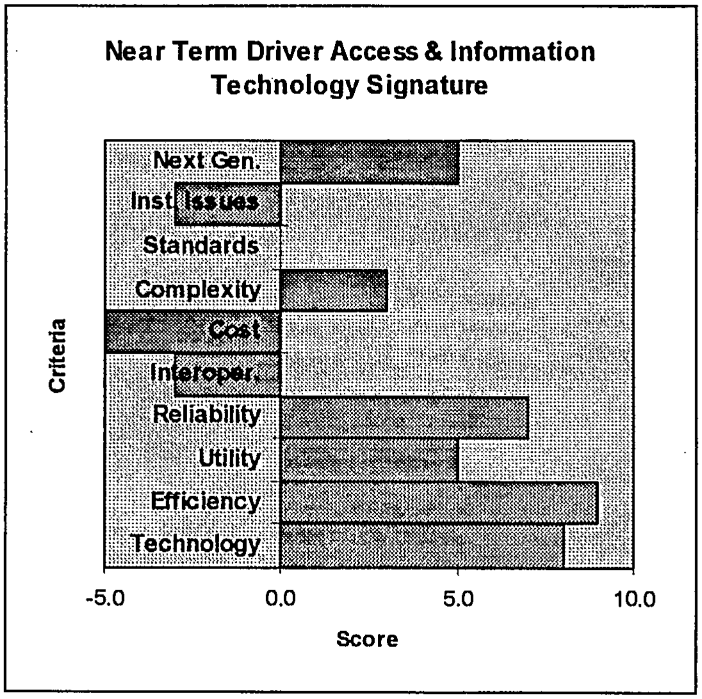
Key Technology Directions:

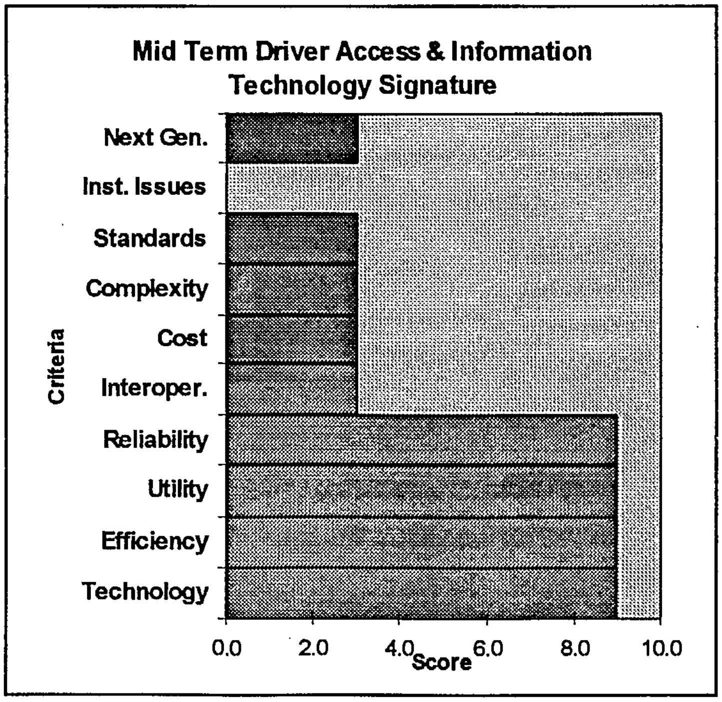
- Improved two-way communication technologies (LEO & MEO satellites)

Critical Implementation Issues:

- Some interoperability issues

2.8 Technology evaluation: Driver access and information





Evaluation:

This area also ranks well as an ITS application. Including applications such as the provision of real-time communication and dispatch, this area has come into its own in North America and is expected to follow suit in Europe. The broad utility of these applications in Japan remains a question. Technologies are very strong and the utility and efficiencies gained through the use of such systems in commercial applications such as the long-haul trucking market are well proven. In the longer term, improvements to the already complex technologies through improved utilization of the global positioning satellite (GPS), new communications technologies, and additional satellite communication networks using low and medium altitude earth orbits (LEO and MEO) will further enhance the technology.

Related User Services: Freight mobility, on-board safety monitoring.

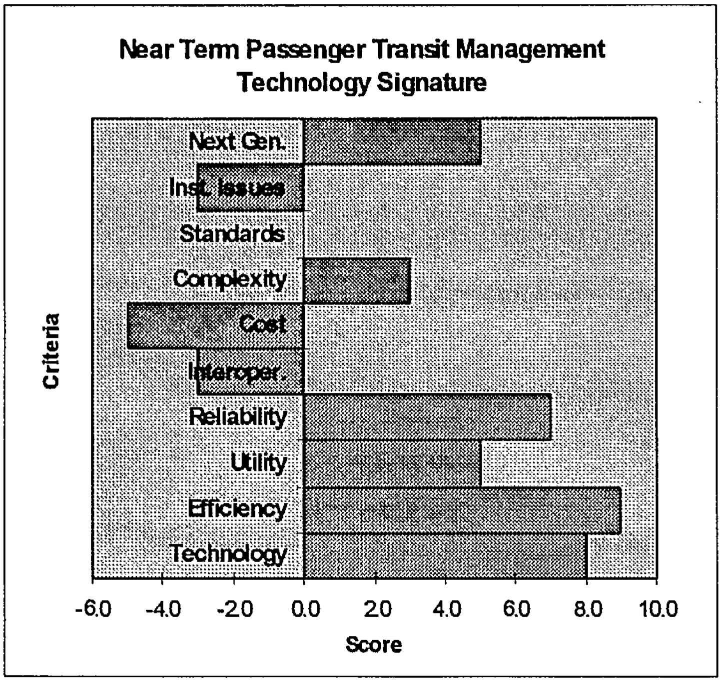
Key Technology Directions:

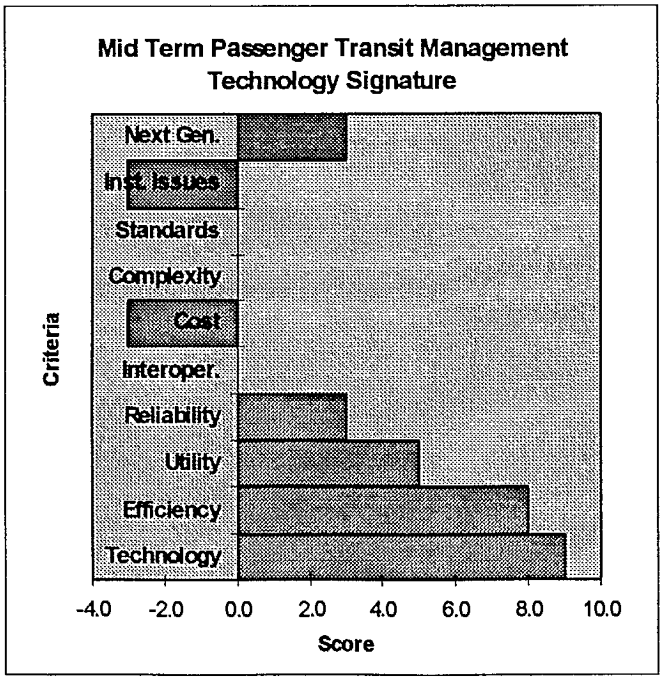
- Expanded differential GPS usage (DGPS)
- LEO and MEO satellite communications systems
- RDS communications technologies
- Digital Audio Broadcast communications technologies

Critical Implementation Issues:

- Interoperability between systems

2.9 Technology evaluation: Passenger transit management





Evaluation:

Public transit agencies have been implementing ITS-like applications for passenger management for some years. Focusing primarily on vehicle tracking, 2-way driver/dispatch communication, passenger counting and routing and scheduling technologies, these applications have led to the development of a mature and proven technology base. High costs are a current impediment which is expected to continue to exist in the future, particularly in the North American context of transit system budget cutbacks . Standards are not a current problem and in the mid-term, the integration of various applications is expected to overcome interoperability issues that exist at present. European transit agencies - with their more sophisticated and well-established systems are seen as particularly likely to be able to benefit from developments in this technology area.

Related User Services: Public transportation management, en-route transit information, personalized public transit

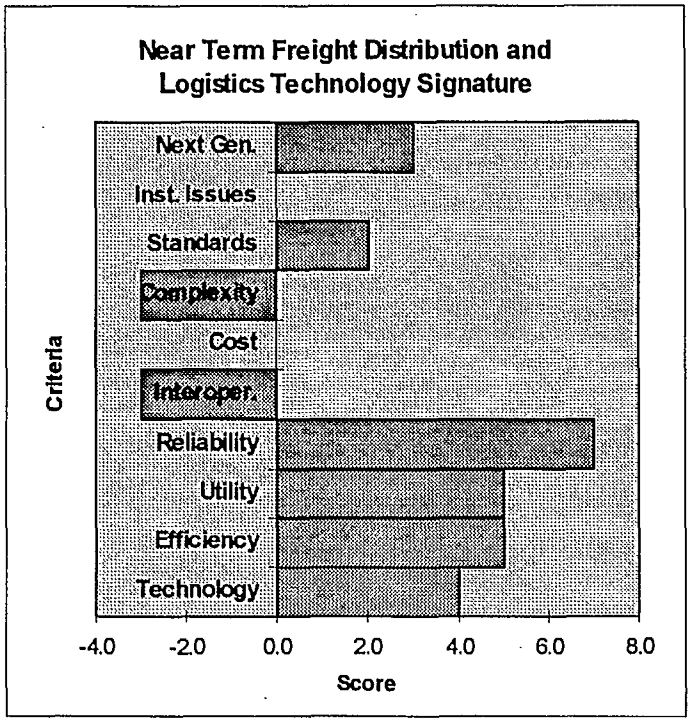
Key Technology Directions:

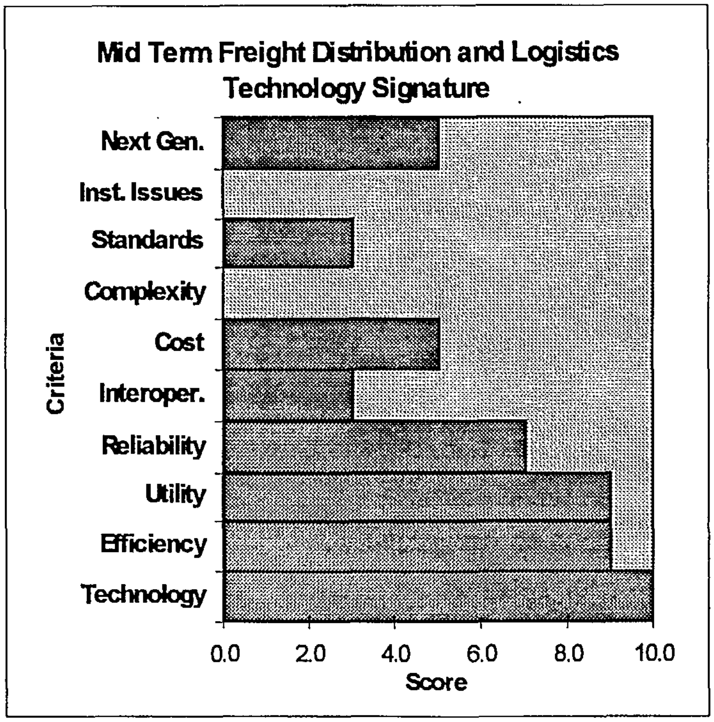
- Improved passenger information dissemination technologies
- System integration for interoperability and information exchange
- Dynamic demand-responsive fleet routing and scheduling software

Critical Implementation Issues:

- Institutional: constrained government budgets (North America)

2.10 Technology evaluation: Freight distribution and logistics





Evaluation:

Another commercial vehicle and fleet management application that has already made inroads in the marketplace - particularly in North America - this area clearly shows its immediate strengths and mid-term potential for very significant improvements. Its already well established track record of utility, efficiency and reliability is expected to significantly improve in the future. The resolution of current interoperability problems to facilitate cargo and vehicle tracking in intermodal applications, border crossing applications, and driver and cargo security monitoring within one communicating system are expected to be resolved in the mid-term forecast period. This is a strong technology application area with a proven track record in providing users with a significant benefit stream.

Related User Services: CV electronic clearance, automated safety inspections, on-board safety monitoring, CV administrative processes

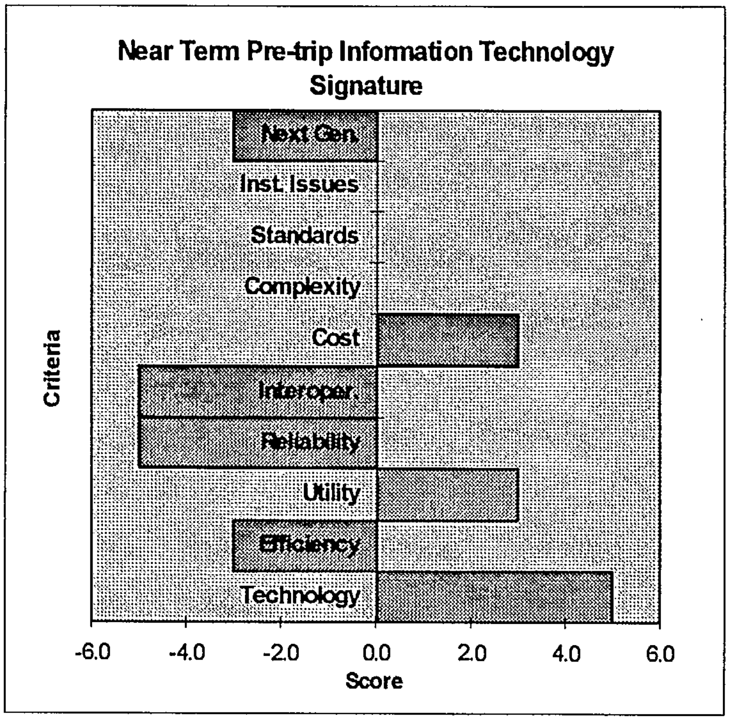
Key Technology Directions:

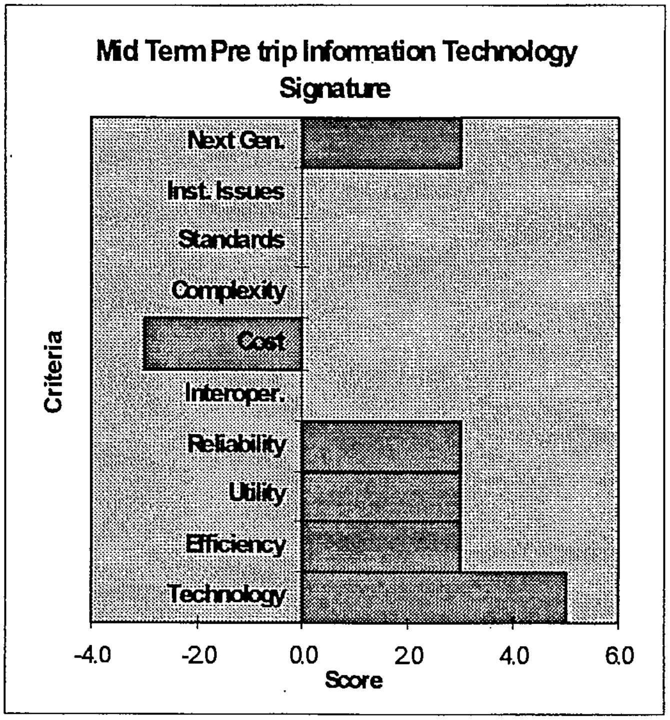
- System integration for application and jurisdictional interoperability
- Cost reductions for in-vehicle navigation/positioning systems

Critical Implementation Issues:

- Standards and interoperability
- System costs
- Privacy and driver acceptance

2.11 Technology evaluation: Pre-trip information





Evaluation:

While the information dissemination technology (WorldWideWeb, Cable television, FM sidebands, pagers, etc) for this area is strong, applications can be implemented at relatively low cost, and their utility is perceived to be high by experts, the data gathering infrastructure to support their comprehensive implementation is still very sparse, and is expensive to put in place. In addition, much of that infrastructure is dependent on investment by cash-strapped government agencies. Reliability, timeliness and accuracy of data gathered from multiple modes is also difficult to ensure, and the integration of such sources into one system poses substantial interoperability and reliability problems. While many of these obstacles are expected to be overcome in the mid-term, it is expected that commercial fleets and other driving intensive industries will probably represent the major marketplace initially. Specific. Localized applications with singular data sources are also likely to proceed early on. Unfortunately, recent events at the Atlanta Olympics ITS Showcase have probably hurt the cause of this technology in the near term.

Related User Services: Pre-trip travel information, demand management, ride-matching & reservations

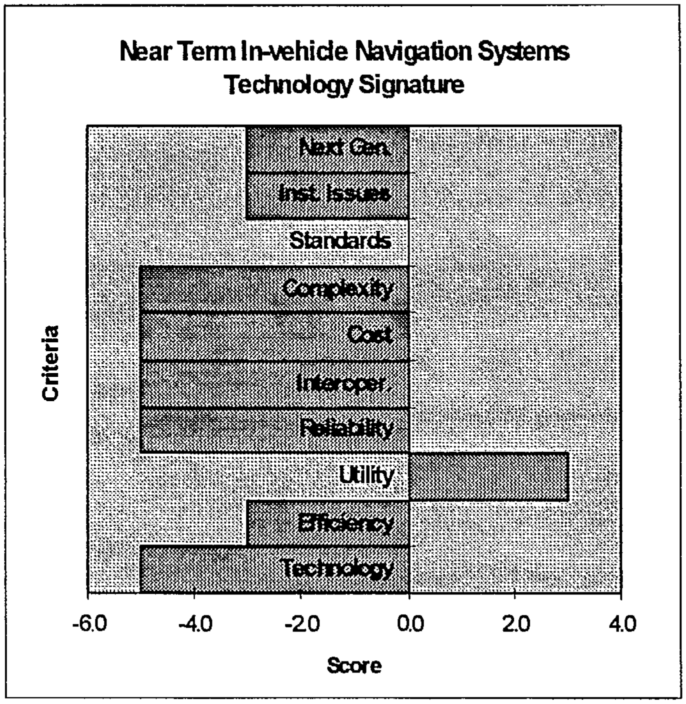
Key Technology Directions:

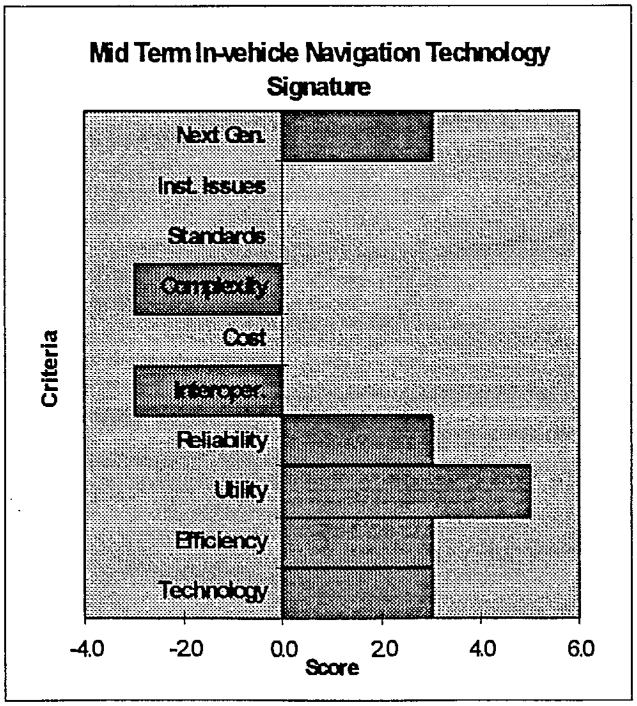
- Communications technologies including sub-carrier FM broadcast
- RDS/TMC broadcast applications in Europe
- Digital Audio Broadcast (DAB) technologies for dynamic data exchange

Critical Implementation Issues:

- Institutional: constrained government budgets for sensor infrastructure
- System integration and information dissemination capabilities

2.12 Technology evaluation: In-vehicle navigation technology





Evaluation:

In vehicle navigation systems have been a major emphasis area of the Japanese, and it is in this country that their commercialization is most advanced. In the near term, their utility has been proven for specific types of applications, and the autonomous navigation systems now coming available in high-end vehicles from both North American and European automakers reflect a longer term confidence in the potential for this area. Currently their utility and efficiency are limited both by limited mapping data (in North America), and by the lack of data to support dynamic route guidance. Although costs are high at present, increased competition is expected to bring these down rapidly. Institutional issues related to the need for public sector investment in infrastructure to support dynamic route guidance, and potential liability issues arising from active route guidance also represent impediments to the penetration of this technology into the marketplace. Nonetheless, this area is expected to advance steadily, particularly in large-fleet and time-sensitive sectors such as rental cars, urban courier companies etc.

Related User Services: Route guidance, en-route travel information

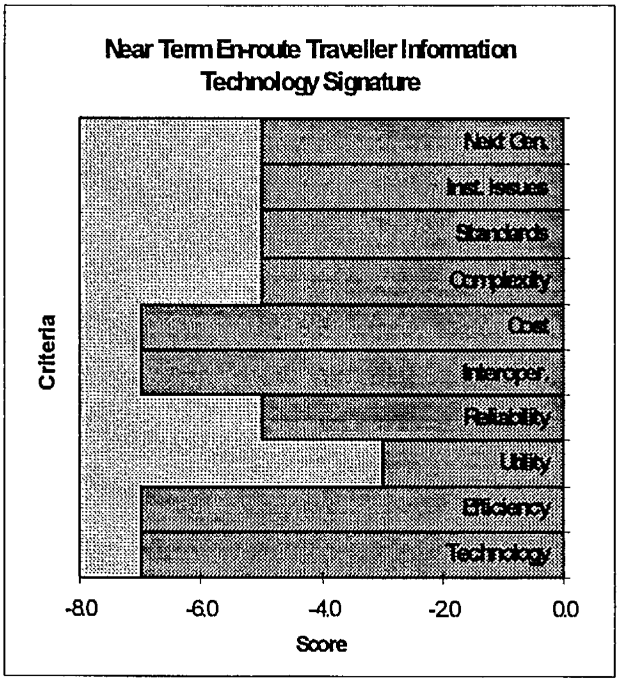
Key Technology Directions:

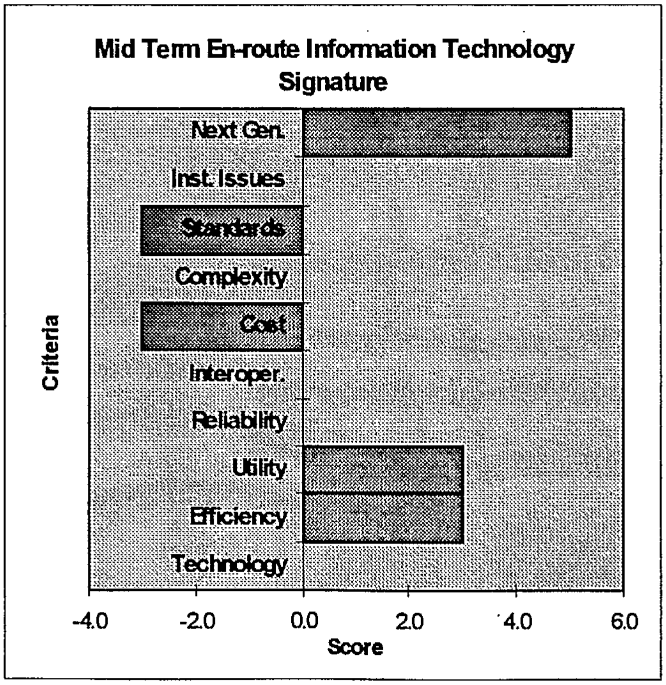
- Multi-functional in-vehicle units (navigation, guidance, entertainment)
- Equipment cost reductions
- Improved communication technologies (dynamic route guidance)

Critical Implementation Issues:

- Institutional: constrained government budgets
- Digital map data availability
- Interoperability and standards

2.13 Technology evaluation: En-route information





Evaluation:

The picture for near-term en-route driver information systems is quite negative. Substantial weaknesses in the technology, costs and interoperability are major impediments to market progress in this area except in Japan, dynamic route guidance and en-route traveler information has been a long-term goal and government has (and is) investing heavily in infrastructure to support it. In the mid-term, the technology, reliability and interoperability problems are expected to be solved particularly as new communications technology options become available. Nonetheless, with the exception of Japan, the basic problem of providing a core infrastructure for data collection to support this application area is expected to be a continuing one that will see this technology assume its place in the market more slowly than most others.

Related User Services: En-route driver information, route guidance traveler services information, demand management

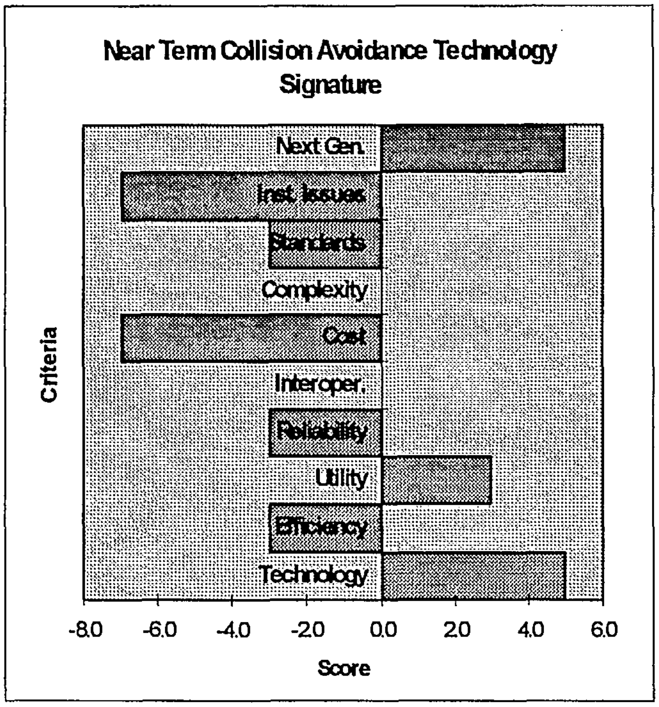
Key Technology Directions:

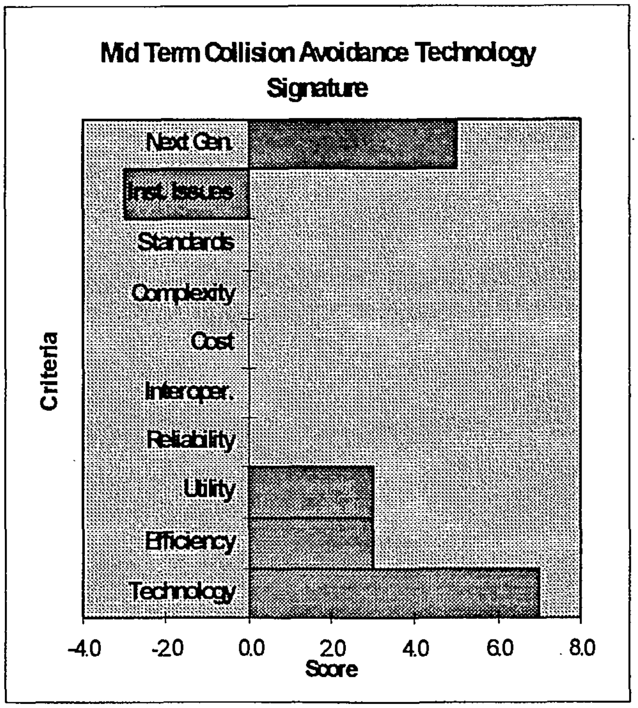
- Communications technologies including sub-carrier FM broadcast
- RDS/TMC broadcast applications in Europe
- Digital Audio Broadcast (DAB) technologies for dynamic data exchange

Critical Implementation Issues:

- Institutional: constrained government budgets: for supporting data gathering infrastructure
- Interoperability and standards

2.14 Technology evaluation: Collision avoidance





Evaluation:

Collision warning and avoidance technologies are based on strong detection technologies, and in fact, in some instances are already being marketed for limited, fleet-based applications and some higher-end personal automobiles. Generally speaking however, the efficiency and reliability of most of the potential applications are still unproven and relatively high in cost. Reliability and redundancy will be critical to the successful implementation of collision warning and avoidance technologies, and mid-term prospects appear good for solving these issues for tightly defined application areas. The acceptability of many of these applications to drivers is also still an open question, as is the problem of potential manufacturer liability which arises in the event of an equipment failure. Fleet markets may provide the main outlet for these technologies in the future, however safety experts have also noted that improvement to the current driver environment (i.e. lights, mirrors etc.), and better driver training may also bring many similar benefits at much lower cost.

Related User Services: Longitudinal collision avoidance, lateral collision avoidance, intersection collision avoidance

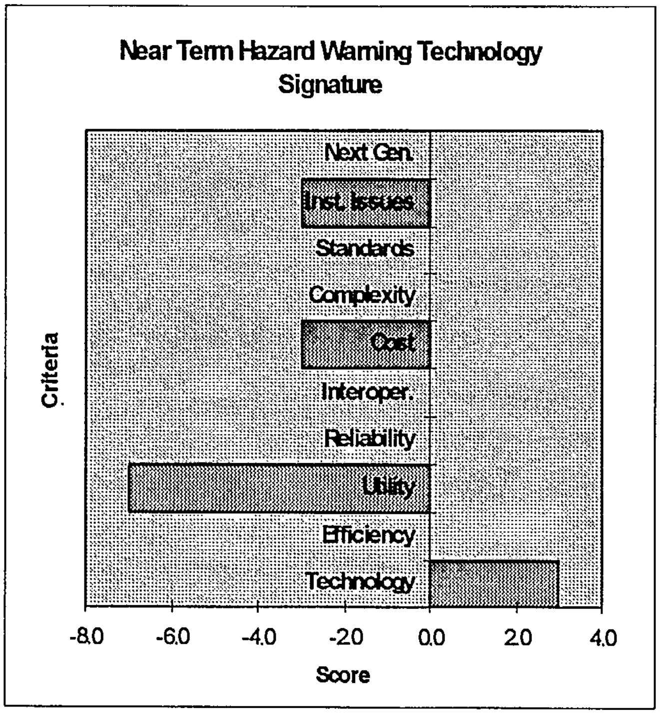
Key Technology Directions:

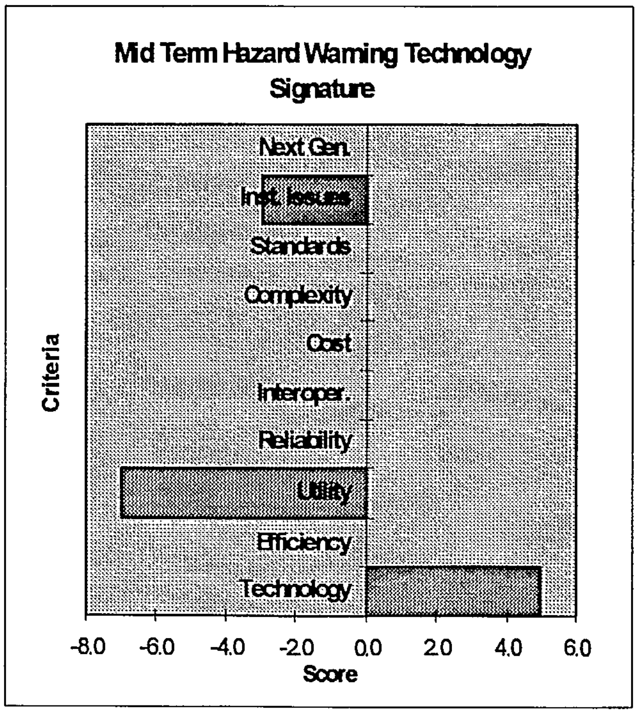
- technology reliability and redundancy improvements

Critical Implementation Issues:

- Driver acceptance
- Manufacturer liability
- Technology benefits

2.15 Technology evaluation: Hazard warning





Evaluation:

The technologies employed in hazard warning applications such as those produced by weather and road construction are available and well suited to the work. At present, the cost effectiveness of applying such measures is in doubt, and because of the spot nature of such applications (rather than system-wide) their will probably remain in question well into the mid-term future. Institutional issues related to the standardization and uniform application of such traffic warning devices (closely codified under various uniform traffic control device guidelines) will probably present a major obstacle to the implementation of these applications on a widespread basis. One possible exception to this is the area of at-grade railway crossing warning systems, which are widespread across North America, but limited in extent in Europe and Japan.

Related User Services: Vision enhancement, railway crossings

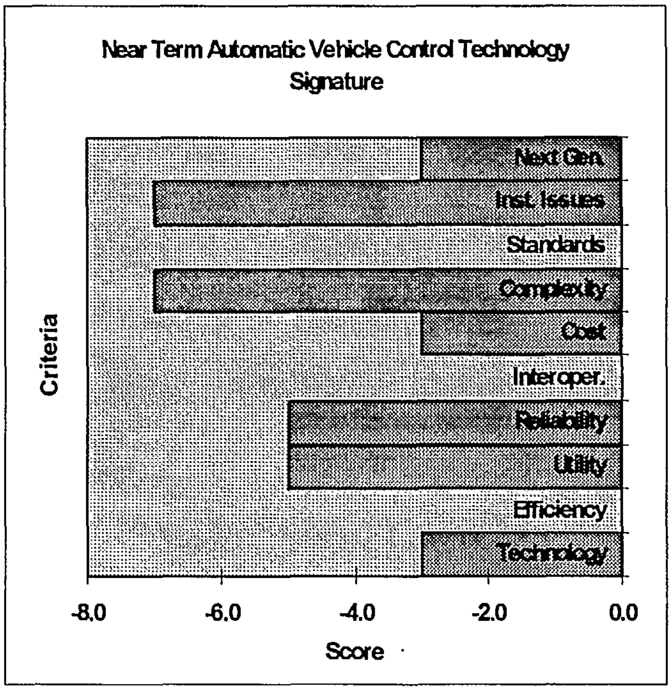
Key Technology Directions:

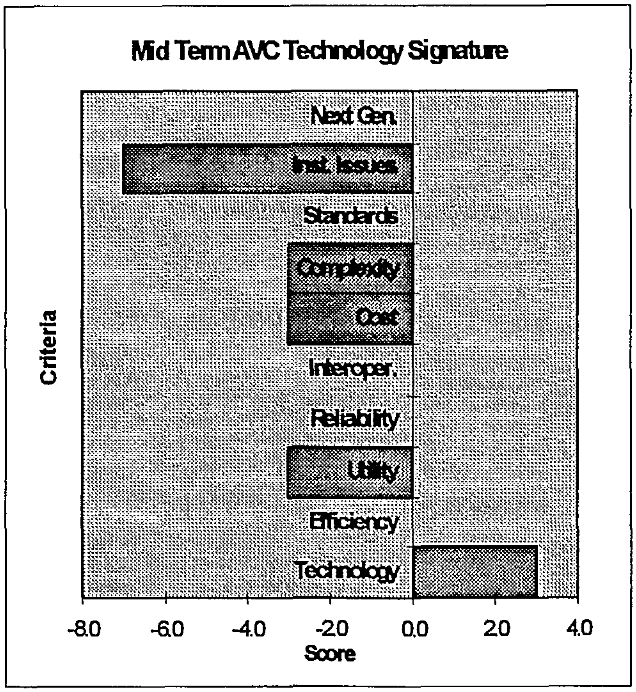
- Not applicable

Critical Implementation Issues:

- Existing institutionalized traffic control warning device standards

2.16 Technology evaluation: Automatic vehicle control





Evaluation:

Cruise control and antilock braking systems represent automatic vehicle control technologies that are in place today, and efforts are being pursued to provide additional "driver assistance" functionality through other devices. Of course, the US Automated Highway System (and similar commercial vehicle oriented efforts currently underway in Japan) represents the ultimate extension of this application area. Nonetheless, safety experts have serious concerns about the utility and reliability of such systems as well as the way in which drivers interact with them, to the point that the ability of these technologies to actually improve safety is questioned. The liability of manufacturers in the face of any failures which might occur is also a serious institutional concern, and high costs will continue to be an impediment to progress as well.

Related User Services: Longitudinal collision avoidance, lateral collision avoidance, intersection collision avoidance, automated highway system.

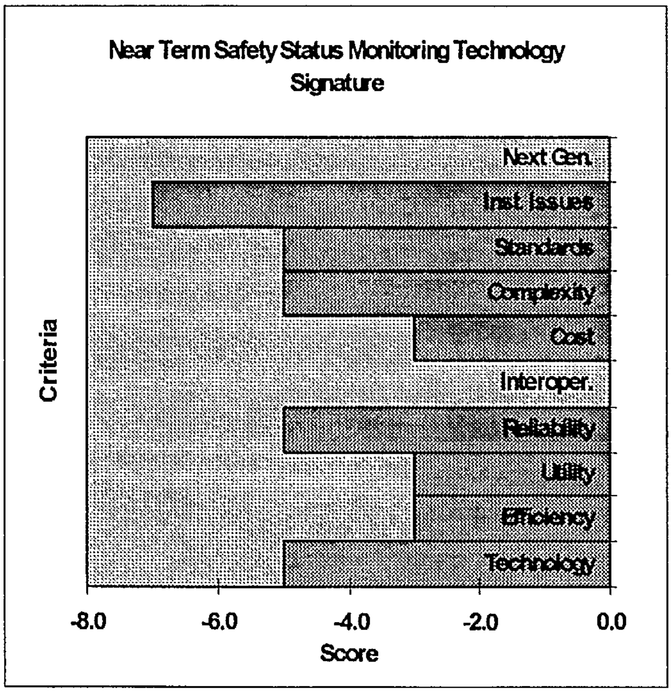
Key Technology Directions:

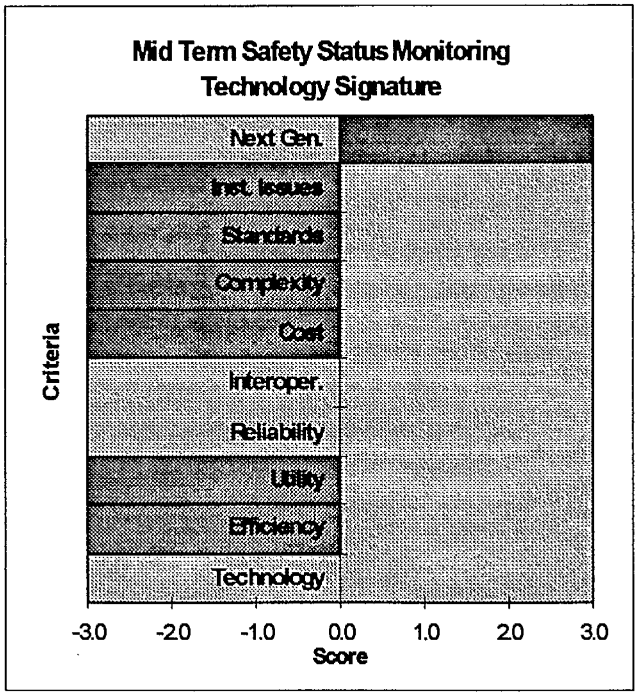
- Improved, lower-cost sensors.
- On-vehicle processing and electro-mechanical system integration

Critical Implementation Issues:

- Institutional: manufacturer liability issues
- Utility and benefits
- Consumer acceptance

2.17 Technology evaluation: Safety status monitoring





Evaluation:

Monitoring the status of the condition of the physiological condition of the driver (tired, impaired, inattentive etc.) and the vehicle (condition of mechanical and electrical systems such as brakes, tires, lights etc.) could conceivably offer clear safety benefits. However building such systems which can take into account the broad spectrum of "normal" human performance offers a substantial challenge and many vehicles already incorporate internal monitoring systems for various safety-related functions. External monitoring of such conditions could face institutional impediments from a privacy standpoint, although a commercial vehicle "black box" technology and other related monitoring systems are currently available. If this area proceeds, it is likely to do so in the commercial vehicle and fleet management marketplace.

Related User Services: Safety readiness, on-board safety monitoring.

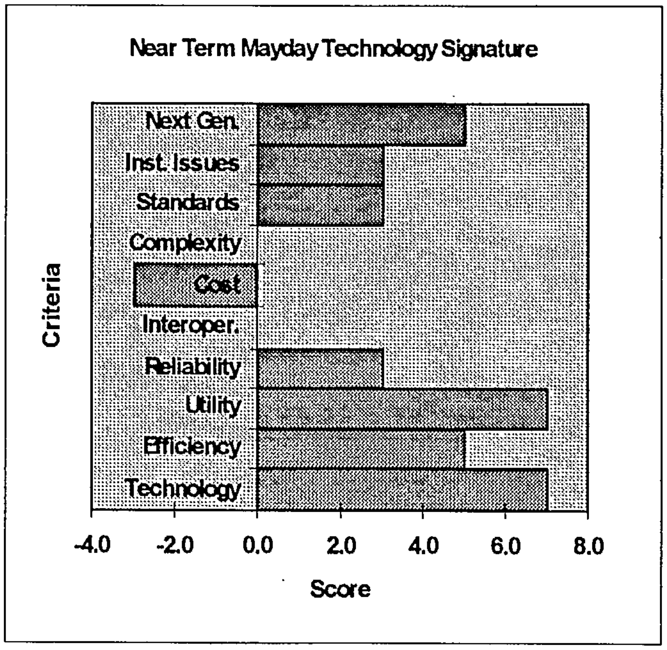
Key Technology Directions:

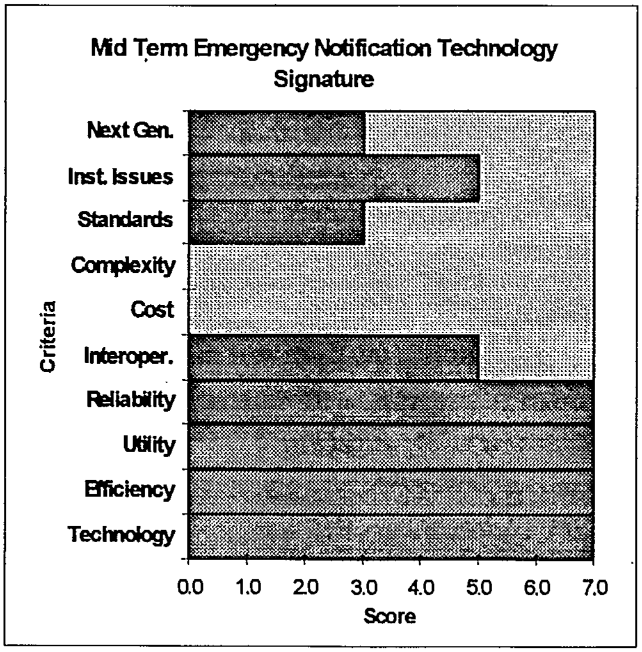
- improved sensor technologies for monitoring human physiological performance

Critical Implementation Issues:

- Institutional: privacy
- Consumer acceptance
- Cost effectiveness versus other conventional approaches

2.19 Technology evaluation: Emergency notification





Evaluation:

Personal safety and security is a major concern today. This application area had the highest current and mid-term overall performance ratings. Technologies available for Mayday purposes are robust, reliable and as production rises, will be so at reasonable cost. The utility of these applications is high and they appear to be attractive in the marketplace depending on cost. Standards and interoperability could cause some limited problems with wide-area coverage, but these are not expected to be a serious impediment to their implementation. Several vehicle manufacturers offer Mayday systems at present, (e.g. Ford's RESCUE and GM's ONSTAR systems), and more are expected in the near future.

Related User Services: Emergency notification, HAZMAT response, emergency vehicle management.

Key Technology Directions:

- reducing technology costs.
- system integration with other ITS in-vehicle applications

Critical Implementation Issues:

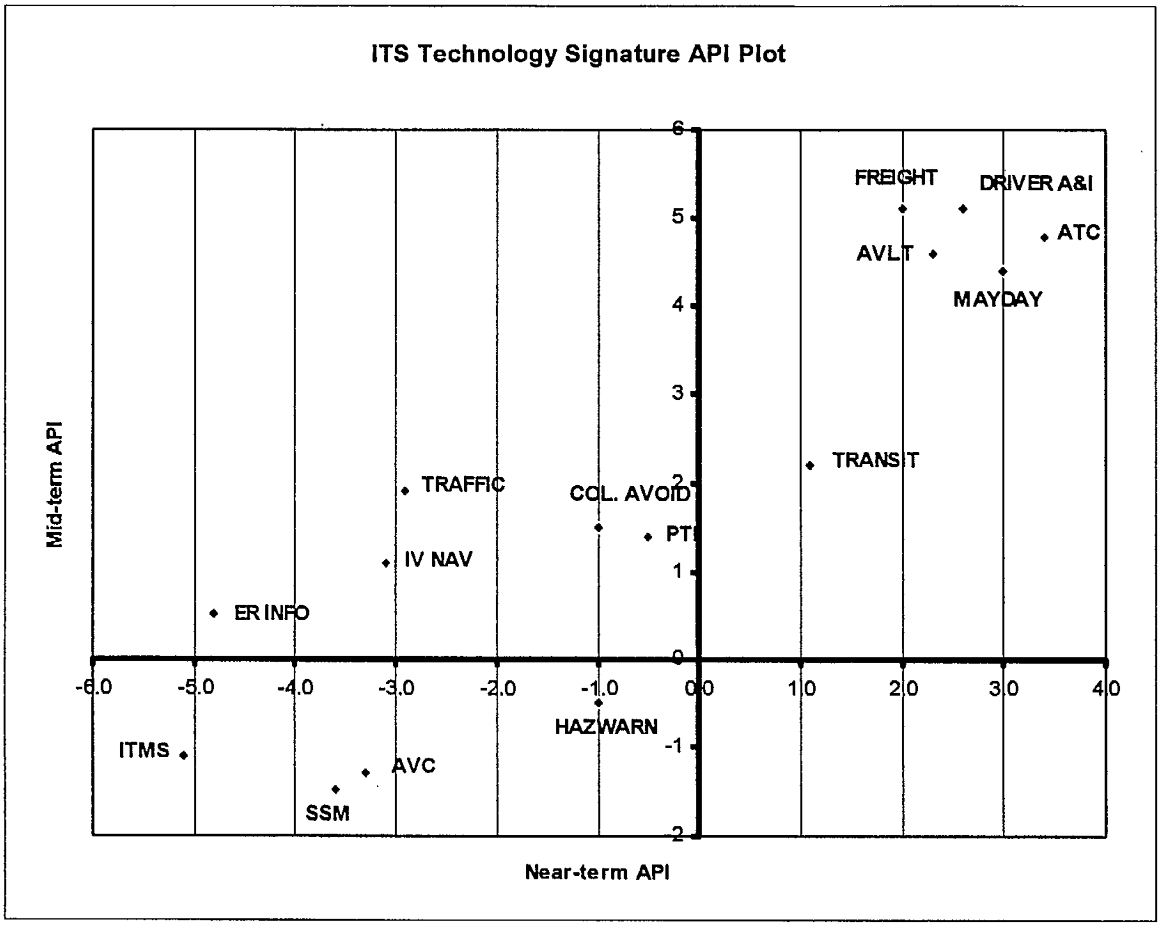
- Institutional: potential liability concerns for response providers
- Institutional: allocation of public vs. private response resources

2.20 Summary of key technology issues

It is clear that there is a marked differentiation of ITS applications and their related user services in terms of their "readiness" for the marketplace. To help illustrate this visually, we prepared the graph below. Although it appears complex, it is really quite simple and is based on the technology signatures we just talked about in sections 2.4 through 2.19 of this report.

To develop the graph, we took each technology signature (for both the near and mid-terms) and simply averaged the score on each of the 10 parameters that make it up (ie. Cost, interoperability, standards etc.). We called these average numbers "Average Parameter Indexes", or API's for short. This gave us two Average Parameter Indexes for each technology group: one for the near term, and a second for the mid term. Obviously, the higher the value of the API, the more mature the technology at the point in time which the given API value represents. For this graph, we've simply used the two API values of each technology area as x (near-term) and y (mid-term) coordinates. More mature technologies will appear at the upper right side of the graph. Lesser ones will tend to appear further down and to the left. The terminology used on the graph comes from the SRI report which was used as a basis for the technology assessments. See Table 2.1 (page 8) to relate this to the more straightforward ITS America terminology.

Figure 2.1
Technology Maturity Graph



- Standards and interoperability are fundamental issues affecting ITS technology market penetration.
- Institutional constraints in the form of government budget cutbacks have a direct impact on the likelihood of ITS technology deployments.
- Technologies which are advancing the fastest in ITS are those which have developed proven performance records - usually through showcase or demonstration projects.
- Communications technologies will play a key role in the deployment potential of most ITS technology areas.
- ITS technologies which provide immediate "bottom-line" payback to users are those which are moving most quickly into deployment. CVO and ATC applications are good examples.
- User acceptance is a key to successful ITS technology deployments.

Chapter 3: The Global ITS Environment: II

Current Activities

3.0 Chapter overview: Current activities

This chapter is intended to provide an overview of the global ITS environment from a number of different standpoints. Focusing on North America (primarily the US), Europe and Japan, it begins with a discussion of some basic geographic characteristics which contribute to the differentiation of interest, activity and deployment of ITS technologies in these regions. The history of public funding of ITS programs in each region is reviewed and followed by a discussion of their respective technology deployment patterns.

A separate section on ITS architecture and standards looks at international efforts and developments in this critical technical area and their implications for ITS activity. A brief section is included which examines the potential for ITS deployment in developing countries. The closing section of this chapter provides a summary of key issues arising from the global ITS environment which could influence the development of both the near and mid-term marketplace and the effectiveness of various strategic marketing approaches to it.

3.1 The influence of geography

The geography of the three main regions of interest influences ITS deployment patterns within each. These characteristics are outlined below.

- **The United States**: Much of the population of the US (and Canada) is concentrated in large towns and cities generally well separated (apart from a few zones such as the Eastern Seaboard, California, the Quebec/Windsor corridor in Canada etc.) and sharply distinct from rural areas. Urban centres in the US and the three major cities in Canada (Toronto, Vancouver and Montreal) experience heavy traffic congestion, however interstate and interprovincial highways are much less traveled, although these rural highways do not generally offer acceptable alternative routes to congested urban facilities except perhaps in the immediate areas around large urbanized areas. Although the concept of highway tolling is gaining momentum quickly in North America, such facilities are still relatively rare. In general, the Canadian context, with about 29 million people in 10,000,000 sq. km is considerably more dispersed than that of the US.

- **Japan**: Japan experiences heavy traffic throughout much of its national highway network, leading to a continuum of congestion - and consequently, information needs - especially along the entire eastern coast. Toll roads are common, with frequent, closely-spaced, manual toll plazas.

While most through traffic is carried on fairly modern multilane highways, urban street networks tend to be confusing and offer relatively poor traffic service, with frequent signals. This context has led to the intensive development of autonomous navigation systems and extensive information displays, but little dynamic route guidance to date.

- **Europe:** Europe has a wide variation in geography, but tends towards the Japanese characteristic of heavy traffic throughout much of the highway network as well as in urban areas. The latter often merge into one conurbation, as found in the Ruhr (Germany), the Rhône Valley (France), the Randstad (Netherlands) and the regions around Birmingham and Sheffield in the UK. The highway and urban networks are usually fairly distinct and often administered by different levels of government. Tolls are common in Italy (Autostrade), on most but not all "autoroutes" in France, on the limited length of "autopista" in Spain and elsewhere at specific geographic points such as major bridges and tunnels. Traffic signals tend to be limited to highways with heavy traffic, including much of the Dutch network, substantial lengths of the British and German road systems, and more locally in France and Italy. All-purpose urban street networks, heavily signalized, usually offer limited capacity for relief of congestion on the highway systems, but tend to merge with those systems as urban limited-access multilane roads are built to link the two. Modern highways may parallel older roads, which have often been downgraded as a consequence and are thus less suitable for through traffic which might be diverted to them. Often, the newer routes are distant from the older, and for geographical and traffic loading reasons, diversion is not usually a practical alternative except in extreme conditions.

Some consequences of these geographical differences include:

- a significant and well founded interest and technological capability in in-vehicle navigation systems technologies in Japan.

- an extensive employment base at manual tolling stations in Japan which may ultimately have some influence on the role for electronic tolling in that country.

- separation between urban and inter-urban traffic control and management systems with potentially different objectives and competing administrations. This is true in all countries to various degrees and involving different administrative structures. In Europe, one major achievement of the European Union R&D programs has been to encourage bridge-building between such interests, and in many cases close cooperation is now developing. With the advent of the VICS program in Japan, similar competing interests in the five ministries involved in ITS programs and road administration are now also beginning to work together. In the North American context, this problem is recognized, but has not been dealt with effectively as yet.

- in Europe, the closeness of conurbations has led to quite different broadcasting technology from that common in North America. While there are long-range AM stations serving whole countries, especially in France and Britain, and many local medium-wave AM stations, the great majority (and almost all of those radio stations created during the explosive radio broadcasting expansion of the past 10 to 15 years), are FM stations. Most of these offer limited coverage due both to their inherent line-of-sight characteristic and their low authorized radiated power which is dictated by the need to minimize interference. In the Rhine valley for instance, countless close transmitters mean that in places more stations can be received on the French side in German than in French, and sometimes vice-versa. Italy has over 4000 FM transmitters. London is approaching 300. Most of these serve local stations, but a minority radiate national channels, and thus occupy different frequencies which can be reused only at distances exceeding about 150 km. This European arrangement has implications for traffic message broadcasting and is discussed in more depth in the communications section of this Chapter.

3.2 Public funding for ITS technology development

3.2.1 Overview

ITS developments are currently moving most rapidly in Europe, Japan and the United States. Driven by the imperative of severe traffic congestion and safety problems, both Europe and Japan have had significant programs of research, development and demonstration (RDD) underway since the mid 1980's, although work was proceeding in this area even before that time - particularly in Japan. The table below provides a summary of centrally provided public funding for ITS programs in each of these locations.

Table 3.1
Centrally ProvidedPublic Funding for ITS Programs (US$)

Europe	United States	Japan
• **PROMETHEUS:** spending planned for 1987 - 1993: $770M • **DRIVE** budget for 1988-91: $70M • **DRIVE II** budget for 1991-94: $160M • **DRIVE III** budget for 1995-98: $275M • **EC DGVII** (Transport Directorate) RTI/ITS under Framework IV: $25M	**Federal government RD&D:** • 1989: $2M • 1990: $13M • 1991: $24M • 1992: $234M • 1993: $143M • 1994: $203M • 1995: $227M • 1996: $223M • 1997: $228M (tentative)[1]	**1973 - 1979:** • $180M for CACS R&D **1985 - 1992: for R&D** • $1.9M (NPA & MOT) • $5.0M (MOC) • $5.4M (MITI) **1985 - 1992: for deployment** • $1.875Billion (NPA) [2] • $519.5M (MOC) • $17.9M (MOT)

source: International Program Assessment, Kan Chen. Paper prepared for ITS America BEC Committee (12)
[1] ITS America News, July 1996. House of Representatives proposed allocation. Proposed Senate allocation: $244M
[2] Primarily for updating of ITS beacon system

3.2.2 Europe

The **European program of Road Transport Informatics** (RTI) or Advanced Transport Telematics (ATT) as ITS is called in Europe, has had two primary elements: Prometheus and Drive. Investments by both government and the private sector to date in both research and demonstration projects, has exceeded $1 billion (US)since 1987. It is interesting to note that both are taking place at the European Union level, with multiple country participation and the need to coordinate a broad range of activities within a very complex interjurisdictional environment.

PROMETHEUS, working under the aegis of the European artificial intelligence and high technology initiative EUREKA, is primarily a private sector effort. It began in 1986, and ran until 1994, was vehicle oriented, and had an investment level in the order of US$770 million . It was aimed at the development of technologies for active driver support, cooperative driving, and traffic management.

The **DRIVE** program, now entering its third phase, focuses on road infrastructure technologies in the area of demand management, traveller information systems, traffic management, fleet management, and other areas. In Phase 1 of the program which started in 1988 and ran until 1991, over US$140 million was invested by government and industry in 72 projects which were essentially pre-competitive research. In phase II, the DRIVE program had 56 projects - primarily of a field trial nature, and a combined public/private sector investment level of US$300 million .

In addition to European efforts under the new US$275 million DRIVE III program which will run until 1998, Europe is also supporting ITS through the European Commission (EC) Transport Directorate (DGVII) under the EC Fourth Framework initiative to bring total public centrally provided funding for the 1995-98 period to in excess of US$300 million. Other EC Directorates are also contributing to this sum. Private sector and local government support of the approximately 80 approved transport telematics projects will substantially boost overall investment in ITS in Europe during the period (15). About half of these are dedicated to, or will impact upon advanced traffic management system types of applications - primarily in metropolitan traffic management - reflecting the greater degree of urbanization and resulting complexity of Europe's road systems. (see comments under Section 3.1 of this chapter.)

3.2.3 Japan

Japanese efforts in ITS began in the 1970's and early 1980's,however, the program of work crystallized in the 1980's around two major efforts: **the road Automobile Communications System (RACS)** and **the Advanced Mobile Traffic Information and Communications System (AMTICS).** Both were concerned with traffic management and traveller information systems - notably navigation and traffic information dissemination. Where RACS was oriented to expressway traffic, AMTICS dealt primarily with arterial street systems, and both were sponsored by different ministries within the country. By the 1990's however, both programs had been completed, and their successor program **the Vehicle Information and Communication System (VICS),** aims at complete system integration with real-time traffic management and route guidance as the primary objectives. The Japanese efforts are probably the most advanced in the world in terms of putting down fully operational infrastructure for drivers across the country. Forecasts by some experts predict that they will have this task complete by the turn of the century (13). If so, the Japanese will be the first to accomplish this. As can be seen in the table, the vast majority of public money has been invested in providing public infrastructure to support the ITS applications developed in their R&D program.

Investment in ITS continues in Japan with the National ITS budget for the fiscal year which began in April 1996 for year one of their new ITS national plan being set at US$665 million (14) - almost double the amount requested by the US Dot in its 1997 budget. While the vast majority of this is deployment oriented, over US$100 million has been allocated to R&D in Japan's automated highway system initiative - a technology area that is quite controversial in both the United States and Europe. In spite of these allocations, some experts suggest that growing financial deficits in Japan (government debt/GDP rations approaching 70%) could weaken the government's ability to follow through on ITS investments in the future.

3.2.4 United States

The **United States** is a relative latecomer to the ITS arena, however the public sector commitment of the early 1990's as set out in the provisions of the 1991 **Intermodal Surface Transportation Efficiency Act (ISTEA)** allowed for funding of $660 million from the federal government for ITS related projects. Combined with yearly appropriations directly to ITS under the Department of Transportations regular budget, the US will have spent in excess of $1 billion on ITS RD&D and deployment by the end of fiscal year 1997. The work program has been application oriented, and of course the federal investments only represent one part of the funding picture, since states, cities, and the private sector were required to invest in moving ITS forward quickly in that country. Several corridor projects and technology areas already involve joint U.S-Canada participation and it can be expected that developments in that country will strongly influence what is to be done in Canada.

With the end of the ISTEA program in 1997, US transportation officials are already working on its successor legislation which has been unofficially termed NEXTEA. Needless to say, with constraint being the watchword at the federal level, decision makers are beginning to look for positive results and returns from their past investment and there is some doubt as to the commitment of the federal government to its leadership role in the area. Nonetheless, at present, the program still appears to be on solid ground, and DoT has moved very much to a deployment emphasis in its planning, with the Secretary of Transportation's Operation Timesaver announcement which is intended to be the first initiative in a long term plan to develop a national Intelligent Transportation Infrastructure (ITI) in the 75 largest cities in the US within ten years. Initial model city deployments will begin with 2 or 3 cities in 1997. DoT has requested funding in the order of US$100 million for this and the Commercial Vehicle Information Systems and Networks (CVISN) initiative during the 1997 fiscal year. The overall funding request by DoT for FY1997 is in the order of US$336 million, however current House of Representatives and Senate appropriation recommendations are US$228 million and US$244 million respectively. Calls for state participation have already been announced for CVISN.

3.2.5 Some important observations

In comparing public funding for ITS programs in the US, Japan and Europe, a number of important observations can be made:

- European and Japanese programs have had a five to ten year start over the United States, so it is reasonable to expect that both their R&D and deployment efforts would be further ahead. Nonetheless, US efforts since the early 1990's have moved the United States quickly into a very competitive position in a number of key ITS technology areas.

- It is not only American decision makers that are beginning to ask for proof of the benefits that flow from ITS. European authorities are also looking for similar data.

- Public/private sector partnerships are a key to moving ahead in ITS. Early forecasts of total cumulative expenditures on R&D and deployment expenditures by the year 2011 in the US suggested that over 80% of the total would be spent by consumers and private sector interests. Both European and Japanese programs have been built on such partnerships -

led by early catalytic investment by government. Nonetheless, as Chen points out in his comparative update of European, US and Japanese ITS activities (12), there is some concern that US decision makers don't recognize the need for such underlying investment - both in RD&D and in building the public infrastructure which is needed for many applications to move ahead. A similar phenomenon is evident in Canada, where, with the noted exception of Ontario, both federal and provincial governments have maintained a very hands-off position on ITS technology opportunities.

3.3 Deployment

This section is not intended as a comprehensive overview of ITS deployment. Rather, it is intended to provide readers with a general idea of how ITS technologies are moving within each of the three primary geographic areas of interest. Thus, not all applications are listed and those that are, are not generally described in great detail.

3.3.1 North America: Canada/US deployment

This section on deployment emphasizes a Canadian perspective, although from a deployment standpoint, the general characteristics of deployment patterns are similar for both this country and the US.

ITS extensions of traffic control applications are relatively common throughout North America. An outgrowth of conventional traffic control technology, magnetic loop, microwave, and video-based detection systems are all used to help monitor and adjust traffic control devices - most commonly traffic signals. A number of municipalities are using centralized traffic control systems and in a few, adaptive, real-time traffic control systems such as SCOOT are now appearing. (Halifax, Red Deer, and Toronto in Canada for instance. Anaheim in the United States). Freeway management systems involving multiple data inputs, control centres, variable message signing and highway advisory radio can be found in both Canada (COMPASS, in Toronto) and in many cities in the United States.

Commercial traffic reporting by radio and television is common. While experiments are ongoing in methods to deliver dynamic traffic information to users in vehicles exploiting technologies such as digital cellular telephone, paging systems, portable personal communications devices, in-vehicle sub-carrier radio, and palm-top computers, none of these have led to widespread application of travel information services - primarily because of the lack of comprehensive input data. Obtaining the latter requires a very substantial investment in data monitoring and collection systems - normally a function of government. Static route guidance systems are available as options on some vehicles, in rental cars and as personal computer packages - primarily in the United States, since Canadian maps- although plentiful in government hands - have not been made commercially available at cost effective prices. Dynamic route guidance is not yet commercially available.

Still not widely exploited, current efforts in the **travel demand management** area tend to be more oriented to public transportation services, with increasing numbers of transit agencies providing dial-up or kiosk based pre-trip information services to prospective passengers. Multimodal pre-trip travel information services , and demand management and operations services are not yet in place. Ride matching and reservation services tend to be present only within agencies or groups of employers and are run as private systems for employees, rather than being open to broader participation.

Virtually all large and medium-sized **public transit operations** use scheduling and run-cutting software for route planning and resource allocation services. A number of agencies in Canada such as Metro Transit (Halifax), and OC-Transpo (Ottawa-Carleton) are using automatic vehicle location and tracking systems to help monitor resource distribution and schedule compliance. Similar patterns of deployment are found in the US. Demand-responsive trip routing and scheduling software has become widespread, particularly to increase the accessibility of public transit services to all travelers. A number of systems maintain automated dial-up route information and schedule services for public access, as well as kiosk-based route information services in transit stations and other public locations.

Still limited in its application, **electronic payment systems** are nonetheless beginning to make inroads in both the road tolling and public transit systems. Some systems have been extended to both parking facilities and telephone usage. In 1995, the U.S. reported electronic payment systems being planned or deployed at 20 toll facilities in the U.S. The public/private sector partnership Highway 407 project in Toronto has been designed as an all-electronic tolling (ETC) application. It opens this fall. The Province of Nova Scotia has entered into a public/private sector partnership agreement for the construction of a section of its Highway 104, which will be a toll facility, but will probably not use electronic toll collection technologies. A number of other provincial governments in Canada (New Brunswick and British Columbia among others) are contemplating tolled facilities in which ETC could play a role. Interoperability questions and a lack of standards in this technology area are inhibiting factors which could still influence the spread of this technology in the near-term future. Similar interest and patterns of planning and designing for ETC toll facilities are moving ahead quickly in the US on a much larger scale.

One of the fastest growing application areas, the **commercial vehicle operations** application is definitely the subject of a major "market-pull" - particularly from the highly competitive commercial freight carriers. Over half of North American truck fleets have deployed some form of fleet management system - most frequently to facilitate dispatching, vehicle location and fleet resource allocation in response to changing customer demands. Truck and driver condition monitoring systems are also being deployed, and intermodal operations are being facilitated through the electronic identification of containers and vehicles.

At the administrative level, as noted earlier, both weigh-in-motion (WIM) and automatic vehicle identification (AVI) technologies are being used to gather information on truck weights and vehicle credentials. The HELP Inc. project is now operational and is using electronic clearing services to permit safe and legal trucks equipped with transponders to bypass weigh stations and state ports-of-entry at highway speeds in the western parts of the US and Canada. Advantage I-75, which will incorporate portions of Highway 401in Ontario, will soon be implemented as an operational test of similar technologies both for commercial vehicle pre-clearance and automated border crossings. In the United States, efforts are going forward with Mexican authorities at selected border crossing locations. Other corridor applications are also planned. Continent-wide interoperability is still an unresolved issue.

In the U.S. in 1995, 24 **emergency management systems** were equipped with automatic vehicle location systems and a further 104 were moving forward with plans to implement. Exact figures are not available for Canada, but informal surveys indicate that the trend is similar. Police, fire and ambulance services are primary clients for such services. Commercial in-vehicle "mayday" systems are now being offered as options in high-end vehicles by Ford, with Chrysler and General Motors expected to follow suit

A few **advanced vehicle control applications** in the form of longitudinal and lateral collision warning systems are available on the market and are being deployed - primarily by commercial bus and truck operators. General Motors is offering such a system on its Cadillac

Seville vehicle as an option. All of the major North American automobile manufacturers are working on intelligent cruise control systems - systems designed to maintain constant vehicle headway - and are expected to bring operational technologies to market within 3 to 5 years.

3.3.2 European deployment

In Europe, there exists a strong relationship between government, service providers and the manufacturing industry. ITS deployment has moved ahead very much as a partnership effort led by catalytic funding from government.

Urban traffic management and traveler information applications in Europe have generally used as a starting point the existing integrated urban traffic control systems, where connections to a Traffic Control Centre and/or Traffic Information Centre have followed from the decision to provide optimized area-wide control using software systems such as SCOOT (British), PRODYN (French), or SCATS (Australian). About 30 major cities have led the way. Standards and interchangeability of equipment still pose problems, with the result that local (domestic national) suppliers often have an advantage over external providers. Typically, city clients have looked to invest in traffic management and traveller information systems in parallel because of the obvious synergy which exists between the two. Traveler information services have focused on the use of variable message signs (VMS) on roads and kiosks in public transit stations. Integrated information exchange between traffic and public transit systems has been accomplished. Pre-trip planning information is available in homes and offices through telecommunications links.

While European efforts in the **ATIS** area have been significant, they have often been exploratory, and delays in funding infrastructure to support private sector ventures (i.e. beacons etc.) have led to consequential delays in the commercialization of the ATIS extensions to ATMS. The recent failure of the Siemens-led COPILOT project was a major blow to the use of infrared beacon technologies for ATIS and in-vehicle dynamic routing applications, however it has apparently enhanced interest in autonomous navigation systems such as the successful BMW CARIN option. This system (based on the CARMINAT technology) sold 10 times more units (4000) than expected in the first year it was offered (1995). Europe's considerable strengths and proven experience in the underlying Radio Data System / Traffic Message Channel (RDS/TMC) FM sideband broadcasting technology that supports CARMINAT has led countries such as Germany to commit to providing traffic information on 3000 km of its expressways free of charge.

In the UK, one of the most **successful traffic information** implementations has been the British TrafficMaster, which provides a range of services at different subscription levels. Now covering the busiest part of the English/Welsh road network, and based on a statistical sampling network of Doppler-effect infrared detectors to measure traffic speed, traffic congestion information is presented on in-vehicle units or on PC's for trip planning. The system is now commercially viable and is being introduced in the European mainland through a partnership agreement with a German company.

While **tolled facilities** are not uncommon in Europe and the interest in electronic tolling solutions is high (particularly multilane free-flow solutions that can be implemented without the need for large and space-consuming toll plazas in the constrained right-of-way environment of that region), finding a common solution among the European countries has been a task plagued with difficulty. The recent poor performance of the 5.8GHz communications technology in German tests and its rejection as the European standard for Dedicated Short Range Communications (DSRC) have increased the difficulty of finding a common solution. Nonetheless, in spite of a rejection of the concept of tolling private automobiles (but not trucks) by Germany, and continued delays in UK tolling trials which have resulted in four of eight consortia pulling out of that country's motorway experiments, interest continues to mount in the conversion of existing extensive toll roads systems in Italy, as well as in other European countries including Spain, Portugal, France and Holland.

Europe is well advanced in the research and development of **multipurpose smart cards** which could be used not only for intermodal transportation (fares, tolls, parking etc.), but also for other purposes such as pay phones, retail purchases and holding medical records. This technology holds significant promise for several ITS application areas.

Projects in the **commercial vehicle** area in Europe have generally focused on the load rather than the vehicle, essentially in support of multimodal traffic (particularly rail/road), which is ubiquitous in that region. As such, the principal ITS element is that of the tracking of shipments, communication with drivers, location and security of vehicles and awareness of the status and position of hazardous consignments. Many commercial applications dealing with fleet utilization, scheduling etc. are regarded as highly proprietary and as such, are generally closely held by their fleet owners, rather than being exploited for commercial purposes.

3.3.3 Japanese deployment

Japan was the earliest entry in the ITS area. Beginning in 1973, it has built up the largest investment in this area (almost US$2.6 billion) - a great deal of which has been oriented to physical deployment of the beacon infrastructure necessary to support their primary area of interest - the combined ATIS/ATMS function. Building around their Vehicle Information and Communications Systems (VICS) program, the long-term goal is to allow end-users to download dynamic traffic congestion and travel time information through microwave and optical beacons as well as by FM multiplex broadcasting anywhere in the country.

The ability to support this systems flows from the long history and experience of the Japanese in building and operating the traffic management systems and associated data collection infrastructure which provide the information needed for real-time, dynamic traffic information applications. The country has over 160 traffic control centres, a comprehensive system of detectors and surveillance systems on all expressways and the majority of their arterial street system, and a wide network of variable message signs which have been the primary means of communication with motorists to date. A public/private sector partnerships known as the ATIS Corporation, which began operations in 1994 will utilize and distribute the information from the core infrastructure. Commercial fleets have been the first users to take advantage of this information service, however private users have been slower to enter the marketplace as consumers (12).

Autonomous navigation systems have flourished in Japan, and the over one million units sold to date has allowed the support of multiple technology vendors. Some researchers (13) attribute the acceptance of this technology at least in part to the Japanese drivers' penchant for new technologies - suggesting that this level of success may not be achieved elsewhere. Whether or not this is the case, Chen (12) points out the obvious fact that such a depth of experience in building and marketing these units provides such companies with a significant advantage in the marketplace and cites the example of Zexel's success in the US and Europe.

While tolling is extensive (in fact ubiquitous) on the Japanese expressway network, Japanese interest in the domestic application of electronic tolling is virtually non-existent. Various reasons have been cited for this, ranging from radio frequency allocation control issues (12) to labour concerns (15). Nonetheless, the Japanese Ministry of Construction has committed to an ETC research project to begin in 1997.

3.3.4 Deployment: Technical perspective

In comparing the efforts of the three leading ITS investment communities, there are definite differences in the strengths of each, as well as the approach being taken in each Region. In general, The United States has in place a strong coordinating organization, with a top-down planning approach and an orientation to operational testing and demonstration projects. In terms of technical deployment, America leads in the ETC and CVO areas.

Japan on the other hand, with a stronger investment from the private sector, and a heavy public input into ITS infrastructure for traffic management and driver information, holds a definite lead in both of these areas. Experts have suggested that Japan will be the first country in the world to deploy traffic and traveller information services nationwide - probably by the turn of the century or shortly thereafter.

Europe's more broadly-based partnership-oriented R&D program has provided it with a solid base upon which to build applications in the future. At the application level, Europeans have become leaders in the development and deployment of adaptive traffic control systems and broadcast-based dynamic traffic information dissemination. Because of their extensive involvement in ITS applications through the vehicle-oriented PROMETHEUS program, European car manufacturers appear to have an advantage in the vehicle control and safety area.

3.4 Architecture and standards

3.4.1 Architecture

Among the three major regions of interest, it is the United States that has made the most substantial effort to put in place an overall architecture for Intelligent Transportation Systems. Europeans have also been working at an overall architecture however, the Japanese have done little in this area. Chen summarizes this situation as follows:

> *It appears that while the US is taking a top-down approach to develop a system architecture to assure interoperability and to help attract private investment in products and services, the Europeans have been taking a de facto bottom-up approach due to political reasons, and the Japanese have been following their traditional approach of market determination.* (16)

It's interesting to note that the European efforts, being carried out under the Drive II System Architecture and Traffic Control Integration (SATIN) task force and led by ERTICO has a similar framework to that of the American effort, but that whereas US efforts are aimed at ensuring interoperability and compatibility, the European project underlines the fact that the use of systems which do not fit within the architecture requirements need only be fully justified. (12)

The Americans have now produced the final reports of their overall architecture development program and are the only region to have in place a comprehensive framework for this purpose. The authors of the final reports explain the role of this architecture as follows:

> *To fully maximize the potential of ITS technologies, system design solutions must be compatible at the system interface level in order to share data, provide coordinated area-wide integrated operations, and support interoperable equipment and services where appropriate. The National ITS Architecture provides this overall guidance to ensure system, product, and service compatibility/interoperability, without limiteg the design options of the stakeholder.* (17)

The US effort is a world-leader and without doubt sets the stage for the very substantial North American ITS technology market. It is our view that because of the global nature of the ITS marketplace and the very substantial portion of it that America represents, the US architecture will in fact have an influence well beyond the North American continent.

The final report summarizes the purpose of the US architecture as follows:

- it defines the functions that must be performed to implement a given user service
- it defines the physical entities or subsystems where these functions reside - such as the vehicle, or the roadside
- it defines the interfaces/information flows between the physical subsystems and the communication requirements for them (e.g. wireline or wireless)
- it identifies and specifies the requirements for the standards needed to support national and regional interoperability, as well as product standards needed to support economy of scale considerations in deployment.

Canadian authorities have tracked and monitored the US architecture efforts carefully, given the substantial impact that they will have on our country. In effect, the US architecture will determine the technical framework for ITS developments across the whole of the North American Free Trade Agreement (NAFTA) zone. As noted earlier, we expect that its influence could in fact extend well beyond this.

3.4.2 Standards

The key to ITS technology is its ability to bring together the road user, the vehicle and the road infrastructure into one communicating system. This integration allows these elements to exchange information in order to allow for better management and use of the resources available. An ITS architecture can set out the framework within which this integration takes place - as is evident from reading through the purpose of the US effort. Standards represent the critical tool needed to implement this architecture.

In his 1994 work comparing ITS developments in the US, Europe and Japan, Robert French points out:

> *International standards for IVHS products will also provide for greater economies of scale and facilitate international competition on the basis of performance and cost.* (18)

At the international level, current efforts in standards setting for ITS revolve around two key organizations: the International Standards Organization (ISO) and the European Committee for Normalization (CEN). The former carries out its work through its Technical Committee on Transportation Information and Control Systems (ISO/TC204). The CEN work is carried on via its Technical Committee CEN/TC278. Political reasons underlie the European duplication of ISO activities, since within Europe, CEN standards are obligatory, but conformance to ISO standards is not. Both groups have agreed to cooperate however, as the table below illustrates.

Table 3.2
Standards Harmonization between ISO and CEN

Working Group (WG)	Lead	Cooperating WG
Architecture	ISO	CEN WG12, 13
Quality and reliability	ISO	
Map database	ISO	CEN WG7
Fee & toll collection	CEN WG1	
General fleet management	ISO	CEN WG2
Commercial fleet management	ISO	CEN WG2
Public/emergency fleet	ISO	CEN WG2,3
Traffic management information & control	ISO	CEN WG5
Traveler information	CEN WG4	
Route guidance	ISO	CEN WG4
Human factors/man machine interface	ISO	ISO/TC22/SC13/WG8
Vehicle road warning and control	ISO	
Short range communications	CEN WG9	
Wide area communications	ISO	CEN WG11

source: International Program Assessment, Kan Chen. Paper prepared for ITS America BEC Committee (12)

The standards work is extensive and critical to ensuring the protection of national interests and future possible market position. European and US national interests currently strive to ensure that they are well represented across the committee structures. The US efforts in ITS architecture have placed them in a position of de-facto leadership on the ISO committees - a position which they feel is essential to protecting American industry interests (12). It is interesting to note that European representatives on various standards committees are often financially supported by their national governments because of the importance with which such participation is viewed. US participants are also currently working towards this end. The linkage between helping to shape international ITS standards and ensuring that national ITS technology industry interests are protected is unmistakable.

In related work early in 1996, the US Department of Transportation announced awards of over US$16 million to develop national ITS standards. Five independent technical organizations received the awards as follows:

- The American Association of State Highway and Transportation Officials (AASHTO): for roadside infrastructure standards

- The American Society for Testing and Materials (ASTM): for short range communications systems essential to ITS

- The Institute of Electrical and Electronics Engineers (IEEE): for electronics and communications message sets and protocols

- The Institute of Transportation Engineers: for traffic management and transportation planning systems

- The Society of Automotive Engineers: for in-vehicle and traveler information systems.

Through the coordinating efforts of ITS Canada, Canada has attempted to stay involved in the international standards setting process - particularly with respect to the ISO/TC204 efforts. In 1993, the Society formed the Canadian Advisory Committee (CAC) and enlisted a roster of volunteers to work in the various ISO working groups.

Unfortunately, because of funding constraints and the substantial amount of travel involved for such members, it has been difficult for Canada to participate effectively in these efforts. In the fall of 1996 however, a meeting of the CAC was held, at which Transport Canada asserted its determination to support efforts to rejuvenate the CAC in order to ensure both monitoring and direct participation in international standards activities where the interests of Canadian companies and agencies are likely to be affected.

This commitment has been complemented by the recent decision of the Standards Council of Canada to establish the Canadian Advisory Committee for ITS Standards to support Canadian activities is ISO/TC204. While specific funding commitments are still being sought from both Transport Canada and Industry Canada, these recent developments are expected to considerably enhance Canada's ability to participate effectively in standards setting activities at the international level.

In addition, recent initiatives by both Industry Canada and Transport Canada to maintain close contact and coordination with United States national efforts at ITS-related standardization have been more successful and a good working relationship appears to have been established which will stand Canada in good stead as the North American ITS marketplace continues to evolve rapidly over the next few years.

While government must continue to play a major role in leading these efforts, it is evident that the successful efforts of other countries in participating in international standards setting work depends heavily on participation from all ITS stakeholders. For Canadian efforts to be successful, a similar approach will have to be taken, and active participation from other federal agencies, as well as provincial and municipal governments, industry, academia and other research organizations must be assured.

3.5 A word on emerging industrialized countries

While the majority of this report focuses on the regions which have been most intensively involved in ITS development to date, there is little doubt that other markets are opening up. One of the most significant of these is represented by the emerging industrialized nations around the world. Kan Chen notes:

> *A significant advantage of these countries in ITS funding is that, unlike the industrially mature regions in the world, they still have mammoth bulding programs. Instead of building traditional highways, they are aware of their late-comer's advantage by building smart highways from scratch rather than retrofitting new conventional highways with information technologies at a later stage. And a small percentage of their highway building funds can go a long way toward equipping their roads with ITS core infrastructure.* (19)

This sentiment was echoed in a presentation by the Chief Executive Officer of ERTICO, (ITS Europe), Mr. Olivier Mossé, at the 1996 ITS America meetings where he noted that the

ITS market in developing countries was very significant, and in his opinion, perhaps represented a greater opportunity than anywhere else in the world.

Finally, in their analysis of the ITS marketplace in Europe, Japan and North America, SRI Consulting observed:

> *Even though we confine the geographic markets of this study to North America, Europe and Japan, we are aware that with the sometimes slow deployment of ITS in these geographic regions many companies are seeking and finding good markets for their technologies in other parts of the world, especially South America and many Asian countries other than Japan. This refocus by many companies for active market is understandable, but is not distracting the industry from the still very large markets developing in our three geographic regions. The ITS industry is gaining good experience, credibility, market partners and revenue from its activities elsewhere in the word while it waits for home markets to develop. Our researches show that over the next five to ten years some of these home markets will grow considerably, and companies with global experience and proven competitively-priced products will be in a strong position to dominate their market. A third area of focus is also emerging - one with huge ITS potential in the long-term: that of the densely populated countries of India and China. Although the markets are still future markets, companies are positioning themselves to address these country's major traffic problems and consumer markets when the time is ripe.* (20)

The potential and nature of these marketplaces is discussed in additional detail in Chapter 5 of this document.

3.6 Key ITS environment issues

There is no one mechanism that can be prescribed for a country that wants to develop its ITS capabilities in order to both take advantage of the benefits of the technology as well as to promote its industrial development. In most cases, the mechanisms that will work depend to a significant extent on the constitutional structure of the country and the traditional mechanisms that have been put in place to foster cooperation in the past.

In the European case, the contintental cooperation required has been fostered to a significant degree by the European Union effort, the ERTICO organization, and cooperative structures already in place. In Japan, the tradition of managed competition run through such agencies as MITI, has allowed that country to advance the development of its technologies in a structured and managed fashion, minimizing waste, and exploiting the strengths of the Japanese technology industry.

The United States has used ISTEA as the cornerstone of its ITS efforts from a financial standpoint. However, the creation of ITS America as a body which could bring together all of the parties interested in ITS to discuss, exchange information, and provide advice to the federal government on technical and policy issues has strengthened the ability of the various communities to work together.

The mechanisms differ from country to country, however the key ingredients are the same wherever ITS is moving ahead quickly:

- There is a national coordinating (not dictating) mechanism whose primary aim is to protect and promote national interests both domestically and abroad. This mechanism is usually an office (or offices) of the central government in some form: US DOT in the United States; MITI in association with other critical ministries in Japan; the European Commission Directorates on that continent.

- All sectors are involved: public, private, and academia. Government and private sector cooperation are seen as essential. Partnerships are the key to successful ITS development and deployment and both financial risks <u>and benefits</u> have to be shared in the longer term. The way to achieving such partnerships is often smoothed through some form of independent (or quasi-independent) group or society such as: ITS America (US), ERTICO (ITS Europe), ITS Focus (Great Britain), VERTIS (Japan).

- Catalytic funding from central government is available and is crucial to helping gain partnership involvement from other stakeholders.

- There is a heavy emphasis on demonstration projects - re-iterating the need for ITS to prove its worth through the demonstration of benefits but also providing a vital "showcase" function to allow domestic industries to demonstrate their abilities. This showcasing function is important not only from a "proof of benefit" point of view, but also from the standpoint of marketing domestic capabilities internationally.

- International cooperation and coordination are seen as keys to opening new market opportunities for national industries . Participation in such efforts - particularly in relevant standards setting activities is seen by all participants as being critical to protecting national industry interests and helping to ensure that ITS develops as a global marketplace. Shaping standards is closely related to helping to shape the marketplace.

Chapter 4: Building the Background: I

An ITS demographics review

4.0 Chapter overview: ITS Demographics

In beginning to build the lines of evidence for the ITS marketplace analysis we felt it would be useful to look at a range of specific transportation system characteristics of individual markets to see if there were any indirect indicators that might provide us with initial evidence of any specific market biases or tendencies that might exist. We termed this analysis an "ITS demographics review".

This chapter describes the results of that review. Beginning with an outline of the geographic and technical basis for the work, it first sets out the selection of descriptors used and their relationship to various ITS User Service categories. A global perspective on the four analysis regions is then provided, followed by a review of each individual region.

4.1 Analysis parameters and methodology

4.1.1 General approach:

We began the work with a comprehensive search of various databases published in the literature and found online on the World Wide Web. Numerous sources were identified. In general, three major sources of information were used:

- Urban population and city size distributions were based on data published by the United Nations in its *UN Demographic Yearbook, 1995 edition.*
- Population and GNP statistics came from the *World Fact Book* located on the *Stategis* web site of Industry Canada
- Road traffic, accident and expenditure data came from the International Road Federation *World Road Statistics (1990-1994)*, 1995 edition.

4.1.2 Geographic Scope of the work:

We divided our analysis regions into four distinct geographic areas. In general, this helped to keep the regions somewhat homogeneous in their characteristics, however there are of course a number of anomalies which quickly become evident. Nonetheless, we feel that the geographic areas outlined in the table on the page following are appropriate. That table provides a summary of the countries examined, grouped by geographic region. China and India were not included in this ITS demographic review.

Table 4.1
Countries Reviewed in ITS Demographic Analysis

North America	Western Europe	Pacific Rim & Australia	Mexico & Latin America
Canada	Denmark	Japan	Mexico
United States	Norway	South Korea	Chile
	Sweden	Taiwan	Argentina
	Finland	Singapore	Brazil
	Germany	Australia	Venezuela
	France		
	Holland		
	Belgium		
	Austria		
	Italy		
	Switzerland		
	Spain		
	Portugal		
	United Kingdom		

4.1.3 Statistics examined:

A combination of socio-demographic, statistical and transportation data were deemed useful for this study. The statistics we examined included: total population; Gross National Product (GNP); percentage urban population; number of vehicles of all types; rate of ownership of all types of vehicles per 1000 population; the rate of ownership of all types of vehicles per km of road network; the number of cars per household; the number of km of road network, highways and secondary roads; total vehicle kilometers of travel by various vehicle types; the average annual distance traveled by all types of vehicles; the number of road accidents resulting in personal injuries and fatalities; and the road expenditures by central governments on road maintenance, transportation research and new road construction. The majority of transportation statistics gathered were as of Dec. 31st, 1994. Population information was as of July, 1995.

In many instances, complete information was not available for every country. In addition, some obvious definitional problems were encountered - particularly with respect to financial information. As a result, the majority of data gathered on road expenditures was not included in our analysis, although it has been retained in our database for future reference.

4.1.4 Interpreting the information and key indicators:

We regarded this review as another basic descriptor of the potential for countries to use ITS technologies. It was intended as one link in our lines of evidence to help distinguish marketplaces from one another by various characteristics. Obviously, we used this in addition to much more specific marketplace information discussed in Chapter 5 and other locations in this report. As such, interpretation of the data in isolation - as we do in this chapter - must be carried out with caution. Nonetheless, we believe that the review provides some good indicators and discriminators that are worth adding to our intelligence base of information on world ITS markets.

While many statistics were examined, once we had an opportunity to analyze the data, we focused on a number of indexes as primary descriptors of "ITS potential". These key parameters - and their roles are outlined below.

- **% of country population living in urban areas**: presumably, the potential for cost effective use of certain ITS technologies is enhanced in heavily urbanized countries where congestion is more likely to be a problem. *Variable name: urbpop*

- **% of urban population living in centres with populations greater than 1 million**: larger population centres tend to be subject to greater levels of congestion, and could conceivably benefit to a greater degree from the application of certain ITS technologies. *Variable name: 1M+*

- **car ownership per 1000 persons of population**: greater car ownership implies a denser marketplace as well as greater wealth, and a commensurate greater ability to pay for optional ITS services. *Variable name: cars1000*

- **car ownership per household**: similar to the index immediately above, greater car ownership per household implies a denser marketplace as well as greater wealth, and a commensurate greater ability to pay for optional ITS services. *Variable name: carshous*

- **vehicle ownership per km of road network**: this index provides an indirect measure of the potential for congestion on a road network - and hence the potential for the application of mitigating measures involving the application of congestion-oriented ITS technologies. *Variable name: vehkm*

- **injury accidents per 100 million vehicle kilometers**: greater accident rates may reflect higher levels of congestion and traffic density, as well as a justification for the use of ITS technologies as one element of an accident reduction program. Unfortunately, injury accidents are subject to definitional interpretation and in some cases obvious low thresholds of reporting, thus making this index one which must be interpreted with care. *Variable name: injr*

- **fatal accidents per 100 million vehicle kilometers**: a complement to the injury accidents index - but probably more reliable because of the apparently better reporting consistency - greater fatality rates may reflect higher levels of congestion and traffic density, as well as a justification for the use of ITS technologies as one element of an accident reduction program. *Variable name: fatalr*

4.1.5 Statistical variable / User service linkage:

Each of the statistical variables could be indicative of the potential for the application of a number of the previously defined 30 ITS user services. We tried to discriminate in these various potentials by establishing three levels of "linkage" between the two. This approach is obviously somewhat arbitrary, but it does help provide some indicator of technological discrimination which can be verified through more rigorous market analysis, such as that undertaken in other portions of this study. Table 4.1summarizes the linkages established for the purposes of this ITS Demographics Review.

Table 4.2
Summary of ITS Demographic Index / User Services Linkages

Index variable name	Primary link	Secondary link	Tertiary link
Urbpop	Traffic control Public transportation management	Electronic payment	Enroute driver info Enroute transit info
1M+	Traffic Control Demand management Public transportation info	Electronic payment	Enroute driver info Enroute transit info
cars1000	Enroute drive info Personal security	Traveler services information Route guidance	Demand management Traffic control
carshous	Enroute drive info Personal security	Traveler services information Route guidance	Demand management Traffic control
vehkm	Traffic control Electronic payment	Demand management Freight mobility	Route guidance
injr	Traffic control Demand management	Public transportation management Emergency vehicle management	Incident management Commercial vehicle administration processes
fatalr	Traffic control Demand management	Public transportation management Emergency vehicle management	Incident management Commercial vehicle administration processes

This table must be read with great caution. In preparing it, we discounted user services which are not within the immediate time horizon, but emphasized those which appear to be available now or within 5 years. In addition, the indexes used do not necessarily cover all of the user service groups. As a result, many user services are not represented within the table.

4.2 A global overview:

Both Canada and the US are affluent countries possessing the two highest rates of vehicle ownership per 1000 population of the countries in this study (630 and 748 respectively). North America also possesses the lowest rate of vehicle ownership per kilometer of road (avg.: 25 per km). This is in contrast to the Pacific Rim which possesses the highest rate of vehicle ownership per km of road (111 per km).

Of the countries for which information was available, Japan spends the most money on administration and research of road technology. In absolute terms, the US had the largest total of persons killed in road accidents (40,115) while Singapore has the lowest (255). Singapore also recorded the lowest number of persons injured in road accidents (5,728) while US recorded the largest number of persons injured in road accidents (3,449,211). Obviously, these absolute numbers - as opposed to rates - do not tell us a lot about any particular aspect of road transportation in these countries except perhaps their relative populations.

The United States has the highest annual total vehicle kilometers (v-km) of truck travel (891,406 million v-km). This number is far higher than in any other country we examined. The next highest total of truck travel is recorded in Japan (263,790 million v-km). The US also had the highest rate of car travel (2,613,529 million v-km annually), while once again the next highest total annual car travel statistic was recorded in Japan (1,137,453 million v-km).

The most extensive road network can be found in the US, with 6,284,039 km of roads, while the least extensive road network is in Singapore with only 2,943 km of roads. The highest number of cars per household is found in Australia (1.7), with the lowest in South Korea (0.4). The highest number of cars per 1,000 persons is found in the US (565.0). Mexico recorded the lowest number of cars per 1,000 persons (88.7)

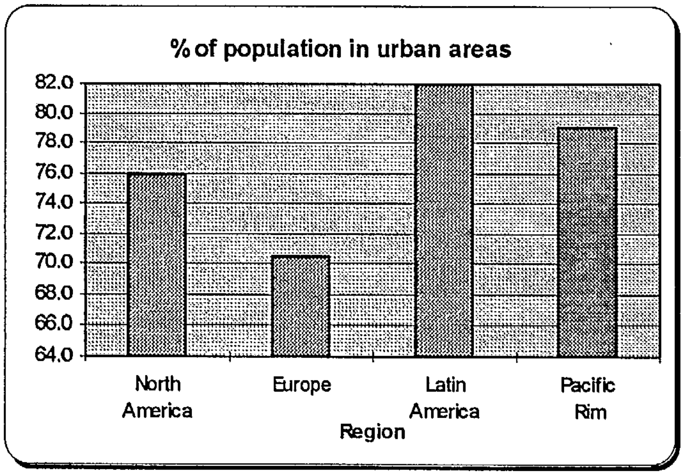
Interestingly, Italy had the highest percentage population living in urban centres (97%), while the lowest percentage of urban population was found in Portugal (34%). The largest country included in this study, by population, is the United States (263,814,032). This is 103,076,543 people more than the next largest country in this study: Brazil, which has a population of 160,737,489. The third largest country included in this analysis is Japan (125,506,492), while the smallest country included is Singapore (2,890,468).

While these figures are interesting, they begin to reveal more meaningful information when they are examined on a comparative basis against our key indexes. The table below summarizes this comparison.

Table 4.3
Summary Global comparison of key indexes

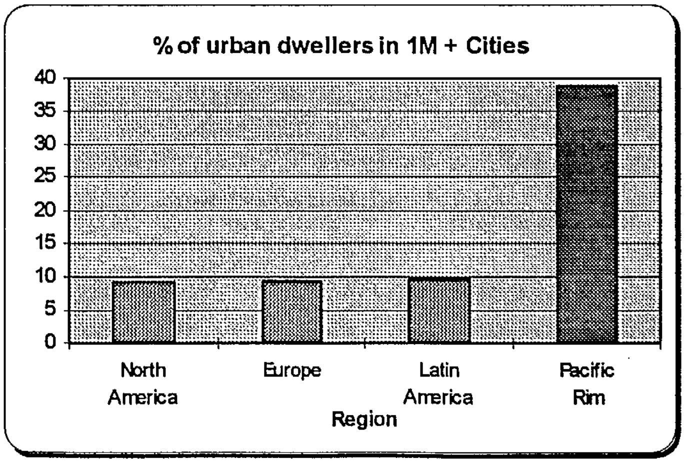
Country	urbpop	1M+	cars1000	carshous	vehkm	injr	fatalr
	%	%	cars/1000	cars/hh	v-km	/100M.v-k	/100M.v-k
North America	75.9	9	528.8	1.2	25.0	95.7	1.8
Europe	70.6	9	383.5	1.0	41.5	76.6	2.4
Latin America	82.0	10	111.3	0.5	36.7	65.7	10.0
Pacific Rim	79.1	39	240.7	0.9	110.7	427.0	11.3
Average:	**76.9**	**17**	**316.0**	**0.9**	**53.4**	**166.2**	**6.4**
St. Deviation:	**4.2**	**13**	**156.1**	**0.3**	**33.6**	**150.9**	**4.3**

These comparisons are also presented in a series of graphs which can be found below.

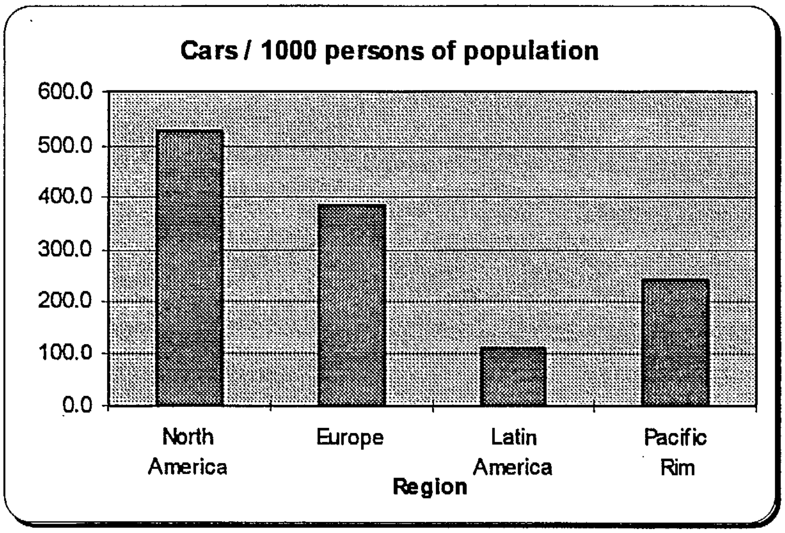


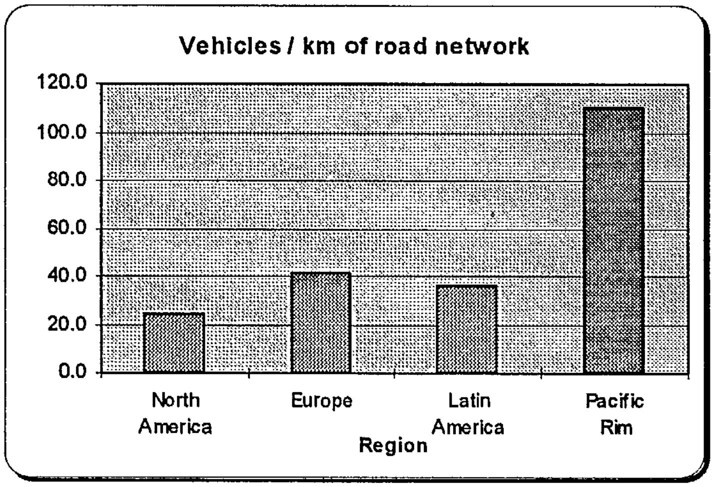
The Latin American group of countries has the highest concentration of people living in urban areas - reflecting the known trend towards urbanization in this region. As expected, the Pacific Rim group provided the next highest urban concentrations of population, with North America third, and Western Europe clearly trailing the group. The range, nonetheless, is small, with Europe and North America grouped between 71% and 76%, and the other two groups more nearly resembling each other - between 79% and 82%.

Clearly, the Pacific Rim countries display a distinct difference in development patterns, with almost 40% of their urban dwellers living in cities with in excess of 1 million people. This apparent trend to large urban agglomerations is necessarily accompanied by transportation problems and issues which are very different from those encountered in the other three regions. Very significant levels of congestion are accompanied by high levels of use of alternative vehicles (i.e. bicycles and other non-motorized alternatives) which could lead to a market definition that leans towards distinctive or highly modified versions of very specific groups of ITS user services.



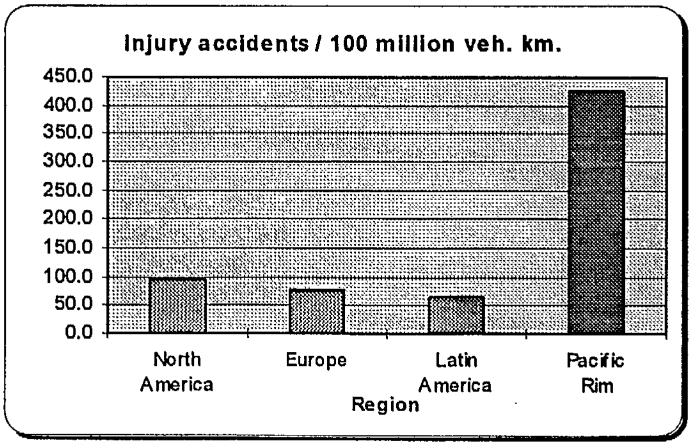
North America and Europe clearly demonstrate the commitment to the personal ownership of automobiles indicative of wealthy regions. Once again, this will directly influence the tendency to adopt certain types of ITS technologies. Personal ownership of vehicles will tend to drive the use of personalized services and/or technologies flowing from ITS. The relatively depressed levels of personal car ownership clearly demonstrated in Latin America - and the median levels which appear at the aggregate level for the Pacific Rim, tend to indicate that ITS technology markets in these areas may be more closely geared to the need to maximize road capacity and control demand.





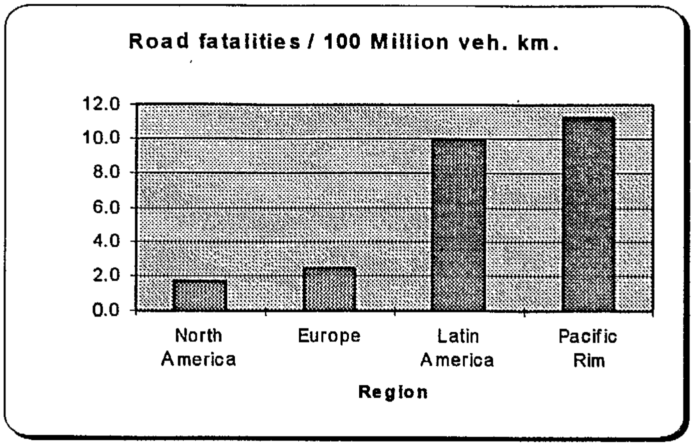
In looking at vehicle ownership per km of road network, the Pacific Rim countries stand out - reflecting the congested conditions referred to previously. With vehicle/network densities over four times that of North American and two and a half times that of Europe, we expect the Pacific Rim countries to demonstrate clear commitment to ITS technologies related to either managing demand, or making better use of existing road capacity. The corollary to this commitment will necessarily be the expansion of infrastructure - probably in the context of the use of self-financing facilities (an already clear trend) using electronic payment technologies flowing from ITS.

Commercial vehicle applications - particularly those related to administrative and control functions can also be expected to flourish in this environment.



In comparing injury accident rates, the Pacific Rim group of countries clearly outpaced all of the other regions - by a factor of at least four. While the Latin American rate is the lowest of all regions, this could be a result of reporting and/or definitional problems, since a review of fatal accidents revealed a pattern clearly similar to that of the Pacific Rim. (see below). Europe had the lowest injury accident rate of all groups.

Road fatality rates confirmed the observations made regarding the Pacific Rim group of countries, and brought out a similar pattern within the Latin American region. North America and Europe provide a stark contrast to the other regions.



The last two patterns are difficult to interpret. Traffic control and regulatory ITS applications are obvious candidate technologies to help out in these area. As noted before, the construction of new facilities - accompanied by the use of ITS traffic management and electronic payment technologies is another obvious area of market potential.

4.3 Looking Deeper: Europe

A deeper look at the basic indexes we defined for our exploration helped reveal some key differences which existed within the countries of Western Europe. These differences are important since they help to define to some degree, how the focus of the market shifts within the overall region. Once again, while these indicators do provide some guidance in looking at potential ITS markets, readers are cautioned against extending this analysis too far in that respect. Table 4.4 provides a summary of the key indeces and their values across the 15 European countries examined. Variable names used in the table headings correspond to those defined in Section 4.1.4 of this Chapter.

Table 4.4
Summary European comparison of key indexes

Country	urbpop	1M +	vehkm	cars1000	carshous	injr	fatalr
	%	%	veh/km	cars/1000	cars/hh	/100M.v-k	/100M.v-k
Austria		17	29.0	434.0			
Belgium			33.0	407.0	1.1	143.2	3.3
Denmark		25	26.6	320.0	0.6	30.0	1.7
Finland	62	0	27.4	367.0	0.8	19.4	1.2
France	74	11	36.8	431.0	1.4	39.1	1.8
Germany	76	4	65.0	482.0		90.0	2.0
G. Britain		0.2	63.0	355.0		74.0	0.9
Ireland	57		11.2	253.0		38.0	1.7
Italy	97	6	91.0	496.0		62.9	1.9
Netherlands	89	8	65.0	383.0	1.0	48.0	1.3
Norway	72		22.0	380.0	0.8		
Portugal	34	67	27.0	242.2		233.6	7.5
Spain	64	4	48.9	343.0	1.2	84.8	4.2
Sweden	83		28.0	410.0			
Switzerland	68		48.1	449.0	1.1	56.3	1.3
Average:	71	9	41.5	383.5	1.0	76.6	2.4
Standard Deviation:	16	17	20.8	71.4	0.2	57.1	1.8

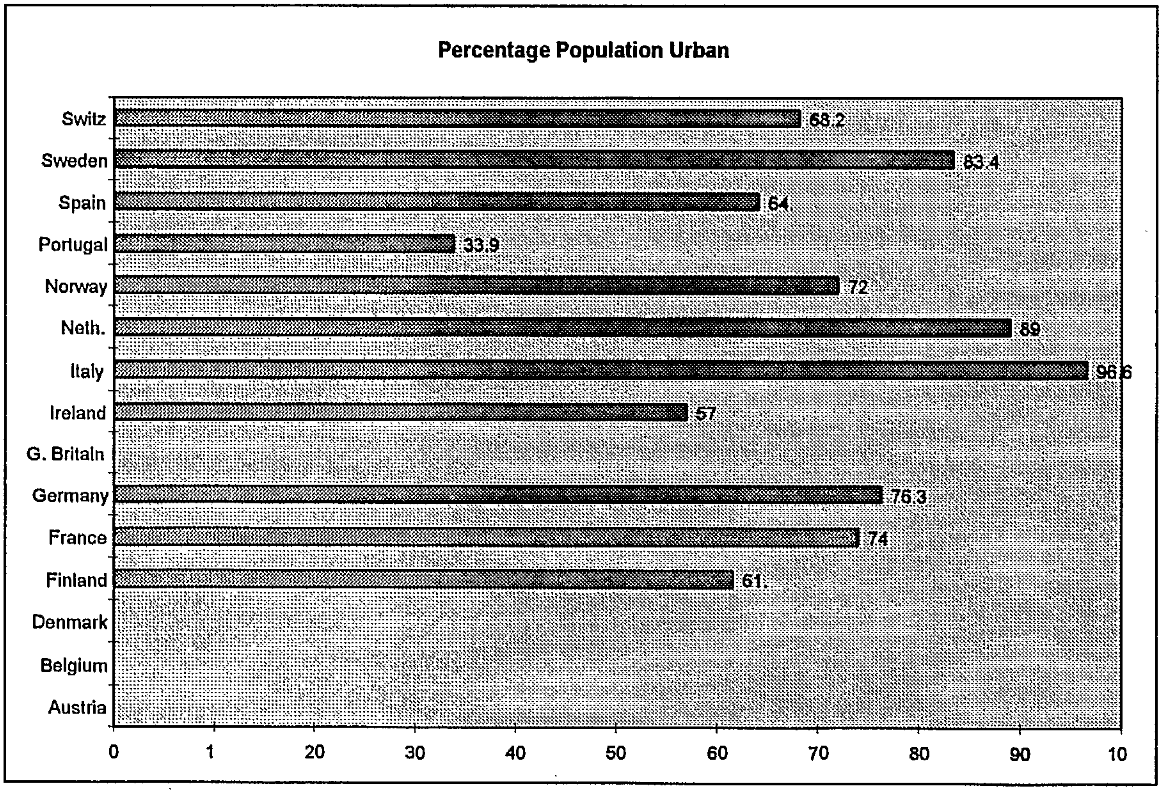
4.3.1 Key observations: Europe

- The percentage population resident in urban settings in the fifteen European countries in this analysis varies widely, ranging from a low of 34% in Portugal to over 96% in Italy, with an average of 71% across the region.

- Exceptionally highly urbanized countries such as Italy, the Netherlands (89%), and Sweden (83%) are prime candidates for technologies oriented to traffic control, public transportation management and electronic payment. Germany, Norway, Switzerland and Spain - ranging from 64% urban populations (Spain) to 76% (Germany) appear also to be prime targets for the application of these technologies, and current activities in these countries bear this out.

- At the low end of the spectrum, both Portugal and Ireland are still highly rural environments, although 67% of the population that live in urban areas in Portugal, do so in one of its two major cities, Lisbon or Oporto - suggesting that these municipalities may be significant candidates for ITS technologies as well.

The graph below provides a summary of the percentage of the population of the various countries in this region that live in urban areas.



- The busiest road network in Europe as expressed by vehicle ownership per km of road network is Italy's, with 91 vehicles per km of road. The next highest are Germany, the Netherlands and Great Britain, around the 65 mark, with Switzerland and Spain coming in around 48. The remaining countries fall below this point with Ireland being the lowest at 11.2. The average for all of Europe is 41.5 vehicles per km of road network.

- Personal ownership of vehicles in Europe - as expressed by the number of cars per 1000 persons of population, varies quite widely from a low of 242 in Portugal to a high of 496 per person in Italy. Italy, Germany, Switzerland, Austria, France, Sweden and Belgium, all fall over the 400 mark. As noted before, these high rates of personal car ownership are indicative of a market for personalized ITS products and services, as well as begin a potential indicator of the general need for infrastructure investment (when examined in the context of vehicle density on the network).

- Injury and fatality rates also vary widely in the region. Portugal (233.6), Belgium (143.2), Germany (90), and Spain (84.8) all have higher than average (76.6) rates of road accidents resulting in injuries per million km of vehicle travel of the fifteen European countries. Portugal (7.5), Spain (4.2), and Belgium (3.3), also experience higher than average (2.4) rates of road accidents resulting in fatalities per million km of vehicle travel.

- Primary European markets for ITS technologies appear to focus on the following countries:

- Italy
- The Netherlands
- Germany
- Austria
- Switzerland
- Sweden
- Great Britain
- France
- Belgium

Within this context, the primary focus is within urban areas. Traffic Management, Demand Management, Public Transportation Information, and Electronic Payment Systems are user services for which there would appear to be a potential market pull. Relatively high car ownership rates would also suggest that personal services and technologies such as vehicle navigation and personal security applications could also find fertile ground in this market - but initially at least, this is still probably a secondary application. Relatively high personal injury and fatality accident rates in Belgium and Germany, combined with high personal car ownership rates, are suggestive of a niche market for selected advanced vehicle safety systems.

4.4 Looking deeper: The Pacific Rim and Australia

A similar analysis of the countries comprising the Pacific Rim group helped us identify a number of important distinctions between various parts of the region. The table below provides a summary of the key indeces and their values across the 5 Pacific Rim countries examined. It should be noted that additional countries in this region may be explored as the work develops further.

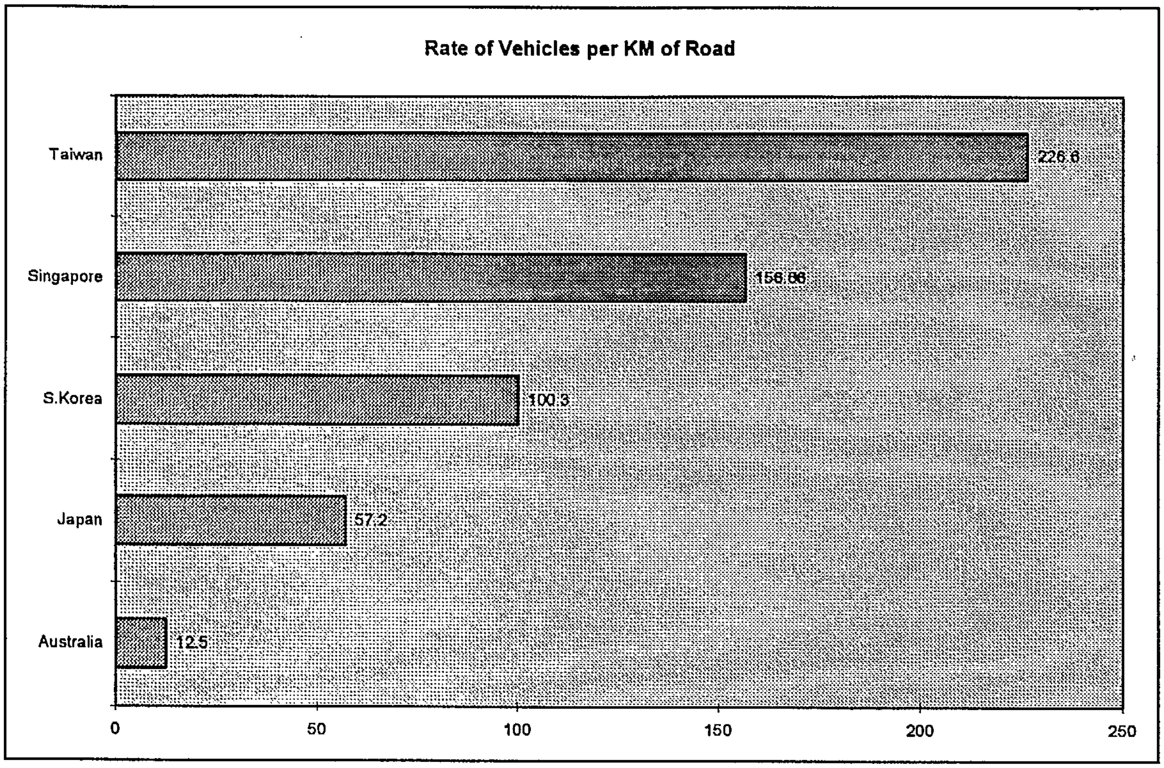
Table 4.5
Summary Pacific Rim comparison of key indexes

Country	urbpop	1M+	vehkm	cars1000	carshous	injr	fatalr
	%	%	veh/km	cars/1000	cars/hh	/100M.v-k	/100M.v-k
Australia	85.4	36	12.5	455.7	1.7		
Japan	77.4	5	57.2	341.4	1.0	129.0	1.5
South Korea	74.4	15	100.3	115.8	0.4	725.0	21.0
Singapore		100	156.7	110.6			
Taiwan			226.6	179.8	0.7		
Average:	79.1	39	110.7	240.7	0.9	427.0	11.3
St. Deviation:	4.6	37	75.0	136.1	0.5	298.0	9.8

4.4.1 Key Observations: Pacific Rim

- Urban populations for the countries for which statistics were available ranged between 74% and 85% of country populations (not including Singapore, which is 100% urbanized). The average across the region was about 79%. While specific statistics were not available for all countries, this is generally consistently higher than was found for the European case. The need for ITS technologies has been clearly demonstrated in this region with both Japan and Singapore already exploiting key its technologies related to traffic management (Japan and Singapore), demand management (Singapore) and electronic payment (Singapore).

- Vehicle densities as expressed by ownership per km of road network vary widely across the region - as could be expected given the disparity of socio-economic conditions and geography encountered in this group of countries. Australia (12 veh/km) is at the low end, with Japan (57 veh/km) holding the middle range at slightly higher than the European densities. The other three member countries however are all over 100, with South Korea at 100 veh/km, Singapore at about 157 veh/km and Taiwan topping off the list at in excess of 226 veh/km. The very significant figures for the last three signal important existing market opportunities for traffic management, demand management and electronic payment ITS technologies.



- Personal ownership of automobiles is highest in Australia, with car ownership at over 455 cars per 1000 population and 1.7 vehicles per household. While this is not quite as high as found in North America (528 cars / 1000 population), it is still indicative of a very similar environment in respect of this parameter. Japan is not far behind, at 341 cars / 1000 population, but Taiwan (180), South Korea (116), and Singapore (110) all fall significantly lower than the other two. The Japanese value - coupled with the vehicle ownership densities - confirm the demonstrated commitment and market pull that exist in that country with respect to personal ITS services with the primary focus being on the provision of dynamic traffic and routing information obtained from traffic management centres used for congestion management and traffic control.

- Traffic accident statistics were not widely available in readily comparable form, but Table 4.5 clearly demonstrates the very significant differences that exist in this region from the others (with the possible exception of Latin America with respect to fatalities). Traffic control and demand management technologies are ITS measures which can help mitigate such situations.

- The market focus in Pacific Rim countries appears to vary widely. In the countries considered, there is little doubt that key large-scale markets include:

  - South Korea
  - Taiwan
  - Singapore
  - Japan

- Within this market area, the focus seems to be quite distinctly divided into two potential types: that typified by Japan with heavy levels of congestion coupled to high personal car ownership, which should tend to generate a market pull for traffic management and dynamic route guidance/traffic information technologies; and that exemplified by Singapore, Taiwan and South Korea - with extremely high levels of congestion and related safety problems coupled to lower personal car ownership rates. The latter environment appears to favour traffic control and demand management technologies coupled with electronic payment services and public transport management services.

4.5 Looking deeper: Mexico and Latin America

Latin American information was somewhat sparse, but sufficient data was obtained to allow a number of observations to be made. A somewhat greater degree of uniformity was expected in the countries included in this region - and the statistics bore this out to some degree. Table 4.6 provides a summary of these.

Table 4.6
Summary Mexico & Latin American comparison of key indexes

Country	urbpop	1M+	vehkm	cars1000	carshous	injr	fatalr
	%	%	veh/km	cars/1000	cars/hh	/100M.v-k	/100M.v-k
Argentina		12	27.8	133.8			
Brazil	76.6	13					
Chile	85.3	5					
Mexico		8	45.5	88.7	0.5	65.7	10.0
Venezuela	84.1	10	0.0				
Average:	82.0	10	36.7	111.3	0.5	65.7	10.0
St. Deviation:	3.8	3	8.9	22.6	0.0	0.0	0.0

4.5.1 Key observations: Latin America

- In the countries for which data was available, urbanization was high, ranging from 76% of the population resident in urban areas in Brazil, to just over 85 % in Chile. Each of the five countries in this region had the largest percentage of cities in the 100,000 to 500,000 range. For three countries (Argentina (12%), Brazil (13%), and Venezuela (10%)) over 10% of their respective cities had populations in excess of 1,000,000. This significant degree of urbanization in substantially sized municipal units signals good potential for traffic control and public transportation management ITS technologies.

- Road densities revealed little in this analysis - primarily because of the lack of data. Data was available for only Mexico (45 veh / km) and Argentina (28 veh / km). The values in this country were similar to those found in Europe (average: 42 veh / km).

- Personal car ownership rates in countries with available data were substantially lower than those found in Europe, and generally comparable to the lower tier countries in this respect in the Pacific Rim. Assuming some consistency in this regard across the region, ITS investments in this area can probably be expected to focus primarily on infrastructure and management-oriented applications such as : traffic control; public transportation management; and electronic payment services.

- Injury data revealed little with respect to ITS technology potentials in Latin America - primarily because of the lack of data. The only data available was for Mexico where the rate of injury accidents per 100M veh. km. (66) fell below that of the European average (reporting problems ??) but the fatality rate (10.0 fatal accidents / 100M veh. km. was 5 times the European average.

- Primary opportunities in the Latin American countries will probably focus across all of the countries considered in this analysis. Brazil's substantive road network (in excess of 1.8 Million Km.) make it a logical prime focus for activities. We expect much of the effort in this region to be oriented to self-funding infrastructure expansion -and consequently see a market for electronic payment services and technologies as one important axis of ITS adoption in Latin America.

4.6 Looking deeper: North America

North America is without doubt the most auto oriented of the regions reviewed in the course of this work. Although consisting of only two countries, Canada and the United States, for the purposes of our analysis, the picture here is dominated by the US with its much greater population, road network, and overall level of travel demand Table 4.7 summarizes the key indexes and their values for this two-country region.

Table 4.7
Summary North American comparison of key indexes

Country	urbpop	1M+	vehkm	cars1000	carshous	injr	fatalr
	%	%	veh/km	cars/1000	cars/hh	/100M.v-k	/100M.v-k
Canada	76.6	6	19.1	493.1	1.0		
U.S.	75.2	12	30.8	564.5	1.3	95.7	1.8
Average	**75.9**	**9**	**25.0**	**528.8**	**1.2**	**95.7**	**1.8**

4.6.1 Key observations: North America

- Urbanization is relatively uniform across North America, although a greater preponderance of larger urban centres occurs in the U.S. where over 12% of those living in urban areas, do so in cities with populations over 1,000,000. Only 6% of Canadians living in urban centres do so in one of our three cities that fall in this category.

- Densities of vehicle ownership as expressed by the number of vehicles per km of road network are markedly different in Canada (19) and the U.S. (31) although both of these densities fall below the European average of 42 and dramatically below the Pacific Rim average of 111 vehicles per km of road. The Canada / U.S. differential is reflected in government interest in the potential of ITS as a means of congestion relief: where U.S. authorities are already actively pursuing and implementing ITS technologies, Canadian governments - while interested - have made no significant commitment in this regard.

- As expected, individual car ownership in the U.S. (565 veh / 1000 pop.) is the highest in the world when expressed in terms of vehicles per 1000 population. Italy ranks second with 496, but Canada - at 493 vehicles per 1000 population is a close third. The high level of personal car ownership is indicative of the potential for ITS personal services and technologies in the marketplace. Immediate indications are that such services are currently focused on personal security and map-based navigation and static routing.

- The North American context is quite different than that in Europe - although superficially, they seem quite similar. Not evident in the statistics presented in this report but analyzed in the course of this task were indicators (truck vehicle miles of travel for instance) that provided a clear indication of the important potential of various commercial vehicle operations user services - particularly focusing at present on commercial vehicle pre-clearance strategies and technologies.

4.7 Concluding remarks:

Some brief concluding remarks are warranted.

- This analysis is only intended as a framework to provide some real-world context for assessing ITS market potential. It provides general indications and helps differentiate markets in a broad way. It also provides some indicators as to market focus both within and between regions.

- The analysis showed clearly that inter-regional and intra-regional differences do exist in the ITS marketplace. It is important that these differences be recognized in any model of the ITS world market.

- It is important not to read too much into this analysis. While this is a useful tool, it is very coarse-grained and must be used with caution.

Chapter 5: Building the Background: II

World Market Estimates

5.0 Chapter overview: World market estimates

This chapter is central to our work. It presents quantitative estimates of ITS market sizes by technology area for the three key markets of North America, Europe and Japan. It also provides a general outlook of the enormous potential of ITS in the emerging industrial countries - including India and China.

The chapter begins with a brief outline of our market model framework. This helps set the stage for subsequent more interpretive discussions in Chapter 6. We outline our information sources, set out the scope of our work, and then provide an initial market overview. This is then broken down in subsequent sections dealing with traffic/transportation management, electronic payment, commercial vehicle operations, public transit, and traveler information systems.

The chapter then turns its attention to three specific potential market areas of interest: emerging industrial countries; China and India; and the niche market including ITS technologies for transportation of the elderly and disabled.

5.1 An ITS market model

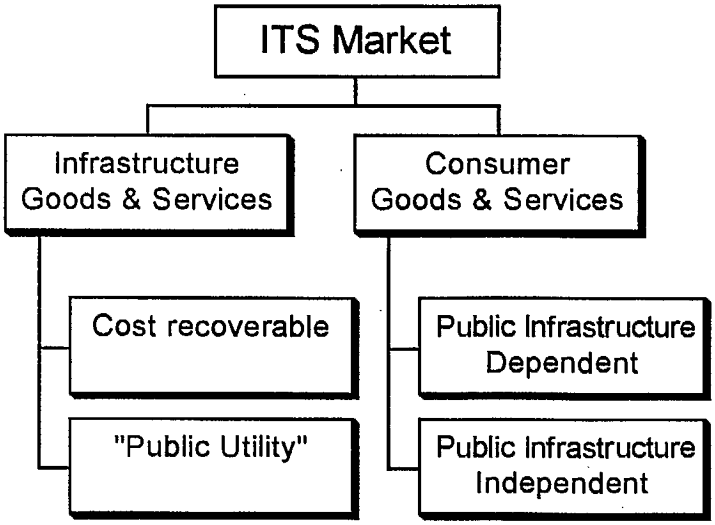
5.1.1 Background

At this stage in the analysis prior to presenting quantitative estimates of market potential it is useful to place the ITS marketplace in some kind of framework that relates to the likely deployment pattern that ITS technologies will follow. This model isn't quantitative in nature, but simply attempts to define the primary market segments which relate to various parties involved in the provision and consumption of ITS products and services. In so doing, we can begin to identify factors in the external environment and elsewhere which might influence the rate and means of adoption of various types of ITS technologies by their end-users. It's another linkage in our lines of evidence approach to looking at the overall shape of the marketplace.

5.1.2 The Market Model

It's important to remember that this market representation is just that - a schematic - not a perfect illustration of how the market is segmented. But it does help us look at various applications and understand some of the relationships that drive ITS market growth. Not all of our 30 ITS User Services can be neatly categorized into unique slots. In some cases, services might fit into more than one niche, depending on how they are delivered - thus providing us with some clues as to alternative means by which ITS goods can be marketed.

Figure 5.1
Proposed ITS Market Model Framework



5.1.3 An explanation of the model

We see the basic ITS marketplace dividing into two fundamental types of goods and services:

- Those which constitute part of the road/transport system infrastructure such as traffic control systems, weigh-in-motion technologies, vehicle pre-clearance systems etc. These we have described using the term: "Infrastructure Goods and Services".
- Those which are "consumed" by the private consumer (corporate or individual citizen), such as Autonomous Route Guidance systems and Traveler Information Services. These we have termed "Consumer Goods and Services".

The distinction between these two broad categories is important. Investment in infrastructure-oriented technologies are extensive (broad-based) and can only be made by government - or government acting in concert with the private sector. A conscious decision must be taken by administrations to spend moneys on these ITS technologies. To do so, they must be convinced of the benefits, have the financing ability to purchase, and have the political will to stand by their investments over the long-term. Consumer-level technologies on the other hand are bought by individuals and/or corporations that see the value in the products. The level to which these technologies can penetrate the marketplace will be directly influenced by their perceived utility, their level of functional dependence on public infrastructure, and of course their cost relative to the consumer's ability to pay.

By looking at the ITS marketplace in this way, we can begin to see the interactions and influence of the general transportation environment itself on the growth and penetration of ITS technologies in the long term. We can directly relate certain technologies to the need for foundation investment by government before they can proceed - dynamic route guidance with traffic information, for instance. We can relate others - vehicle location & dispatching - to known transportation problem areas such as the need for effective long-range routing and dispatching for trucking companies. Still others such as static route guidance and "yellow pages" types of ATIS information - can be regarded as "stand-alone" consumer-level products related to a particular market segment or segments : ie. the tourist market. All of these can give us indirect clues as to the relative potential for and speed with which certain technologies will move forward in the marketplace.

We've used this approach as one aspect of our overall look at world market potential. It is not intended to provide a stand-alone, or even a quantitative market assessment. It does, however provide some good supplementary information for our industry analysis and market review.

The table below provides a first cut at "categorizing" ITS user services into the four categories noted above based on funding sources defined in the recently completed USDOT ITS Architecture Study. Please note that not all services can be neatly slotted into one of our categories. We have only entered such services once in the table once in order to maintain some clarity of presentation.

Table 5.1
Summary of ITS User Services by Market Segment

Infrastructure Goods and Services		Consumer Goods and Services	
Cost Recoverable	**"Public Utility"**	**Public Infrastructure Dependent**	**Public Infrastructure Independent**
• Transit services info. • Electronic payment • CVO electronic clearance • Auto. Roadside inspections • CVO Admininstration • Automated highway • Personalized public transit	• Traffic Control • Incident management • Emissions testing • Demand management • Ride matching / reservation • HAZMAT response • Emergency vehicle man. • Public transportation man. • Public travel security • Railway crossings	• Enroute driver info. • Pre-trip travel info. • Enroute transit info.	• Route guidance • On-board safety monitor. • Freight mobility • Personal security • Long. collision avoidance • Lat. collision avoidance • Int. collision avoidance • Vision enhancement • Safety readiness • Pre-crash deployment

5.2 Information sources and methodology

We have based our quantitative market estimates primarily on SRI Consulting's work on ITS market projections for Advanced Traffic Management Systems (ATMS), Electronic Toll Collection (ETC or ATC), Commercial Vehicle Operations (CVO), and Public Vehicle Transportation Management Systems (APTS and Emergency Management) (15). This multi-client study to which Industry Canada is a subscriber as part of this overall ITS Industrial Base study effort, is the most comprehensive, and up-to-date work currently available and deals with the marketplace in North America, Europe and Japan. The work is still ongoing, however we were granted access to their draft material for the areas mentioned above. Unfortunately, their complete study was not yet finished for the ATIS and AVCS areas and we have relied on separate sources for the ATIS. Because AVCS technologies are heavily tied to automotive manufacturers and their R&D capacities, and since our work indicated that Canada has virtually no domestic automotive R&D capability, we have chosen not to provide any forecasts in this area at this stage.

We attempted to confirm assumptions and forecasts or portions of them wherever possible through alternative sources such as the Frost & Sullivan forecasts of US ITS markets (5), some of the early University of Michigan Delphi studies of potential ITS market penetration and timelines for development (20, 21) and other independent sources of such information.

5.3 Scope

We focused our efforts on assembling the best possible set of reliable, realistic and useful market information of interest to our strategy development efforts. Much of what we provide in this report is in summary form. A great deal more detail is available from our primary source: the SRI Consulting report on market forecasts. Where we could not find adequate, justifiable information but felt that a market opportunity existed, we tried to assemble proxy measures of market attractiveness, such as known potential projects or demographic trends. The scope of our work in this area thus covers:

- Quantitative forecasts of ITS market potential in the ATMS, ETC, CVO and APTS areas in Europe, Japan and North America based on the SRI study. We have restricted our work to the "realistic" scenario provided by SRI. The period covered is from 1996 to 2011.

- A quantitative forecast for the ATIS area developed from various sources and providing coverage for the same 1996 to 2011 period.

- A proxy-based overview of the potential in emerging industrialized countries (including India and China) through the medium of a review of potential candidate infrastructure expansion programs which could incorporate elements of ITS.

- A brief look at a niche market which could be of interest to Canadian firms: Elderly and disabled transportation technologies. This is a market that is growing in part simply because of Canadian Demographics. Once again, this overview is accomplished through the use of proxy measures.

5.4 Quantitative ITS market forecasts

In presenting the forecasts in this section, we ask that readers note the following:

- All forecasts are in 1996 US dollars.

- Unless otherwise indicated, all figures were obtained from the SRI Consulting report on ITS Markets for ATMS, ETC, CVO and APTS - commonly referred to as Report 2 of the SRI multi-client ITS series.

- While the geographic coverage of the forecasts is extensive, and does cover the primary markets to date, there is a substantial marketplace developing outside the North America, Europe and Japan marketplace - particularly in the Asia/Pacific Rim countries.

- The ITS marketplace is still very dynamic. Readers should examine these forecasts in the context of the earlier discussions in this report - both with respect to the technical progress of various technologies and the ITS "environment" factors which could have a substantive effect on marketplace development.

5.4.1 Overview

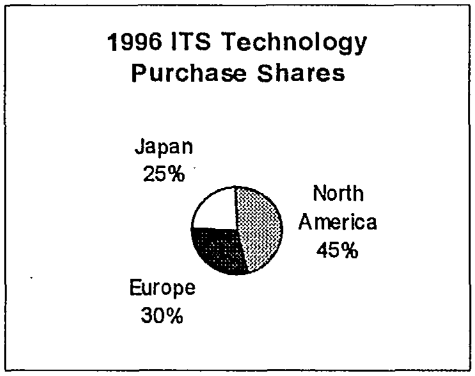
The table below summarizes total yearly expenditures for the four key years of the forecast period, for the four primary ITS application areas considered. ATIS is not included in this overall figure.

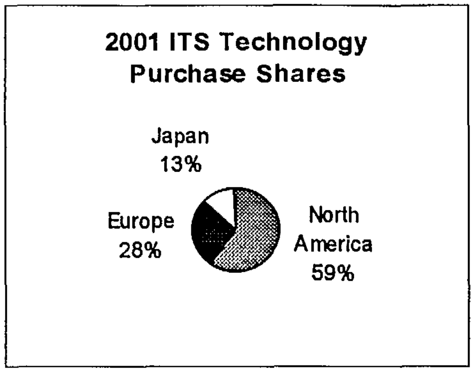
Table 5.2
Overall ITS Expenditures: Key Years by Region

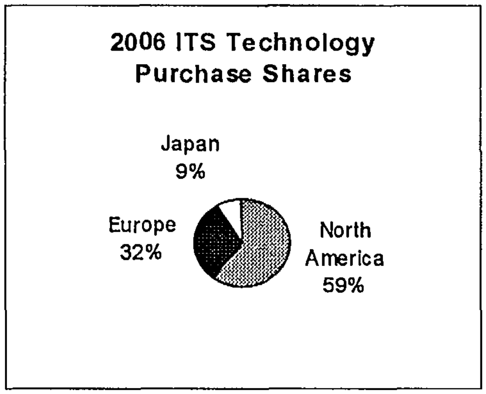
	1996	2001	2006	2011
	Millions of US$			
North America	760.4	3367.5	7119	9036.3
Europe	498.1	1592.2	3788	6771.6
Japan	413.3	746.9	1017.9	1035.9
Total	1671.8	5706.6	11924.9	16843.8

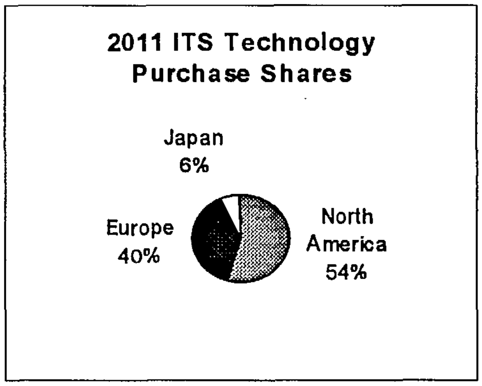
These figures do not include ATIS or AVCS expenditures

These expenditure levels are for the given years only. They are not cumulative. They represent expenditures by all parties on the four key ITS technology areas and reach just over $16.8 billion by the year 2011. If our ATIS estimates are included (see Section 5.4.6) the annual expenditures rise to over US$23 billion in 2011. Building from the assumptions of the SRI report, we have estimated cumulative expenditures between 1996 and 2011 to be in the order of $123 billion. The graphs included below provide some additional breakdown of these expenditures. They are self explanatory and are provided without further comment.









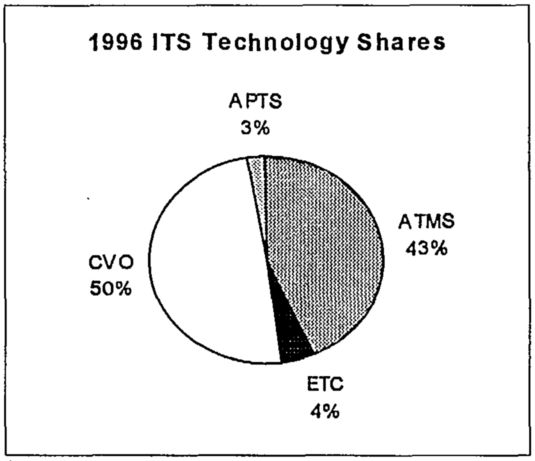
A slightly different look at this forecast is given in the table below.

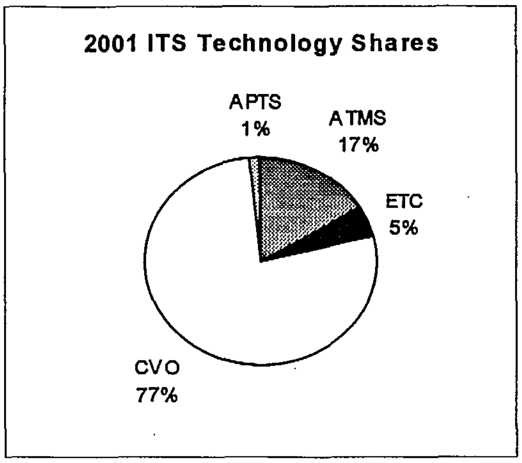
Table 5.3
Overall ITS Expenditures: Key Years by Technology Area

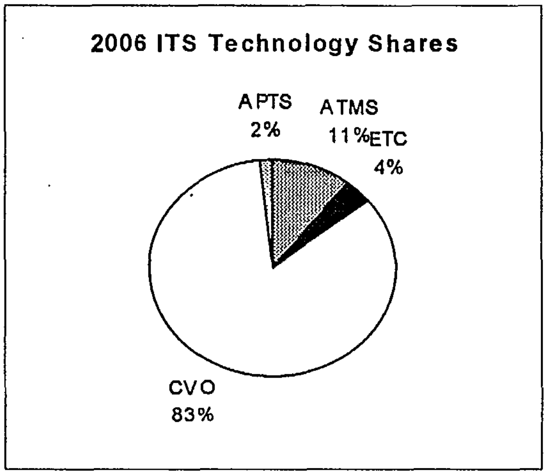
	1996	2001	2006	2011
	Millions of US$			
ATMS	725.0	950.0	1273.0	1389.0
ETC	73.0	274.0	434.0	628.0
CVO	831.0	4403.0	10026.8	14676.4
APTS	42.8	79.6	191.1	150.4
TOTAL	1671.8	5706.6	11924.9	16843.8

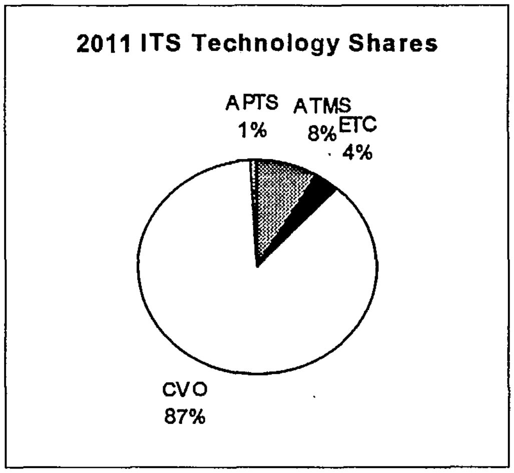
These figures do not include ATIS or AVCS expenditures

Once again, these totals are for the single years given only. Commercial vehicle operations dominate the picture in the later years - primarily because of the service/subscription aspect of commercial vehicle operations products. Additional detail is provided in the section on CVO expenditure forecasts. A number of graphs which further break out the contents of this table are provided below without further comment, since they are quite self explanatory.









5.4.2 Advanced Traffic Management Systems Forecast

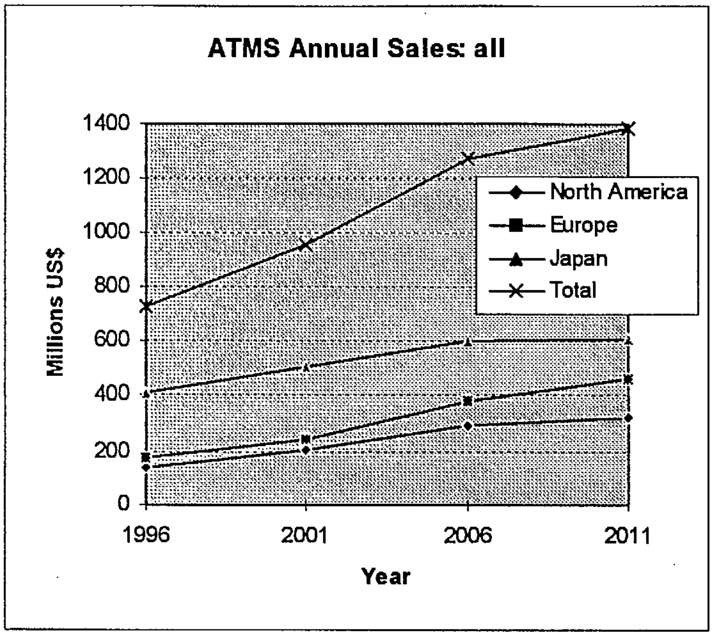
Note: Only summary total figures are provided in the main report. For additional breakdowns on specific market categories readers are asked to refer to Appendix C.

Market Category Breakdown:

- *Sensors*: inductive loops, infrared/ultrasound sensors, CCTV cameras, video detection systems
- *Communications for detectors:* fibre-optic cables, twisted-pair copper wires, wireless communications
- *Control Centres / Data Processing*: computers, displays, consoles, software, system integration
- *Information dissemination:* communications equipment for employee and public information dissemination, variable message signs, cabling etc. for these purposes

Fig. 5.4
ATMS Annual Sales

	1996	2001	2006	2011
	Millions of US$			
North America	142	202	295	322
Europe	175	245	378	460
Japan	408	503	600	607
Total	725	950	1273	1389



5.4.3 Electronic Toll Collection

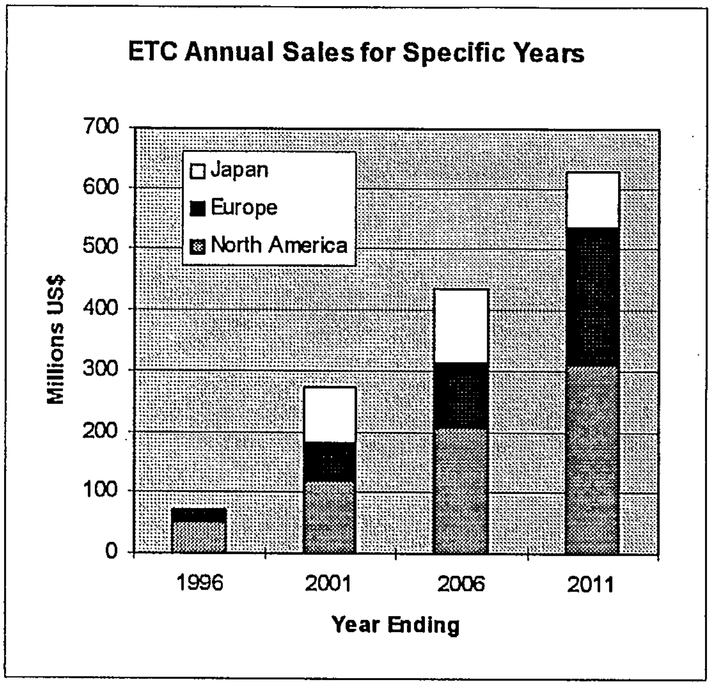
Note: Only summary total figures are provided in the main report. For additional breakdowns on specific market categories readers are asked to refer to Appendix C.

Market Category Breakdown:

- *Sensors*: for presence detection, classification and enforcement. In-road inductive loops, video presence detection systems, CCTV cameras, piezo-electric and infra-red sensors.
- *Communications:* uni and bi-directional communications. In-vehicle transponders, road-side readers, smart cards, wireless and cable networks.
- *Data processing and distribution:* payment processing software, storage and automated processing of video (or other) enforcement data.

Fig. 5.5
ETC Annual Sales: All technologies

	1996	2001	2006	2011
	Millions of US$			
North America	52	120	210	310
Europe	21	64	104	225
Japan	0	90	120	93
Total	73	274	434	628



5.4.4 Commercial Vehicle Operations Forecast

Note: Only summary total figures are provided in the main report. For additional breakdowns on specific market categories readers are asked to refer to Appendix C.

Market Category Breakdown:

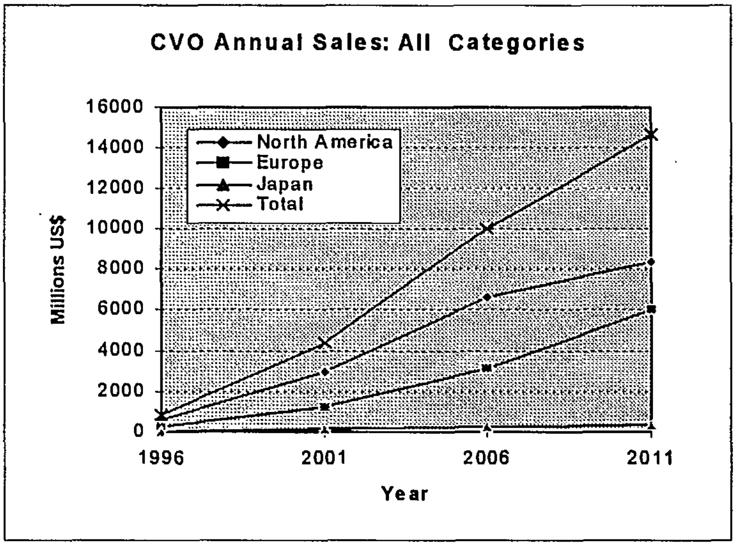
This market will be highly differentiated between North American, European and Japanese applications. North America is presently well ahead in this area whereas Europe is just beginning to move. The Japanese market is still latent and will remain a very small component of the overall picture in the long run. Technology needs in each region will differ as a result of this differentiation.

- *Intelligent transportation infrastructure:* to streamline government and regulatory functions. Sensors, transponders, CCTV and video detection systems, weigh-in-motion equipment, local and wide-area communications, software. Control centres, displays, computers.
- *Freight mobility and private fleet management:* providing links between drivers, dispatchers, intermodal service providers. On-board sensors, uni and bi-directional voice/data communications, satellite communication, GPS positioning, vehicle location and navigation systems.

Service contracts to maintain and provide communications services for CVO freight mobility applications are seen as becoming a major portion of the CVO ITS marketplace. SRI notes that it is not uncommon in similar technology applications for annual service contracts to exceed the value of expenditures for equipment. This is expected to be the same in this case.

Fig. 5.6
CVO Annual Sales: All Technologies and Services

	1996	2001	2006	2011
	Millions of US$			
North America	547	3017	6558	8374
Europe	281	1239	3185	5979
Japan	3	147	284	323
Total	831	4403	10027	14676



5.4.5 Advanced Public Transit Systems

Note: Only summary total figures are provided in the main report. For additional breakdowns on specific market categories readers are asked to refer to Appendix C.

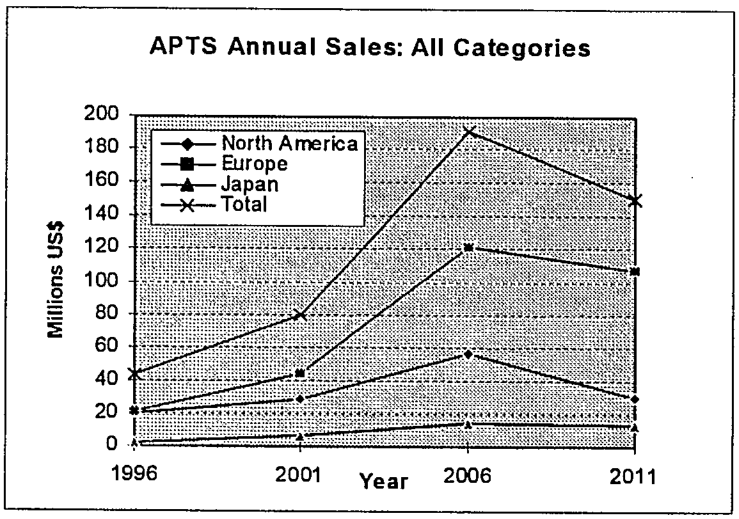
Market Category Breakdown:

This group of applications deals with fleet management systems for fixed-route buses, demand responsive transit and emergency response vehicles. Guided rail applications are not included. In essence, these applications are heavily communications oriented, seeking to expand existing information and communications networks.

- *Communications:* one and two-way communication links are required for both voice and data. Transmitters and mobile receivers are current technology, however new wireless data technologies (cellular digital packet data systems: CDPD) are coming onstream. FM-sideband broadcast technology, Highway Advisory Radio (HAR) and RDS/TMC in Europe are also used. In-vehicle terminals required.
- *CAD/AVL*: Computer-aided-dispatch with automatic vehicle location & routing and scheduling software and hardware. GIS and associated database and software. AVL linked to dispatch. AVL including signpost/beacon, GPS, some terrestrial applications (Japan & Europe). Traffic signal priority systems, automatic passenger counting and mayday systems. Passenger information systems including kiosks, on-vehicle and in-station message boards. Pre-trip transit information.
- *Payment and ticketing*: Electronic payment. IC smart card & electronic farebox. Proximity cards.
- *Emergency response vehicles*: Police, fire, ambulance rescue. Communications, AVL, GPS, routing & dispatch software. GIS.

Fig. 5.7
APTS Annual Sales: All Technologies

	1996	2001	2006	2011
	Millions of US$			
North America	19.4	28.5	56	30.3
Europe	20.9	44.2	121.2	107.2
Japan	2.5	6.9	13.9	12.9
Total	42.8	79.6	191.1	150.4



5.4.6 Advanced Traveler Information Systems

Note: These estimates are interim, pending additional information from the next report of the SRI study. They have been generated by Delphi Systems and are based solely on in-vehicle navigation system sales. We've prepared them considering:

- The volume of total annual car sales in the United States and Canada and the percentage designated luxury vehicles (10%).
- Estimates of a 50% penetration of the luxury car market by 2011 (from UMTRI Delphi II)
- An assumption of an equal new car and aftermarket annual sales volume which are about equal and account for about 85% of all sales.
- Consideration (but not use of) forecasts by various parties including: Frost & Sullivan; J.D. Power, Robert French and others.

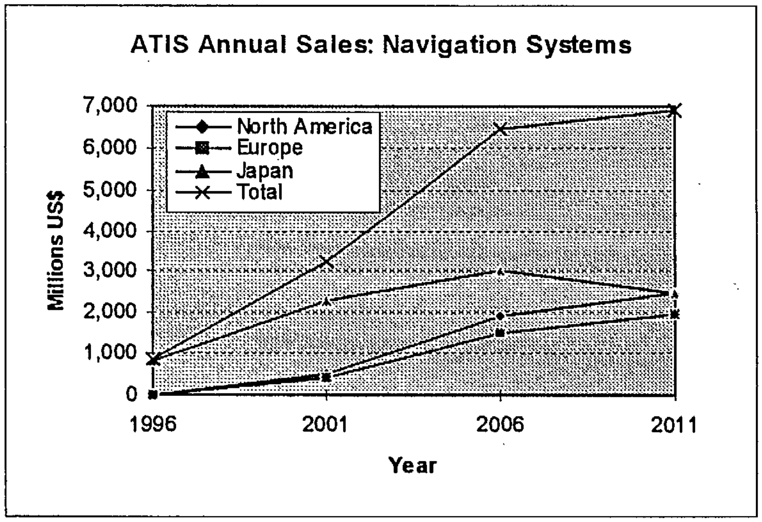
The projections are based solely on equipment sales. No attempt has been made to forecast service subscription costs for dynamic or updating costs for autonomous systems. This service marketplace could be very substantial.

Market Category Breakdown:

- *Autonomous navigation systems*: Estimated to be about 90% of the market. In-vehicle displays / communication units, intelligent maps, GPS systems
- *Dynamic or Advisory navigation systems:* The remaining 10% of the marketplace. In-vehicle displays, voice/data communication units (2-way), GPS systems. Infrastructure costs not included

Fig. 5.8
ATIS Annual Sales: All Technologies

	1996	2001	2006	2011
	Millions of US$			
North America	15	515	1,914	2,465
Europe	12	412	1,531	1,972
Japan	825	2,300	3,000	2,480
Total	852	3,228	6,444	6,918



5.5 Emerging industrialized countries

Emerging industrialized countries represent a very significant potential market for ITS technologies (see Chapter 3, section 3.5). While our mandate did not extend to providing quantitative forecasts for this sector we felt that it certainly could not be ignored outright. This promising market area not only has a very significant dollar potential, much of it is moving now. As was pointed out earlier, in effect these markets offer a "bridging" opportunity in new infrastructure environments while firms wait for certain portions of the markets in the more industrialized and budget-constrained countries to come to fruition.

To illustrate the potential magnitude of such work, we have prepared a table below which summarizes Major Road Project financing currently under consideration by the World Bank - usually in association with other development agencies or banks, national governments, and local authorities where appropriate. It is important to stress that this table is merely intended to be illustrative. It neither accounts for the myriad of other projects which are actively under consideration by both other development banks and national governments, as well as various national and international consortia. Finally we should underline the fact that dollar values presented here - in US dollars as usual - reflect total costs of the facilities - not just the ITS portion of the work.

Table 5.9
Illustrative Developing Countries Major Road Project List

Country	Total $ value of projects under consideration by World Bank or others (millions US$)
Argentina	1772
Brazil	750
China	4254
Columbia	92
Dominican Republic	75
India	5600
Indonesia	168
Kenya	150
Lithuania	45
Vietnam	165
Total	$13,071

Recent announcement such as those made by India and China serve to further illustrate the potential magnitude of the developing country highway market and of course -its related ITS potential. The magnitude of needs in a country like India are staggering. Both goods and passenger movement in that country have been increasingly moving by road, with estimates now indicating the over 65% of freight will move on the highway system by the year 2000, and 87% of passenger trips will do likewise.

The growth rate of vehicle registrations is in the order of 13% in India at present - a direct reflection of a growing affluent middle class and an inadequate public transit system.. Recently, in an effort to deal with this problem, the Ministry of surface Transport identified 27 highway projects for implementation in the private sector - implying the use of toll roads and associated technology. With an estimated total cost of over US$5.6 billion the plans are ambitious, but are moving ahead. Government incentives have been put in place to encourage private sector participation in the required road construction projects.

Finally, it's interesting to note that China has indicated a significant interest in the ITS area in general. The Chinese Ministry of Electronics has announced that it will be sponsoring the 1997 International Autoelectronics and Intelligent Transport Systems Exhibition in Beigjin in April of 1997. Organizers of the conference noted that the Chinese market for electronic automotive/transportation products is expected to reach US$4 billion in 2000. (23)

5.7 ITS and the elderly and disabled market

ITS technologies can be of both general and particular assistance to the Elderly and disabled in this country. In work carried out for the Government of Canada (24), researchers found that ATIS types of systems would be applicable to 59 million people with disabilities and 18 million seniors in North America. Mitchell, in his review of this work, goes on to note:

> *ITS to assist car drivers would be relevant to 18 - 23 million seniors and 7 - 40 million people with disabilities, depending on the system. APTS would apply to about 9 million people with disabilities and 18 million other seniors, but systems related to specialized paratransit services would only apply to about 1 million people. .... The European DRIVE II project EDDIT established that elderly drivers would be willing to pay reasonable prices for ITS equipment that helped them drive more easily and more safely.* (25)

Although neither report developed specific market estimates for ITS applications for the elderly and disabled, the statistics appear indicative of a strong potential market demand for the right products at the right price. Mitchell makes the case for Canadian capabilities in pursuing this market. Additional discussions on this topic are provided in later portions of this report.

5.8 Key observations

A number of key observations can be made from the analysis in this chapter.

- The ITS marketplace is still dynamic in terms of both growth and change. Projecting potential future market sizes on a general world basis is difficult at best, but by any standard - given the ubiquity of the need for transportation and the use of the automobile in both industrialized and emerging industrial countries, the market is very large.

- The SRI forecasts suggest that ITS annual market sales in North America, Europe and Japan for only four key areas of ITS will exceed US$16 billion by the year 2011. When ATIS estimates are added to this (only for in-vehicle navigation systems and not including related service and updating offerings), the annual total jumps to over $US23 billion. Cumulative expenditures between 1996 and 2011 will have reached in excess of US$123 billion (excluding ATIS). None of these estimates include any aspect of vehicle control and safety systems ITS technologies.

- A substantial bridging market appears to exist in emerging industrial countries. No attempt has been made to forecast the size of this market, although our research indicates that it is being very actively pursued by international firms, as well as national organizations such as ITS America in partnership with FHWA on behalf of their national-level ITS technology suppliers.

- The key technology market areas which are forecast to progress the most quickly are:

  - Commercial vehicle operations in North America
  - ATMS applications combined with ATIS in Japan, and ATMS applications oriented to traffic signal system adaptive control and coordination in Europe.
  - Electronic toll collection, which, although limited in ultimate size, is undergoing a dramatic market pull in North America. Similar interest appears to exist in emerging industrialized countries, although this was not included as part of our forecasts.

- The North American marketplace appears to be the largest overall of the three studied in the course of the SRI work. It is evidently a key opportunity for Canadian firms.

- Generally speaking, the forecasts reflect well the technology maturity projections discussed in Chapter 2 of this study, and reaffirm the observations regarding the strengths and weaknesses of various technologies with respect to their readiness for the marketplace.

Chapter 6: An ITS World Market Map

Bringing the evidence together

6.0 Chapter outline

In this chapter we attempt to bring our evidence lines together with the particular aim of better interpreting some of the global numbers, but also in an effort to extend the SRI forecasts much more broadly. This effort is obviously not without risks and further refinement of these figures is carrying on while this draft report is being reviewed.

The chapter begins with a discussion of the lines of evidence and the results of the analysis to define ITS technology priorities in an expanded geographical context of six "regions". This work is used as one input to extending the SRI work to a broader geographical coverage which is intended to embrace all major ITS markets. The results of the extended forecast are presented in the second section of this chapter

6.1 Consolidating the evidence

To this point, three major axes of analysis have been carried out: a review of ITS technologies from a market readiness standpoint; a demographic analysis which provided us with indirect but correlative measures of ITS marketplace potential in different regions; and the forecasts of ITS sales prepared by SRI. Each of these analyses provided additional information about the developing ITS marketplace. Assembled and analyzed together, they provided useful intelligence which we could use to attempt to extend the SRI work further and develop what we have termed an ITS World Market Map.

To consolidate the evidence, we developed a quantitative point-based approach to evaluating the indicators of ITS technology potential arising from each of our three primary lines of evidence. We divided the study period into three "tiers" of ITS technology market penetration:

- First tier: 1996 - 2001
- Second tier: 2001 - 2006
- Third tier: 2006 to 2011 and beyond

We then expanded our regional definitions and created six "regions" of interest. In point of fact these regions were not strictly speaking, geographical in nature. To our three existing primary areas (North America, Europe and Japan) we added:

- Other industrialized countries: to represent countries like Australia - highly developed, with a demonstrated interest in and potential to use ITS technologies

- Pacific Rim countries: to represent emerging industrialized countries of the Pacific Rim area other than Japan, but extending the definition beyond those originally included in our demographic analysis, to cover areas such as Thailand and of course India and China.

- Mexico and Latin America: as defined in our demographic analysis.

We then reviewed each of these regions, and using our lines of evidence data (where available) supplemented by other sources of published information (such as potential road projects in emerging industrialized countries etc.), we scored the potential of various ITS technology types in each marketplace. We used the basic seven-group "User Service Bundles" outlined in Chapter 2 for this purpose and referred to the results as "market pull ratings". The results of our analysis are summarized below. The maximum possible score is 9, the minimum is 1.

Table 6.1
Regional User Service Bundle Market Pull Ratings

Region	Overall ITS market pull ratings					
	CVO and Public Transp.	Electronic Payment	Emergency Management	Transportation Management	Travel Demand Management	Advanced Vehicle Safety
North America	9	6	6	5	4	1
Europe	4	8	2	9	6	1
Japan	2	2	1	9	9	2
Other Indust.	3	3	2	3	2	1
Pacific Rim	3	6	1	6	2	1
Mex + Latin Am.	3	6	1	6	2	1

The grey cells in each row indicate the two highest rated user service bundles. We would expect to see higher rated user service bundles proceed earlier than ones which received lower ratings, however this table should not strictly speaking be interpreted in this way. As with our other devices of this type, it is simply a way of more clearly presenting the results of a fairly complex reasoning chain built through the use of our lines of evidence. The relative values of the ratings between regions mean little, and are more indicative of the quality of our evidence chain for a particular region than anything else. Within regions however, the differences should reflect priorities for user service bundle progression.

The ratings appear to make sense. Higher priority areas in the three key regions correspond well to past and current levels of activity leading to deployment. Similarly, the appearance of electronic tolling and transportation management as priority areas in the Pacific Rim and Mexican + Latin American group correlates well to ongoing interest in and commitment to concession-based tolling activities, other public-private partnership projects, and traffic management interests in various parts of these regions.

It is obvious that all user services within a group are not likely to progress in lock-step, so to further clarify this picture, we broke the user service bundles down into their constituent user services (see Table 2.1 for a breakout of these relationships) and attempted to define those user services which we thought would move in the first wave of deployment versus those which would come later. The results of this analysis are summarized in Table 6.2.

Table 6.2
ITS Priority User Service Markets by Region

Region	Priority Bundles	First Wave User Services	Second Wave User Services
North America	• Commercial vehicle ops. • Electronic payment • Emergency management	• Freight mobility • CV electronic clearance • CV admin. processes • Electronic payment services • Emergency notification • Emergency veh. managm't	• Automated safety inspections • On-board safety monitoring • HAZMAT response • Route guidance • Public transportation management
Europe	• Transportation management • Electronic payment	• Traffic control • Route guidance • Traveler services information • Electronic payment services	• Incident management • Enroute driver information • Freight mobility • CV electronic clearance
Japan	• Transportation management • Travel demand management	• Traffic control • Enroute driver information • Route guidance • Incident management • Pre-trip travel information	• Traveler services information • Demand management
Other industrialized countries	• Transportation management • Electronic payment • Commercial vehicle ops.	• Electronic payment services • Traffic control • Freight mobility • CV electronic clearance • CV admin. processes	• Route guidance
Pacific rim (including India & China + others)	• Electronic payment • Transportation management	• Electronic payment services • Traffic control • Incident management	• Demand management • Pre-trip travel information • Route guidance • Freight mobility
Mexico and Latin America	• Electronic payment • Transportation management	• Electronic payment services • Traffic control	• Demand management • Freight mobility

First wave user services were drawn from the priority bundles listed in Table 6.1. Second wave services reflected a broader selection including some from other areas listed as potential longer term priorities within regions.

6.2 Extended World ITS market forecasts

In developing these extended world forecasts, we built on the core SRI work carried out for North America, Europe and Japan and our ATIS estimates, all described in Chapter 5. This extension of forecasts is necessarily speculative and was not initially in our mandate. However as the study progressed, it became evident that a substantial market existed outside the three primary areas of the SRI review, and we felt it important that we at least provide some order of magnitude estimates based on reasonable assumptions.

The work of Section 6.1 was a starting point. Detailed reviews of published information (hard copy and electronic on the World Wide Web) were also used to help us build a foundation for this extension. Discussions with selected experts in the field assisted in refining some of our assumptions.

We built these forecasts around four geographic areas:

- North America, Europe and Japan (from the SRI work)
- Other industrialized countries as described previously
- Emerging industrialized countries - intended to embrace both the Pacific Rim and Mexico/Latin America groups outlined in Section 6.1
- China and India, because of their unique potential market size and rapid industrialization in selected areas.

The forecasts were aggregate in nature, concentrating on the five primary areas of technology interest which we associated with the earlier forecasts outlined in Chapter 5 : ATMS, ETC, CVO, APTS, and ATIS. In essence, these categories embrace all of the SRI ITS application areas and corresponding User Service bundles, with the exception of Vehicle Safety and Control (Advanced Vehicle Control and Safety Systems). We retained the planning period and time-slice breakouts used by SRI (1996, 2001, 2006, and 2011). A general outline of the underlying assumptions is as follows:

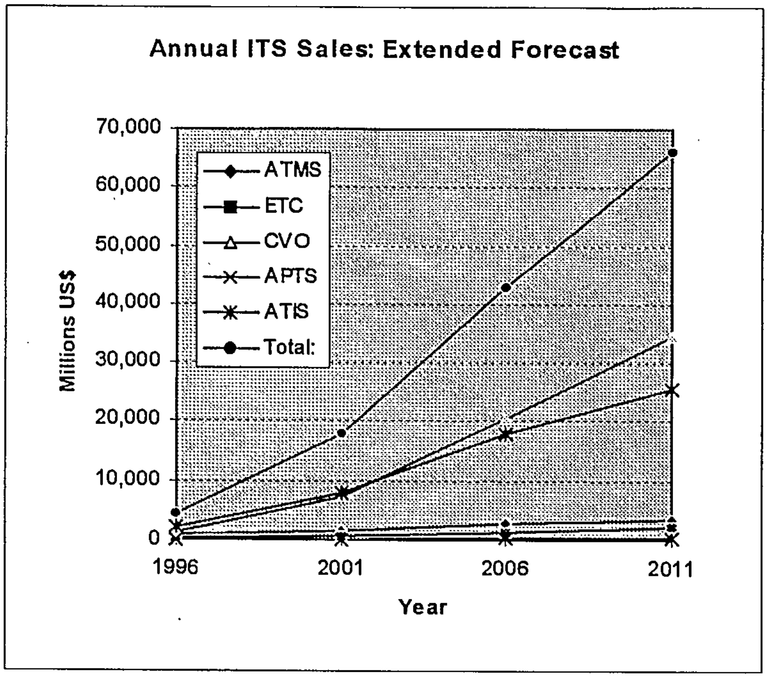
- The ATIS base forecasts were expanded to include service subscriptions (for dynamic routing and traffic information) and update services (for autonomous) including the communications costs. These were treated in the same manner as the CVO service costs and set equal to the volume of annual equipment sales for in-vehicle navigation units.
- Other industrialized countries were assumed to progress in parallel to the core regions of our study and to amount to 25% of the market value of the North America, Europe and Japan markets. This factor was a subjective estimate intended to provide a conservative basis for the forecast. It was based on both the market information developed thus far in the analysis as well as conversations with individuals familiar with such market areas.
- Emerging industrialized countries were assumed to move quickly into both the electronic tolling area - resulting in a robust marketplace among this group of countries. Their market was calculated as being equal to the sum of the SRI ETC market forecasts plus the ETC markets in the other industrialized countries. More gradual implementation of CVO and ATMS technologies were expected to follow, being equivalent to 10% of the SRI forecast area market in 1996, 40% in 2001, and 60% from 2006 onward. We assumed that ATIS deployment market would be equivalent to the North American market but would trail by ten years.
- China and India were seen as moving more slowly than other markets. Initial interest areas in ETC and ATMS were expected to move quickly, followed more slowly by development patterns and magnitudes similar to those in the emerging industrialized countries after 2006, but offset by about 5 years. For computational purposes we assumed that the combined markets in this region would be equivalent to 25% of the market size of the emerging industrialized countries - but would trail them by 5 years.

Table 6.3 summarizes the results of this analysis. It presents the information in aggregate form for all areas, but breaks out the time slices and shares of the primary technology groups of interest.

As noted earlier, this forecast must be read with considerable caution. In reviewing the cumulative results of this analysis, we note that such a market development implies about a 29% annual aggregate ITS marketplace growth rate between 1996 and 2001, continuing to 18% between 2001 and 2006, and then dropping to 9% up to the horizon year of 2011 as the market begins to level off. These figures do not seem unreasonable in light of the early stage of the development of ITS technologies and markets.

Table 6.3
Extended World ITS Market Forecast

	1996	2001	2006	2011
	Millions of US$			
ATMS	997	1,640	2,735	3,472
ETC	205	776	1,428	2,113
CVO	1,143	7,348	20,311	34,635
APTS	59	136	385	408
ATIS	2,130	8,069	17,815	25,454
Total:	4,534	17,969	42,673	66,081



By the year 2011, annual sales of ITS technologies at the world level are forecast to reach $66 billion per year. It's important to note that this very substantive sum includes both equipment and services. The latter in many cases may be provided by non-traditional transportation industries - in particular the communications sector - primarily because so many of the technologies related to in-vehicle services obviously rely on this sector. It's also important to note that it is exactly the types of service which rely on communications - services that provide real-time, quick-response information - that are valued most highly in the marketplace by both commercial and private client sectors alike. We estimate that this service-side market could represent over US$22 billion per year.

Projecting a cumulative market based on these forecasts indicates that cumulative ITS sales worldwide between 1996 and 2011 may reach over US$430 billion. Additional graphs summarizing this marketplace can be found in Figures 6.1 and 6.2 below.

Figure 6.1
Extended World ITS Cumulative Market Forecast
1996 - 2011

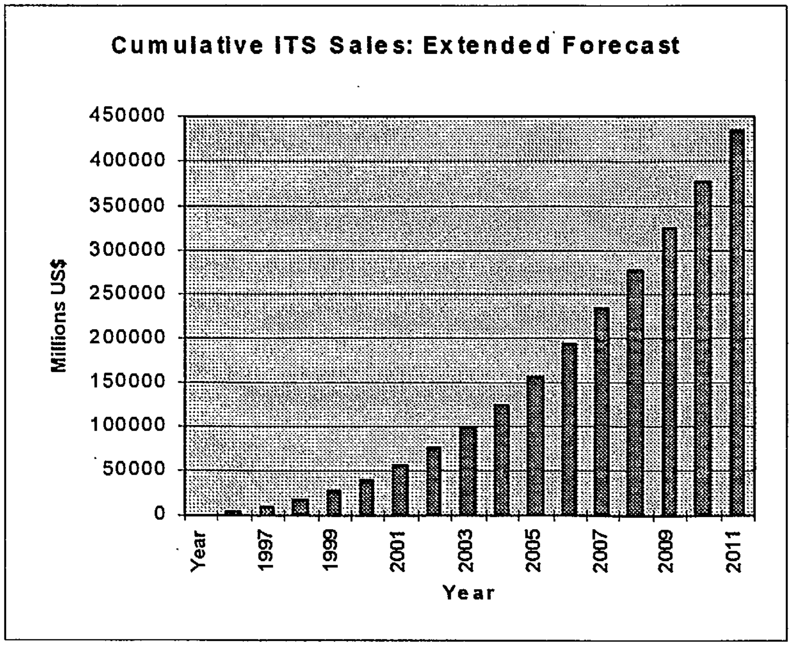
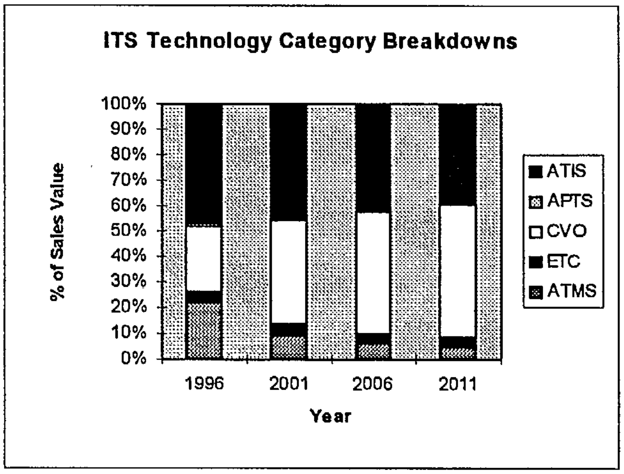


Figure 6.2
Extended World ITS Market Technology Category Breakdowns



Chapter 7: The Canadian Context

Looking at where Canada fits

7.0 Chapter overview

So far we've focused on the marketplace, its magnitude, orientation, and stage of development. This chapter turns us inward to see what Canada is currently doing at government and industry levels in ITS. Our focus in this chapter is not on a detailed inventory of firms, capabilities or current activities. This work has been done by others in the course of the technology assessment studies carried out under the ITS Strategy Development Program (see list of related studies in opening pages of this report). The focus of this chapter is to set the stage for a comparison of Canadian capabilities with ITS market needs.

The chapter begins with very short look at where ITS activity is taking place in Canada today. We then turn to our assessment of Canadian industry capabilities. That review is carried out from the standpoint of six key enabling technology areas and provides us with an overview of strengths, weaknesses, opportunities and threats of each of the enabling technology areas. We use this and the results of an industry consultative program as input to building a Canadian ITS industry map - a concise way of matching our capabilities with world ITS needs - in Chapter 8.

7.1 Canadian ITS activities

This section is by no means intended to provide a comprehensive overview of ITS activities in Canada. It is presented here to provide a snapshot, or general indication of the kinds of activity that are ongoing in the country at the present time.

7.1.1 General overview of public sector activity

The most recent comprehensive inventory of Canadian ITS activities in Canada was carried out as a joint Industry Canada/Transport Canada study and completed in 1994 (26). In that work, the authors found 78 active projects of various types, as well as a number of completed and planned activities to bring the total to about 122 projects. The vast majority of these were public-sector or academic activities. The Ontario and Quebec provincial Departments of Transportation dominated the representation - as would be expected from the provinces with the most densely used road systems in the country. British Columbia was also active - particularly in the area of traffic management, also through its Provincial Department of Transportation.

As the most active transportation department in the country, Ontario's Ministry of Transportation's most current list of projects, summarized in the Table 7.1 on page 80, covers a good cross-section of ITS technology areas. The Province has had a tradition of innovative technology use and in addition to putting into place one of the most advanced freeway management systems in the world, (the Hwy. 401 COMPASS system), well before virtually any jurisdiction anywhere, the Province, in partnership with the private sector, will be opening the first phase of the world's first example of a completely electronically tolled facility in early 1997.

Table 7.1
Summary of Ministry of Transportation of Ontario ITS Activities

Domain	Project Name
Strategic planning	• ITS Strategic plan for Ontario • ITS Ontario Online • Roadway Electrification
ATMS	• Automated speed warning and enforcement • Emergency tracking and response demonstration • COMPASS: Freeway traffic management system • INTEGRATION: ITS microlevel traffic simulation software • Remote traffic microwave sensor evaluation
CVO	• AVION/Advantage I-75 CVO preclearance project • Automated border crossing • Electronic toll collection (Hwy. 407) • Weigh-in-motion installations • CVO safety inspections
APTS	• Ontario AVL/Control initiative • Universal public transportation card iniative
ATIS	• International traveler information interchange standard • Metropolitan transportation information production system • Travel-guide
ARTS (Rural transportation)	• Mayday system
AVCS	• National Automated Highway Consortium member (US) • Vehicle - Roadside communications protocol

Quebec's initiatives also continue with efforts in freeway management (Montreal), Road weather information systems (Quebec City), freight mobility (OCTOPUS), laser technology development for vehicle detection, counting and classification, and real-time video image processing for incident detection.

British Columbia remains active in the traffic control area, particularly in the development of intelligent algorithms for contra-flow lane management. That province and Alberta are also involved in continuing activities in the CVO area, both domestically and in cooperation with US efforts in the HELP initiative.

Municipalities are not absent from the list. The City of Halifax was one of the first municipalities in North America - along with Red Deer, Alberta - to implement the SCOOT adaptive traffic control system beginning in the late 1980's. Both municipalities continue to expand their efforts, and Toronto has recently joined them in a similar effort to revamp its centrally coordinated traffic control system. Transit companies have been using AVL technologies in Canada for over 10 years. Metro Transit in Halifax was one of the first properties in North America to do so. Outouais Transit (Hull, Quebec) and OC Transpo (Regional Municipality of Ottawa Carleton, Ontario), have well developed pre-trip schedule information available as an automated phone service.

The federal government is currently participating in automated border crossing pilot projects in both British Columbia and Ontario, in partnership with the US government, the relevant state and provincial governments, and private sector representatives of the trucking industry.

7.1.2 ITS-related industry snapshot

Canada has a number of companies active in the ITS sector. A review of the listings of the 1996 International ITS Index (27) found 33 listings (some for the same company under differing capability headings). Fleet management, public transit management, and communications skillsets dominated the list (17 of the 33). Detector and display providers accounted for 6 more, and ETC integrators for another two. Some of these companies have been particularly successful, have established world-level capabilities, and export extensively. Most are expanding their employee base. A few examples include:

- *International Road Dynamics Ltd. (Saskatoon).* : A technology provider and system integrator that built their foundation on CVO applications - including Weigh-in-motion truck scales and traffic data collection equipment - the company now offers a full spectrum of technologies for ETC, AVL, vehicle detection and other applications. The vast majority of this company's market is export.

- *GIRO (Montreal):* This company has posted excellent success in the APTS and fleet management application area with its fleet planning, routing and scheduling software. With sales throughout the world, much of this company's business is export oriented.

- *Mark IV Industries Inc. (Mississauga):* Providers of vehicle-roadside communication equipment and technologies for electronic tolling, AVI, and CVO applications , this company continues to market its technologies on a worldwide basis. In March 1994, Mark IV was chosen as the technology provider for the New York - New Jersey - Pennsylvania Interagency Group EZ-PASS electronic tolling initiative.

In work carried out by Industry Canada in 1995, the department identified 56 companies with ITS technology capabilities across the country. This included a large majority that were not currently involved in the industry, but that had substantive capabilities in related enabling technologies such as GPS receiver development, displays, software and systems integration, sensor and detector expertise, and of course, communications technology.

7.2 Canadian ITS Technology Synthesis

To enable us to realistically evaluate Canada's technological position with respect to the ITS marketplace, six related Technology Assessment Studies were carried out by others under the umbrella of the ITS strategy development program. These studies focused on core ITS enabling technology areas: Geographic information systems for ITS; Displays; Sensors; System integration and intelligent software; and Positioning and navigation technologies. The results of this work are summarized in this section. Strengths, weaknesses, opportunities and threats are set out and used as input to help shape a Canadian ITS Industry capability map which is discussed in a subsequent section of this chapter. ***Readers are cautioned that these summaries are greatly simplified representations of sophisticated industry assessments. Those unfamiliar with these sectors will want to read the full reports available as noted in the introductory section of this report (28, 29, 30, 31, 32).***

7.2.1 Technology Assessment: GIS for ITS

Technical Thrust:

This enabling technology deals with mapping applications and technology as applied to GIS. It includes not only the digital mapping requirement, but also the graphics and analytical software to support it.

User services enabled:

Route guidance, enroute driver information, traveler services information, traffic control, incident management, demand management, pretrip travel information, public transport management, enroute transit information, public travel security, cv administrative processing, emergency response, HAZMAT incidence response, freight mobility, emergency notification, emergency vehicle management.

Strengths:

- world level mapping expertise
- strong university programs in geomatics, but not necessarily GIS for ITS
- extensive and strong leadership in international standard setting for GIS
- comprehensive map databases

Weaknesses:

- government crown copyrights impede application development & deployment
- no central coordinating body for public/private sector cooperation
- a weak domestic GIS for transportation market
- government priorities on revenue generation from their proprietary map databases rather than industry development

Opportunities:

- extensive system integration-related opportunities in ITS
- emergency fleet management application market is growing rapidly
- CVO/APTS applications for GIS are growing rapidly for private and public fleets - particularly in routing and scheduling
- data providers for GIS ITS applications (spatial and attribute data)
- GIS standards setting for ITS - because of our extensive GIS standards experience
- tourism applications are growing: tourist kiosks and ATIS yellow pages

Threats:

- offshore operators for application development
- lack of participation in broader ITS standard setting areas could damage our national industry
- strong education and R&D funding in US and UK threaten our strong industry position. Our funding is disappearing.
- public/private sector partnerships in US strengthen their industry position

Recommended actions:

- *Create one national digital roadmap for application development*
- *Set a GIS data standard at the national level*
- *Create a coordinating body for GIS ITS stakeholder discussions*
- *Review and revise government map data access and ownership policies*
- *Provide increased funding & support for R&D in GIS - ITS domain*

7.2.2 Technology Assessment: Display Technologies

Technical Thrust:
This enabling technology area deals with the application of aural and visual displays of four types: Roadway displays; Control centre displays; In-vehicle displays; Transit passenger information displays.

User services enabled:
Route guidance, enroute driver information, traveler services information, traffic control, incident management, emissions testing, pretrip travel information, ride matching, public transport management, enroute transit information, personalized public transit, electronic payment services, cv electronic clearance, on-board safety monitoring, emergency response, HAZMAT incidence response, freight mobility, emergency vehicle management, all collision avoidance services, AHS, railway crossings.

Strengths:
- strong roadway display manufacturing base (industry leaders)
- strong expertise in control centre displays, software image partitioning, system integration
- demonstrated successes in transit passenger information systems/displays

Weaknesses:
- insufficient LED applications to maintain leadership
- weak marketing in key offshore markets (Japan, Europe, Pacific Rim)
- no high resolution monitor capability and weak in LCD (new technologies)
- weak in-vehicle display capability (large potential market)
- lack of integrated marketing approach (with system integrators etc.)

Opportunities:
- component supply to offshore for LED / VMS displays
- software for large multiscreen displays
- teaming with system integrators for control centre and transit passenger information system applications
- Head-up display technologies : transfer from aerospace/defence sector
- Software for voice recognition/synthesis for driver interfaces

Threats:
- high levels of US / Japanese government funding for display technologies
- foreign public/private sector partnerships in displays close markets to us
- lack of participation in standards development will erode our industry
- declining public sector funding around world is decreasing market
- offshore manufacturing of displays by others increases price competition

Recommended actions:
- *Industry Canada should take an active industry support role: foster alliances, showcase products, R&D incentives, support standards participation*
- *Industry should pursue media-wall applications in ITS*
- *R&D organizations should foster R&D : LED/LCD displays, voice recognition & synthesis*
- *Public sector should support showcase opportunities*

7.2.3 Technology Assessment: Sensors

Technical Thrust:
This enabling technology deals both infrastructure-related sensors (traffic monitoring, vehicle classification, vehicle emissions, ambient environment) and on-board sensors for driver oriented functions (excluding intra-vehicle electro-mechanical sensors)

User services enabled:
Route guidance, traffic control, incident management, emissions testing, public transport management, enroute transit information, personalized public transit,electronic payment services, cv electronic clearance, automated roadside inspections, on-board safety monitoring, emergency fleet management, emergency notification, emergency vehicle management, all collision avoidance, safety readiness, AHS, pre-crash deployment.

Strengths:
- proven world-level expertise in infrastructure sensors (IRD, EIS) & related applications
- good system integration capabilities linked to sensors
- latent ITS sensor capability in aerospace & defence sector

Weaknesses:
- lack of breadth and depth in proven industry
- lack of presence in video-based systems (emerging ITS market)
- ability to showcase technologies is weak at public sector level
- substantial strengths in remote sensing (emerging technology for ITS)
- no presence in on-board sensor market

Opportunities:
- could grow in existing strength, but require strong alliances
- domestic strengths in video image processing could provide some openings for companies in this area
- remote sensing for wide-area traffic condition monitoring

Threats:
- high levels of US / Japanese government funding for sensor technologies pushes the technology envelope
- foreign public/private partnerships in sensors closes markets to Canada
- lack of participation in standards development will erode our industry position
- declining public sector funding around the world is decreasing a market that is infrastructure dependent

Recommended actions:
- *Industry Canada should take an active industry support role: foster alliances, showcase products, R&D incentives, support standards participation*
- *Industry should pursue niche opportunities in machine vision, video-image processing areas*
- *Industry should build domestic and offshore alliances with system integrators and others for market access*
- *R&D organizations should foster research in digital video applications, radar and lidar technologies for sensing, and machine vision*

7.2.4 Technology Assessment: System integration, intelligent software

Technical Thrust:
This area deals with system integration activities (subsystem integration, software integration, system calibration, system burn-in, system documentation/training, system commissioning & management) and the development of software and algorithms for database and decision support..

User services enabled:
Applies to all user services.

Strengths:
- strong reputation in software development/information sciences
- strong university programs in relevant areas: teaching and R&D funding
- domestic system integration experience in early ATMS (COMPASS), and recent innovative experience in total ETC facilities (Hwy. 407). The former was well ahead of its time. The latter is a world-level showcase.
- good industry/academic partnership environment

Weaknesses:
- Canadian government retrenching means that there are few domestic clients for system integrators or software developers in ITS
- no national ITS program or coordination puts Canadian industry in a weak position
- Firm sizes are relatively small and alliances are few. This is a self-limiting industry phenomenon.
- Limited domestic deployment provides few opportunities for showcasing
- No support for offshore marketing from Government of Canada

Opportunities:
- System integration for ETC and CVO applications in emerging industrialized countries.

Threats:
- primary threat is from large general systems integrators who have not yet identified the marketplace. Ascension of these to this market would probably destroy existing capabilities.

Recommended actions:
- *Industry Canada should take an active industry support role: foster alliances, showcase products, R&D incentives, support standards participation*
- *Industry should pursue niche opportunities in system integration and software development with ETC and CVO projects in offshore markets*
- *Industry should build domestic alliances with Canadian technology suppliers in sensor and display areas to build stronger teams with turnkey capabilities.*
- *Industry should build offshore alliances with technology suppliers to their local markets to gain access to those markets, for system integrators, software developers, and our own ITS technology component industries.*

7.2.5 Technology Assessment: Positioning & navigation technologies

Technical Thrust:

This enabling technology area deals with: Satellite-based positioning systems (GPS); terrestrial systems; digital map databases; position sensors; navigation systems.

User services enabled:

Enroute driver information, route guidance, incident management, pre-trip travel information, public transport management, enroute transit information, HAZMAT incident response, freight mobility, emergency notification, emergency vehicle management, automated highway system, railway crossings.

Strengths:

- world level GPS product development / system integration capability
- world-class positioning & navigation systems expertise
- strong links to domestic communications firms
- strong cellular positioning & satellite communications capabilities
- opportunities for Canadian map suppliers through ETAK & NAVTEK
- synergy with fleet management capabilities
- strong university-based education & R&D programs

Weaknesses:

- government crown copyrights on comprehensive digital maps impede application development & deployment. This results in few showcase opportunities.
- competition in terrestrial-based paging is high
- no domestic manufacturers of dead-reckoning systems (used with GPS)
- few domestic or foreign alliances: essential for offshore market penetration

Opportunities:

- ATIS applications are a major component of the long-term ITS market Most require positioning & navigation technologies.
- Cellular positioning technologies likely to be mandated in US
- Growing LEO & GEO satellite communications application development
- Recent opening of NAVTEK & ETAK offices in Canada presents alliance, technology, and data supply opportunities to world level navigation & mapping technology firms.

Threats:

- lack of participation in standard setting could damage our national industry
- Presence of offshore firms in Canada also represents a potential threat

Recommended actions:

- *Industry Canada should support and foster strategic alliances among potential industry partners to help strengthen domestic capabilities.*
- *Create one national digital roadmap for application development*
- *Review and revise government map data access and ownership policies*
- *Government should foster industry development of LEO and GEO products*
- *GPS industry should seek offshore dead-reckoning strategic alliances*
- *Foster development of cellular positioning technologies*
- *Joint government/industry marketing of Canadian products*

7.3 Technology Assessments: Emerging critical issues

Although each technology assessment was prepared independently of the others, there are clear common themes and issues which emerge from their analyses. Not surprisingly, since each area was addressed from the standpoint of ITS application needs, there are also synergies between the various areas which could be critical in helping Canadian companies attain both the mass and position in the marketplace. Those who have read the technology assessments will be aware that in many cases, Canadian companies are world leaders in specific areas of their domains. They have often managed to build themselves into strong competitive positions in spite of a weak domestic demand ITS - largely because of strong technology capabilities and participation in a formative marketplace of a set of emerging technology applications.

This is now changing. The competitive environment in the ITS field is increasing rapidly in intensity as major national governments in Japan, Europe and the United States partner with their domestic industries - particularly those from the high technology and aerospace and defence sectors - to aggressively pursue diversification and high technology employment opportunities for their nations. Such government participation allows these competing industries to work from positions of enormous strength as their partner governments help gather and coordinate business intelligence, contribute to high technology research for product development, underwrite demonstration projects aimed at showcasing their industry capabilities, participate actively or help industry participate in standards setting activities that are shaping the ITS technology marketplace, and foster domestic and international strategic alliances. These new arrangements have not come about by accident. They are a direct result of national governments looking at ITS, recognizing a significant industrial opportunity at its very earliest stage, and developing a new partnership paradigm to help them become part of this market.

This environment is reflected in the strategic themes which emerge from the technology assessments.

- Canada has significant strengths in all of the technology areas - often in particular niche areas, but nonetheless capabilities which have enabled industry participants to become active and often world-level participants in the ITS arena.

- The lack of any national-level, government office to work with Canadian ITS industry participants weakens our position in the ITS market. A single, office is needed to coordinate government activities, gather ITS industry intelligence, help foster and promote domestic and international alliances, and assist industry in finding ways to build partnerships and work with the broad cross section of government departments with existing resources ranging from business intelligence groups to high technology R&D funding, to international marketing.

- The need for national government participation and assistance to industry for participating in international standards setting activities dealing with ITS technologies. This is a critical area which is being used by other national governments to shape the marketplace to their wishes. Canada has to have - and is capable of providing - strong leadership in many of the relevant areas currently under consideration.

- The relatively low level of ITS activity in this country - due in great part to the severe financial constraints which all levels of government are facing - means that our industry is focused on export markets - a very positive thing. However it also means that there are few opportunities to showcase our industry capabilities here at home. Such showcases are strong selling tools in the aggressive export marketplace, and industry and all levels of government have to find ways not only to build such opportunities, but also to ensure that Canadian ITS technology suppliers are actively sought and encouraged to participate in them. Once again, partnerships between government and industry are often the key.

- Even in the constrained environment which Canadian governments face today, there is a continuing need to invest in the ongoing development of high technology. Canadian leadership in a number of areas is under severe pressure because of the lack of such investment domestically while offshore governments actively partner with their industries to move ahead. Continuing partnership-based means for funding R&D in the ITS sector must be found if our industries are to remain technologically competitive. Risks and benefits must be shared by both partners.

- Proprietary attitudes in government to both technology and data must change. In certain sectors, these attitudes have constrained Canadian industry development and allowed foreign competitors to assume market positions which not only could have remained domestic but could have allowed us to develop applications and skillsets with international market potential. Government policies towards its various digital mapping databases are a prime example of this. On the other hand, certain federal laboratories (i.e. Communications) are setting strong examples for working with industry in exploiting government-developed technologies, data and technical skills in the public marketplace. The latter type of example must be encouraged and fostered throughout government.

These issues helped to define a number of key strategic recommendations which are outlined in later chapters of this report.

7.4 Communications: the foundation for ITS

In addition to the technology assessment work described in Section 7.2, a detailed review of communications needs and standards for ITS was also commissioned. It is safe to say that without the very sophisticated developments in communications technology of the recent past, ITS would quite simply not be possible. Communications is what allows the integration of systems that makes ITS technologies work. As such, ensuring that Canada is on the right path domestically - particularly in terms of standards - is critical.

Once again, readers are cautioned that this summary of the communications work provides only an overview. Those needing a more detailed background to this complex and rapidly changing area should read the Communications Needs and Standards report (33) listed in the introductory pages to this document (page v).

7.4.1 Technical focus

In addition to being a core technology for ITS, communications are a Canadian strength. Few would dispute Canada's technical leadership in this area, and this gives us a strong technical foundation and a lever of expertise which we can - and should - use to help us move forward in the ITS area. In particular, it is essential that we use this expertise to help participate in and shape the ITS communications standards setting activities which are now building the stage for ITS deployment in the future. The communications needs and standards study focused on this area of activity, with a particular accent on following and building a solid intelligence base in and understanding of the US ITS Architecture efforts which were just released in June of this year.

Communications needs in ITS can be divided into two primary categories: fixed and mobile. The US architecture study identifies a requirement for five communication modes within the two major categories:

- Fixed (wireline) communications between fixed elements of the architecture.
- Dedicated short-range communications (DSRC) between the vehicle and the roadside elements of the architecture.
- Extended range two-way communications between the vehicle and the architecture.
- Extended range one-way (broadcast) communications from the architecture to the vehicle.
- Short range communications between vehicles.

7.4.2 Strengths

A number of strengths of our domestic communications industry relative to the ITS domain were noted in the course of the study. These included:

- A proven capability in the provision and installation of fibre-optic cable-based systems (as opposed to cable supply per se) and related fibre optic transmitters, receivers, switches, and related telecommunications equipment. (BNR, Nortel, Newbridge)
- Proven strengths in EHF microwave technology with direct application to transmission of video-based surveillance information in a cost effective and reliable manner. With increasing emphasis on video technology for general surveillance as well as specific vehicle detection, this is a valuable strength. (SR Telecom, Harris Farinon)
- Proven strengths in and major supplier to North American and world market for DSRC mobile communications equipment used for AVI, CVO and ETC applications in ITS currently. Potential use in electronic border crossings, roadside safety inspections, on-board safety monitoring and other areas.
- Proven capability in dispatch radio systems. Directly applicable to a number of fleet-based ITS applications.

7.4.3 Weaknesses

In general, weaknesses in this sector relate more to institutional factors in the ITS market than intrinsic weaknesses in our communications capabilities. Canada does lack a capability in vehicle-to-vehicle communication systems, thus shutting us out of potential AVCS application areas in the immediate future, however most of these have longer-term deployment potential, and thus have no significant bearing on the near or mid-term picture.

Strategic weaknesses in overall levels of ITS activity and the lack of central coordination within government for helping develop, foster and promote our communications capabilities within the ITS marketplace are of concern, since they directly affect the efficiency with which we can compete internationally. In addition, the still very dynamic and unsettled nature of the ITS market - particularly from a communications standards point of view - increase levels of risk for technology suppliers and developers. It also reflects a critical need to become involved at the national government level in international standards setting activities.

7.4.4 Recommended actions

The communications needs and standards study recommended a number of actions which bear directly on the work of this study, and which provide valuable input to the development of our strategies in later chapters of this report. Among the strategic recommendations were the following.

- Priority should be set on developing a strong fixed communications infrastructure for use in the ITS monitoring and data collection activities, without which virtually all other applications founder.

- Canadian mobile ITS communications interests should focus on three complementary components:
  - DSRC to serve electronic tolling, fare payment and electronic clearance applications. US interoperability is critical.
  - High Data Rate FM Sub-carrier Broadcast to economically disseminate ITS data over a wide area using an existing infrastructure compatible with US systems. In complementary work under this ITS Strategy development umbrella (34), this question was studied in detail, with a resulting recommendation for a major proof of concept trial in 1997 to be followed by a more extensive trial the following year. Total costs of the two trials is estimated to be in the order of $2.7 million.
  - Low Data Rate over Dispatch Radio, to capture high value users in a localized area.

- Canada must participate actively in international standards setting activities for both fixed and mobile communications. This participation must be coordinated at the federal level and include active participation by government and industry in such activities. In addition, formal Canadian communication standards are required for ITS applications.

- An ITS desk should be established at the Communications Research Centre to monitor worldwide ITS communications technology developments and provide advice to industry and government on a range of issues including standards setting.

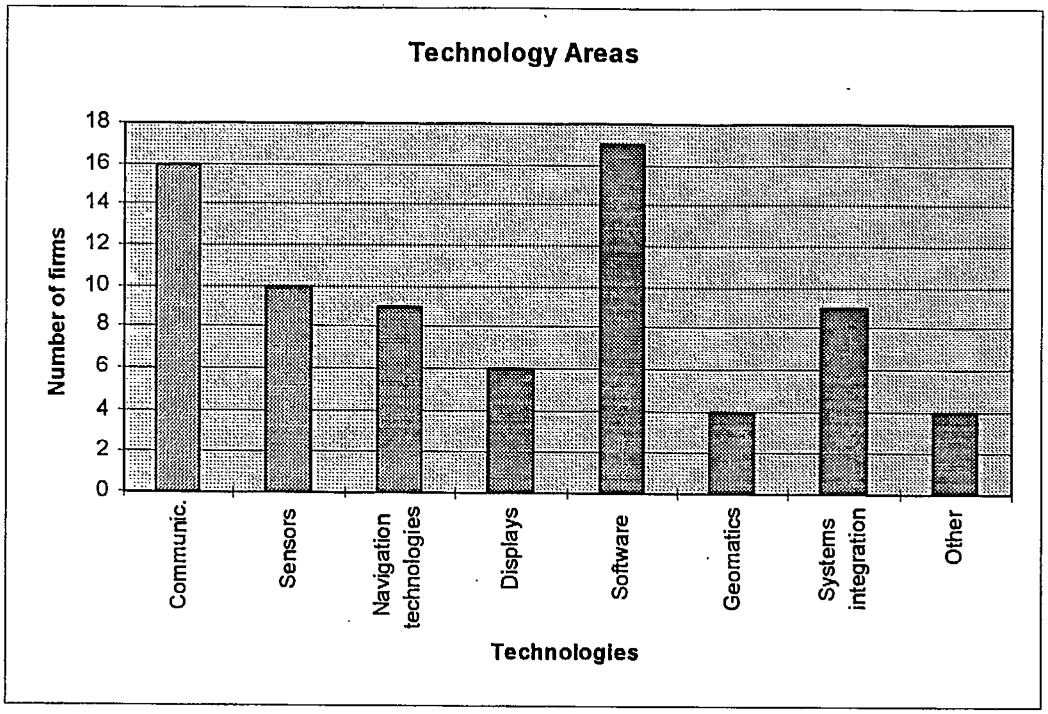
7.5 Industry needs and activies survey

As part of our effort to better understand the existing and nascent ITS industry, we carried out a mail-out survey of firms which had been identified as existing or potential technology suppliers. The basis for this survey was the catalogue of ITS firms developed by Industry Canada in 1995 (34).

Fifty-six firms were identified in that document and surveyed for the purposes of our work. After two rounds of callbacks, we obtained 29 replies. Twenty-one of the firms were actively involved or planning to get involved in the ITS market. Eight indicated that they had considered the market, but had decided against entering it. Of the 29 firms that responded, 25 were technology suppliers - over 86% of the total. Four of the remaining firms were consultants, and the remainder were system integrators.

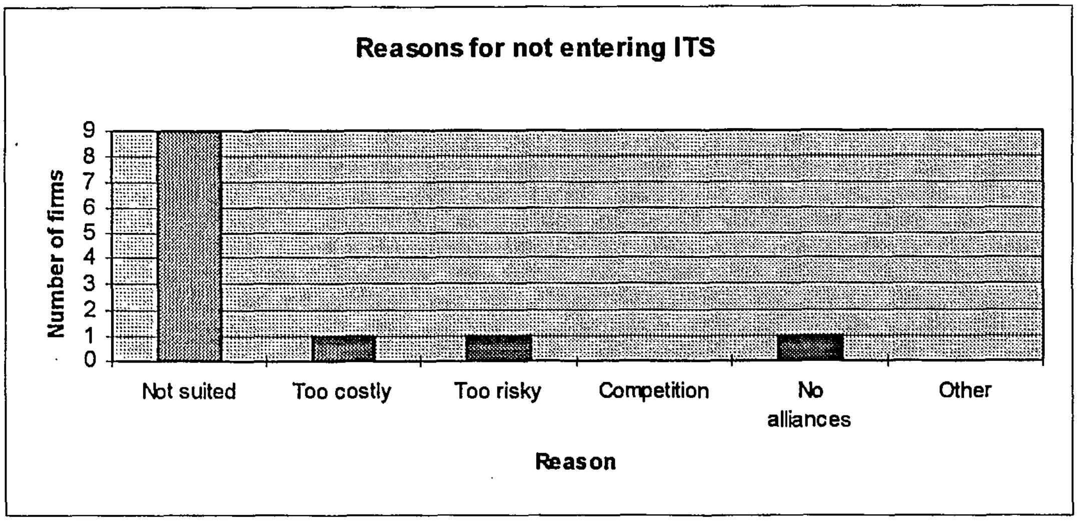
Responses to key questions are summarized in graphical form below. Total responses may be higher than the number of respondents because many respondents are involved in more than one technology area or may offer multiple responses where appropriate on other questions.

Technology areas of respondents.



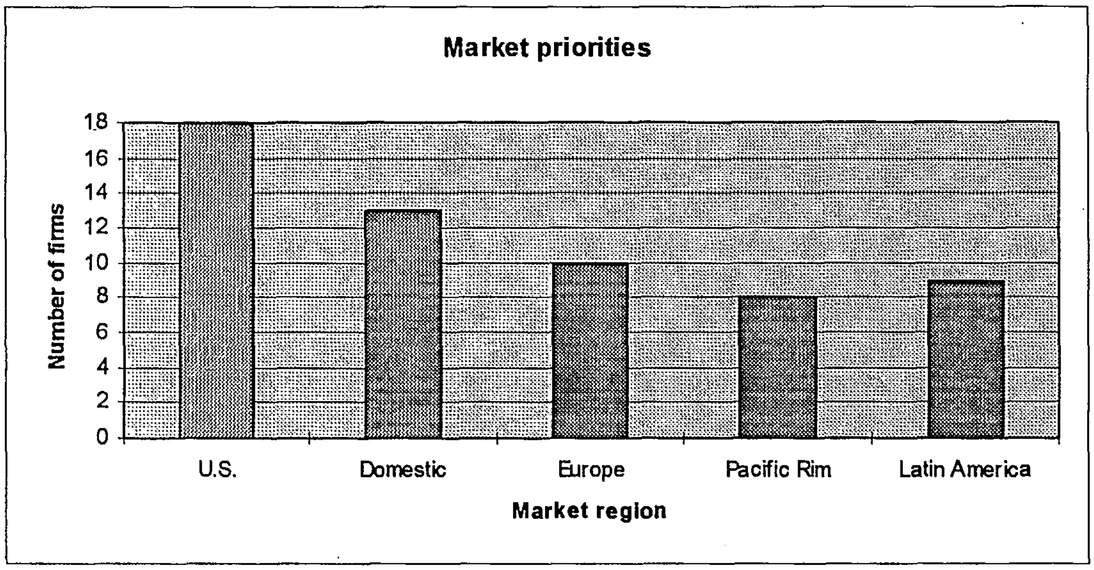
The companies that responded were dominated by communications and software suppliers. Sensor, navigation technology, and system integration services suppliers represented the second tier of respondents and display and geomatics companies the third. Given Canada's strong reputations in communications and software, and their fundamental importance to all user service areas of ITS (see previous discussions under section 7.2) this is not surprising.

Reasons for not entering ITS market



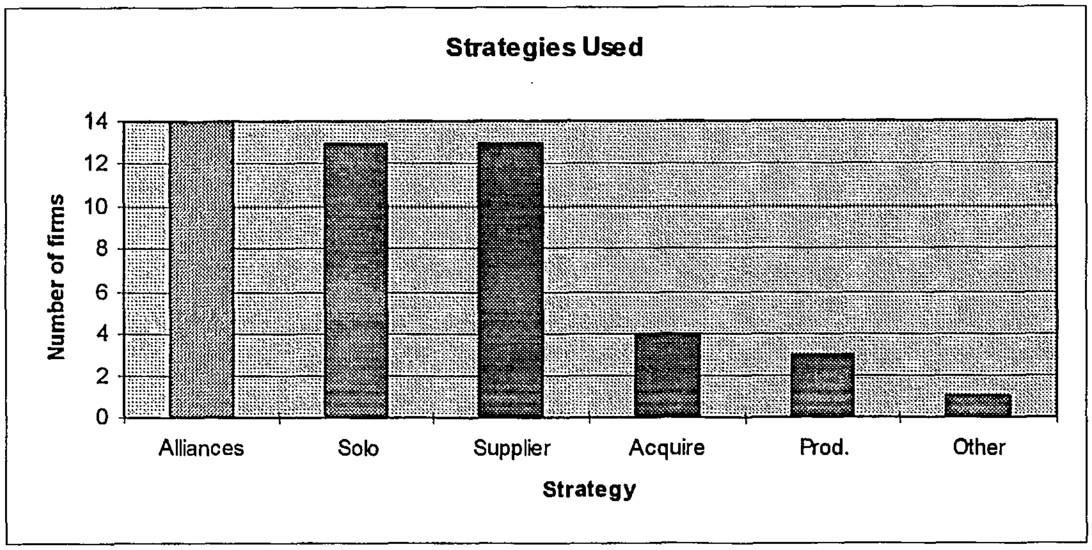
The majority of firms that did not enter the ITS marketplace in spite of having indicated some interest in 1995 indicated that further investigations had convinced them that their technology base was not suited to ITS applications. Only one firm demurred because of risk.

Regional Market Priorities



The United States represented the primary market for most firms participating in the survey. Once again, multiple responses were possible to this question, so total counts on this question will exceed total responses. Most respondents maintain a domestic presence and consider it an important part of their operation. Nonetheless, when we look at the total of non-domestic responses it is evident that the ITS technology marketplace is strongly export oriented.

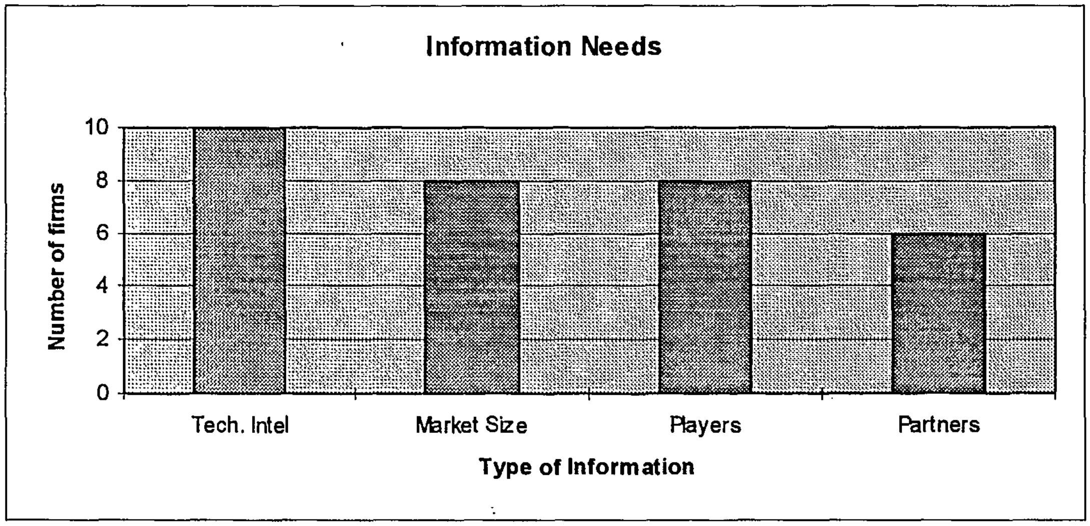
Strategies used to access markets



We asked participants to indicate what their primary strategies were for getting into non-domestic markets. Most used multiple strategies - usually a strategic alliance and/or acting as a supplier of component technology to a system integrator or lead firm. Solo entries were also represented although in significantly smaller numbers that the first two categories combined. Other strategies, including acquisition of another firm and production engineering for an offshore firm represented only a small portion of the responses.

Finally, we explored the importance of various kinds of marketplace information. Technology intelligence headed the list, with potential market size estimates next. Knowledge of key players and potential partners was also regarded as important, partly as means of assessing competition, but also as a way to identify potential allies who could ease entry into the market.

Market information needs



7.6 Key observations: Canadian context

This chapter has provided a first cut profile of the Canadian ITS context and sets the stage for the development of an industry "relevance map" in the next chapter. A number of the key observations and issues which were presented in this chapter are summarized below.

- Canadian governments are active in ITS at all levels, although financial constraints mitigate against extensive programs. Nonetheless, Canada - and in particular the Province of Ontario was in the forefront of ATMS development with the COMPASS system, and is now responsible for a world's first all electronically tolled highway in the form of Highway 407 which opens this fall.

- Unfortunately, although this activity exists, there is no national program or coordination between jurisdictions. This low level of activity makes it difficult to develop showcase products for our industry capabilities.

- Canada does have some world-leading companies in the ITS area. These tend to be concentrated in the ITS areas with the most dramatic market pull: Commercial vehicle operations, electronic tolling, advanced passenger transportation systems. In the longer term we have solid expertise in the ATIS area - one of the largest long-term markets.

- Canada has world-leading capabilities in communications, and in particular in a number of sectors directly related to ITS. Market opportunities for both technology and service markets are excellent in this critical area that underlies all ITS technologies.

- Canada has strengths in all of the key enabling technology areas: GIS, displays, sensors, system integration and software, and positioning and navigation technologies. Nevertheless, some of our technologies are becoming dated and R&D funding to continue development is almost nonexistent. Partnership funding programs should be considered for this purpose.

- There is a distinct need for a national-level government office to coordinate and work with Canadian ITS industries in a number of key areas.

- Canada must participate in ITS standards setting activities in all areas including communications, or risk finding our industry shut out of the market. This is one of the key roles for a national level office.

- GIS digital map data in Canada is developed by various federal, provincial and municipal authorities, each having proprietary rights to their data. Attempts by some of these agencies to generate significant revenues for their offices through the marketing of their data have meant that in many cases it has been impossible for private-sector companies to develop commercially viable applications based upon them. In effect, it appears that such proprietary attitudes in some government offices and areas with respect to the commercial exploitation of data and technology has stifled industry development. This is in contrast to the United States, where government digital map data is available to any individual or agency at minimal cost. This approach has led to the development of a strong GIS-based applications development industry in that country - as can be seen by the now global presence of NAVTEK and ETAK in the intelligent mapping business.

- Key communications technologies should be pursued and developed in Canada in support of ITS. Three emphasis areas are recommended: Digital Short Range Communications (DSRC); high data rate FM sub-carrier broadcast; and low data rate dispatch radio.

- Canadian industry is active and committed. The market is export oriented.

Chapter 8: A Canadian ITS Industry Relevance Map

Canadian capabilities meet world markets

8.0 Chapter outline

This chapter is short but important. Here, we finally bring together our observations on the world marketplace with those on our Canadian industry capability. We do this by initially creating an ITS capability "relevance map" for Canadian industry. This is used to help us interpret our capabilities as they relate to the seven user service bundles and their constituent thirty user services.

We then relate these capabilities back to our prospects for the world market, first from the standpoint of technology maturity, and then from the view of projected sales. In a final section we try to look at what Canadian industry shares in a world marketplace might be.

8.1 The relevance map technique

In the National Strategic ITS Plan (34) produced for Industry Canada/Transport Canada in 1994, Delphi Systems introduced what it then termed and ITS Industry Map. The "map" was actually a number of function/product matrices which were used to help define the strategic context of the Canadian ITS industry and environment at that time. In retrospect, the technique was quite successful. It identified CVO and APTS areas as ones in which Canada had expertise, and for which there was a potential market pull. It also identified ATMS as an additional primary area of logical focus - flowing primarily from our expertise in freeway management systems and related system integration/software solutions.

The relevance map which we have produced for this study represents a modification of this original technique. It deals with three fundamental dimensions of relevance to our strategy development exercise: products, processes or functions, and players. The ITS PRODUCT is represented by the seven user service groups and by implication, their constituent 30 user services.

The ITS PROCESS of technology development and deployment is consistent with that of other high technologies and information systems. In our case, the process is comprised of the following steps:

- Pure R&D
- Applied R&D
- Pre-competitive testing

- Pilot projects and production
- Demonstration and operational testing
- Market introduction
- Market growth and production
- Mandated use

Obviously, not all steps may be represented within a given technology group.

Finally, the PLAYERS or stakeholders in ITS reflect the roles which have emerged to date in the course of marketplace development as well as the unique aspect of ITS deployment. The players represented are: Users, Operators, Owners, Researcher and Providers. These can be further subdivided into public, private, public/private partnerships, and academic sectors.

These dimensions are used to produce two matrices:

- Products Vs players
- Products Vs process role (or function)

We prepared blank versions of these matrices and distributed them to the consultants involved in the six sub-studies. Our own research team also helped out in this exercise. Each cell in each matrix was divided into three parts, and each respondent was asked to provide three individual ratings for each matrix position within a cell. The ratings were based on the following three questions:

- How much are we now doing in this area of ITS in Canada

- How good are we at this now ?

- Considering the global ITS marketplace and the potential for return on investment, how high a priority should we be placing on this area.

Respondents were asked to rate these questions on a numerical rating of 0 to 10. A "0" entry reflected the lowest end of the scale (i.e. Not doing anything, or no payoff...), whereas a "10" reflected the opposite. The resulting returns, when aggregated, and analyzed allowed us to make a number of observations based on the following general considerations:

- Not all ITS products have equal attractiveness or potential for the ITS global market or our industries

- Cells in which an industry position is minimal, (i.e. few players, or weak process steps) are relatively less attractive due to the investment required to ramp up capabilities and the resulting uncertain return.

- All cells can be evaluated from the conflicting environmental perspectives of opportunity or threat, and from the conflicting industry perspectives of weakness or strength.

We aggregated and analyzed the results in a number of ways, looking for patterns of industry capability related to the various user service groups. We also extended the matrices through a technique to plot capabilities versus priorities. The results of these various analyses are presented in Section 8.2.

8.2 Relevance map results

The two tables below provide the primary matrices that make up the results of our Canadian ITS industry relevance map.

Table 8.1
Product Vs Players Matrix

Player	Sector	Transport Management			Demand Management			Public Transport			Electronic Payment			CVO			Emergency Management			Vehicle Control			Average
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
	Question	tm1	tm2	tm3	dm1	dm2	dm3	pt1	pt2	pt3	ep1	ep2	ep3	cv1	cv2	cv3	em1	em2	em3	vc1	vc2	vc3	
USERS	Public Agency	6	5.8	7.3	3.5	3.3	5.8	3.3	3	6.7	3	4.8	7.5	3.5	4.5	8.5	4.3	5.5	7	0.5	0	1	4.5
	Privat (com)	3	3.5	6	2.7	2.7	4.7	1.5	1.5	3.5	2.5	4.3	6.3	4.5	5	7.5	2	3	6	0.8	0.7	3.8	3.6
	Private (pers)	2.5	2.5	5.7	3	3	5	3	3	4.3	1.5	3.3	5.3	2		4	1.3	2	5	0.7	0.5	2	3.0
OPERATORS	Public Agency	6	4.8	5.7	4.3	3.7	5.7	4.3	4.3	5.3	2.7	4	8.3	5	7	9	5	5.5	8.3	0.7	0.5	1.7	4.7
	Private (com)	3.3	3	7	3.7	3.7	5	3.7	3.3	7.3	2.3	2.3	5.7	5	5.7	7.3	2	2.5	4	0.7	0.5	3	3.9
OWNER	Public	6	4	7	4	3.3	6	4.7	4.7	7	3.7	4	7.3	5	7	9	5	5.5	8	0.5	0	1	4.8
	Private	3	4	5.5	4	4	5	1	1	3	2	2	8	4	5	7	4	4	9	0.7	0.5	5.3	3.8
	Public/Private	3	3	7	2	2	2	2	3	5	6	7.5	8	3	4.5	5	1	1	6	0.5	0.5	0.5	3.5
RESEARCHER	Public	5	5.7	7.3	4	4	5.7	3.5	3.5	7	5.3	6.7	8	2.7	4.3	5.7	2.5	2.5	6.5	1	1	1.3	4.4
	Academic	4.3	5.3	7.3	4.5	4.5	5.3	4	4	5.5	3.3	4	6	2.7	3.3	7	3	3	5	1.8	2	4.5	4.3
	Private	3	3.7	7.3	3	3	4.3	2	2	4	3	4	7.7	4	4.7	8.7	5	5	7.5	1.5	1.7	4.8	4.3
PROVIDER	Infrastructure	4.8	5.5	6.3	3.5	3.5	5.5	5.3	5.7	8.7	4.3	4.5	7.3	4.3	5	6.6	3.5	4.5	8	0.8	0.7	4	4.8
	System Integration	5.3	6.5	8	3	2.5	5	3.3	5.3	7.3	5.3	5.8	8.5	3.8	5.3	7.5	6	6	8.5	1	1.3	3	5.1
	Sensors	4	4.5	6.8	3.5	4	5.5	4	4.5	7.5	3.6	4.5	7.8	4.3	5.3	6.8	2.5	2.5	6	1.5	1	3.7	4.5
	Displays	4.5	4.8	6.5	3.5	4	6	3.7	4.3	7	3.8	4.8	6.3	4.3	6	6.8	3.5	3.5	8	1	1	3.7	4.6
	Navigation Tech	5	5	6.3	3	4	5.5	3.5	3.5	7.5	2	4	7.5	5	6.3	7.8	3.5	4	7	3	3	4.5	4.8
	Geomatics	5	4.5	7.5	3	2.5	5	4	4.5	7	2	2	9	3.7	4.3	8.3	6	5.5	7.5	2.8	2.7	4	4.8
	Communications	3.7	5	6.7	3.5	3	4.5	5	5.5	7	5	6	9	5.8	7.3	8	6.5	6.5	7.5	2.6	2.7	3.7	5.4
	Software	4.3	5.3	9	2.5	2	5	4.3	4	7.7	4.3	4.8	9	5	5.7	8.3	5	5.5	8	1	0.7	3.8	4.9
	Average	4.3	4.5	6.8	3.4	3.3	5.1	3.5	3.7	6.1	3.5	4.4	7.2	4.1	5.3	7.3	3.8	4.1	7	1.2	1.1	3.1	
	User Service Group	Tr. Man			Dem. Man.			Pub. Trans.			E-pay			CVO			Emerg. Man.			Veh. Con.			
	Unweighted Group Average	5.2			3.8			4.4			5.0			5.6			4.9			1.8			
	Weighted Average (20.40.40)	5.4			4.0			4.6			5.3			5.9			5.2			1.9			
	Provider Average	4.6	5.1	7.1	3.2	3.2	5.3	4.1	4.7	7.2	3.8	4.5	7.8	4.5	5.6	7.5	4.6	4.8	7.6	1.7	1.6	3.8	

Table 8.2
Product Vs Functions Matrix

ITS RELATED FUNCTIONS	Transport Management			Demand Management			Public Transport			Electronic Payment			CVO			Emergency Management			Vehicle Control			Average
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
Pure R&D	4.5	5.3	6.3	3.7	4.5	4	4.3	5	4.8	2.7	3	8	2.3	2.3	7.5	3	4.5	6.3	2	2	4.8	4.3
Applied R&D	5	6.7	7	3.3	4.5	5	4.7	6	5.3	3.7	4	7.8	3	3.3	7.5	6	6	6.3	3.5	3	4.7	5.1
Pre-competitive testing	4	5.3	6	1	1.5	3.3	4	4.5	5	5.8	5.3	7.6	2.7	3.3	7.5	4	4.5	6	1	1	3.3	4.1
Pilot-Projects/production	5.5	6.7	6.5	1.3	2	3.7	4.5	5.7	5.3	5	6	7.6	4.5	5.7	8.3	6	6	6.3	1.5	1.5	3.3	4.9
Demonstration/testing	4.3	5.7	7.3	1.3	2	3.7	4	5	5.3	4.5	5.3	7.3	3.5	4.7	7.5	5.5	5.5	6	2	1.5	3.3	4.5
Market introduction	4	5.3	7	1.3	2	3.3	3	2.5	4	5.3	5.3	7.8	2.7	4	6.8	3.5	3.5	5.7	1	1	3.3	3.9
Market growth/penetration	3.3	4	6.5	0.7	1	3.3	2	2.5	4.8	5.3	4.7	6.3	3.3	4	7.5	4	3.5	5.3	1	1	3.3	3.7
Mandated	4	8	4	1	4	3.5	5	5	3.5	6	7	2	0	2	2.5	6	7	3.5	2	1	0.5	3.6
Average:	4.3	5.9	6.3	1.7	2.7	3.7	3.9	4.5	4.7	4.7	5.1	6.8	2.8	3.7	6.9	4.8	5.1	5.7	1.8	1.5	3.3	
Unweighted Group Average	5.5			2.7			4.4			5.5			4.4			5.2			2.2			
Weighted Group Average	5.7			2.9			4.5			5.7			4.6			5.3			2.3			

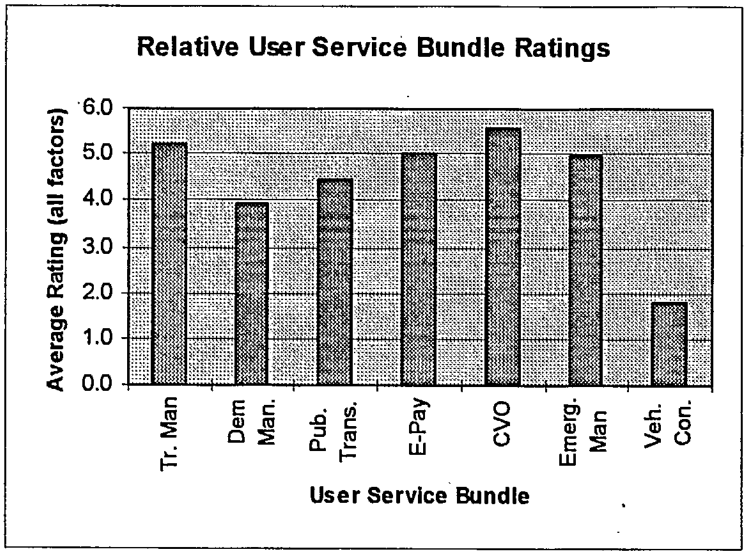
Some interpretative information is useful in helping to read these matrices. Numerical entries represent the average of all respondents to a given position. Null entries were not included in these averages. Each of the three sub-columns under the product groups represent from left to right, respectively, the three ratings asked for *(How much are we doing ? How good are we at this ? Priority ?).* Cells are shaded when average response values equal or exceed "5" (for questions 1 & 2) and "7" for question 3.

The patterns observed in the survey portion of the relevance map development confirmed both past work (National strategic plan, industry capability reviews, Canadian ITS project inventories, and other sources) and the work of the most current technology assessment reports prepared for the joint Industry Canada/Transport Canada ITS effort.

In general, Canadian industry capabilities - as measured by the general overall patterns of both the PRODUCTS Vs PLAYERS and PRODUCTS Vs FUNCTIONS portions of the map - showed:

- Primary strengths lie in Commercial Vehicle Operations, Electronic Payment and Transportation Management areas.
- The Canadian ITS industry has good secondary strengths in the Public Transport area - and latent capability in the Emergency Management area.
- Vehicle control and Demand management areas do not appear to be represented at any significant level of activity or technical strength in Canada at the present time.

The general pattern clearly observable in the quantitative results summarized in Table 8.1 of the attached analysis (ITS PRODUCTS VS PLAYERS MATRIX) is validated by looking deeper at a number of composite measures. Graphs of overall average rating response based on a composite "Relevance Index" (from 0 to 10) consisting of the three basic response components clearly show CVO at the top of the list (5.6), with Transportation Management next (5.2) and Electronic Payment (5.0) in third. (see below)



This same pattern is preserved when the three response components are used in a weighted average relevance index based on the following:

- 20% : How much ?
- 40% : How good are we ?
- 40% : How important is the area ?

When the average relevance scores are disaggregated to the individual question level for each of the seven ITS user-service bundles, the "signature" of the score plotted across each of the bundles clearly shown the same pattern of three dominant Canadian industry relevance areas (CVO, Transport Management and E-Pay). (see "Average" line in Table 8.1)

In looking deeper into the data by calculating a relevance index within the technology supplier category of player only, the same areas emerged as primary - except that the distinction between the primary and secondary areas virtually disappeared - implying that Canadian industry may be running ahead of its domestic marketplace in terms of supplying the ITS market. Given the current low level of ITS application activity in this country, such a finding is intuitively appealing. That finding was confirmed in a review of data from the ITS Canadian Company Survey (see Chapter 7, Section 7.5) also carried out as part of this project. Participants in that survey demonstrated a heavy bias to offshore (particularly United States) markets.

Looking within each subdivision of the technology supplier sector (i.e. infrastructure, system integration etc..) regardless of service bundle category, did not reveal any obvious trends or anomalies. Generally speaking, when examined at this aggregate level, our industries seem to have strengths in the system integration and software areas, however virtually every area scores identically and thus, this analysis was not carried any further.

To help look within the aggregate index and relate our domestic capabilities to priorities, we plotted "Capability" Vs "Priority" graph for each of the eight technology supply sectors as defined by average scores on the responses to these questions within the technology supplier portion of the matrix only. We did this for the five primary and secondary service bundle groups only (Vehicle Control and Demand Management were not examined further at this time). We also plotted the coordinate averages for each technology bundle so that we could get some idea of data scattering.

Ideally, we would hope to see each "Capability/Priority" point (termed "relevance points" for the purposes of this analysis) fall along a diagonal line from the origin at 45 degrees. In such a case, the Capability and Priority values (coordinates of the points) would be identical, which of course is what we would like to see in an ideal world. Analysis of both the relevance point coordinate values and a qualitative assessment of the spatial grouping of the eight points on each graph further strengthened the role of CVO services as the leading ITS application bundle of interest, followed by: Transportation Management providers, Public Transport Technology providers, and (if one outlier point is ignored) electronic payment technology suppliers. The Emergency Management Group of technologies appeared to show the greatest scatter of data.

The graphs can be found on page 103 of this report.

When we turned to ITS Products Vs ITS Functions - the exact order of bundle importance shifted somewhat. Transport Management and Electronic Payment both ended up on the top of this list, based on both weighted and unweighted relevance indices calculated as before. CVO and Public Transport are next, and emergency management are next.

8.2 Market shares

The analysis of Canadian industry capabilities leaves little doubt about the relevance of our active and latent industrial strengths. Our primary strengths in CVO and Electronic payment sectors tie exactly into the fastest moving areas of the ITS market. Our ATMS skills link strongly to that ITS bundle which, while secondary in the North American market, is forecast to move quickly in overseas markets, particularly in the emerging industrialized countries. Our secondary strengths in the Public Transportation - while playing to a relatively smaller portion of the market - are building on an already very strong worldwide installed market base - thus enhancing our ability to further capture market share.

To help better understand the match between our capabilities and the world marketplace, Table 6.2 from Chapter 6 is reproduced below as Table 8.3, with our capability areas highlighted in bold italic. At the user service level, not all user services have been included as Canadian strength areas in recognition of the "bundle-level" measure and the known focused nature of some of our strengths.

Table 8.3
Canadian Capabilities and the World Market

Region	Priority Bundles	First Wave User Services	Second Wave User Services
North America	• ***Commercial vehicle ops.*** • ***Electronic payment*** • ***Emergency management***	• ***Freight mobility*** • ***CV electronic clearance*** • ***CV admin. processes*** • ***Electronic payment services*** • Emergency notification • Emergency veh. managm't	• Automated safety inspections • On-board safety monitoring • HAZMAT response • Route guidance • ***Public transportation management***
Europe	• ***Transportation management*** • ***Electronic payment***	• Traffic control • Route guidance • Traveler services information • ***Electronic payment services***	• Incident management • Enroute driver information • ***Freight mobility*** • ***CV electronic clearance***
Japan	• ***Transportation management*** • Travel demand management	• Traffic control • Enroute driver information • Route guidance • Incident management • Pre-trip travel information	• Traveler services information • Demand management
Other industrialized countries	• ***Transportation management*** • ***Electronic payment*** • ***Commercial vehicle ops.***	• ***Electronic payment services*** • Traffic control • ***Freight mobility*** • ***CV electronic clearance*** • ***CV admin. processes***	• Route guidance
Pacific rim	• ***Electronic payment*** • ***Transportation management***	• ***Electronic payment services*** • ***Traffic control*** • ***Incident management***	• Demand management • Pre-trip travel information • Route guidance • ***Freight mobility***
Mexico and Latin America	• ***Electronic payment*** • ***Transportation management***	• ***Electronic payment services*** • ***Traffic control***	• Demand management • ***Freight mobility***

Table 8.3 provides us with some valuable clues about the nature of our potential marketplace, and the areas we should probably focus on. The following observations are made:

- North America - in the form of the US market - is a key area. The potential is there, and the match of market to skillset is close. We know the market. Alliances already exist. Intergovernmental cooperation and mechanisms for working together are in place. Cross-border government/industry partnerships have worked well in the past, and the environment, although very competitive, is well known.

- Emerging industrialized countries in the Pacific Rim and Mexico/Latin American regions are a second prime market for our ITS technology providers. Once again, market needs in the form of ETC, traffic management and freight mobility map exactly to Canadian capabilities. This area must be a high priority. This same perspective applies to China and India, although the likely slower pace of development of that market should be recognized.

- Other industrialized countries are likely to offer a third excellent match to our skillsets. Canadian skillsets and company scales play well to this market because we are less of a threat and more of a partner.

- Europe could offer a potential market, but European business practices, and culture often mitigate against offshore companies except in very niche areas, or where technology alliances are completely complementary. In some areas, such as Public Transit management we are already in place and competing. We recognize this, and cite it as an example of excellent niche marketing practice. Alliance and niche marketing should form the basis for our market efforts here, but they should probably take a back seat to the primary areas.

- While Japanese markets are impressive in some ITS areas, they match poorly with our current strengths. In addition, this market is often tightly closed to offshore industry except possibly for component supply in niche technological areas. Japan should be regarded as a tertiary market.

With this foundation in mind we attempted to look at projected ITS market sales in the key areas. Estimates were made independent of current manufacturing and delivery capacity. We have simply assumed that industries will be able to expand to meet growing markets, should they come about. Inherent in the assumptions is a new and strong national world presence in ITS for Canada which can only be created by close government/industry partnerships and cooperation in all aspects of ITS industry development. Many of these needs have been cited earlier in this report. Fundamental to them is an ITS Office within Industry Canada to work with ITS technology suppliers in building this market presence.

We based our forecasts on estimates of market share of the total world market as follows:

- ATMS: 5% of SRI market area and 10% of all others
- ETC: 10% of SRI market area and the Other Industrialized Countries and 30% of the Emerging Industrialized Countries and China/India
- CVO: 10% of all world markets
- APTS: 10% of all world markets
- ATIS: 1% of all world markets in 1996 and 2% starting in 2001.

Our market is global, so our competition is as well. We regard market profile and intelligence to be fundamental to our strategic approach. Technology is what ITS is all about, hence a strong intelligence capability that focuses on the enabling technologies, and not the transportation application itself, is crucial. Participation in helping to shape those technologies through standards setting activities is crucial. Standards shape the marketplace and can be direct instruments of market access control. They cannot be left to others to determine.

The ITS world is marked by rapid change in products, applications and enabling technologies. Other national governments are investing literally billions of dollars in partnership with industry in major ITS technology development and demonstration programs. Most are using national technology resources such as their government research laboratories to further help develop their capabilities. Our own national efforts must attempt to emulate this approach insofar as our constrained circumstances will allow. Focus, based on solid technology intelligence, will be critical to such programs.

Finally, someone has to bring this all together and provide coordination and leadership. This is an industry building activity. It is national in scope. It's potential is substantial. It's about creating jobs. It has to be a government function and in our strategy the only player qualified to undertake that role is Industry Canada.

9.1.2 The resulting framework

Our framework is simple - one leadership centre based in Industry Canada - and four strategic axes of activity:

Market Strategies: Under this " who, what, where, when and how " of ITS market opportunities around the globe, specific activities should include:

- working with Canada's global network of trade commissioners and councilors to identify opportunities for Canadian ITS suppliers.
- working with and providing assistance to industry in pursuing these markets aggressively.
- coordinating international marketing activities with other government agencies including DFAIT, CIDA, EDC, and CCC and helping industry to access and work with these groups and their programs.
- working with various levels of government across the country to help develop and foster showcase opportunities for Canadian ITS suppliers in conjunction with domestic deployment activities.
- ensuring, coordinating and fostering a continuing high profile Canadian ITS industry presence and participation at global ITS conferences, trade shows, and in export missions around the world.

Technology Intelligence: The intelligence function must focus on both offshore opportunities and domestic capabilities.

- It must address the need for intelligence on the development of enabling technologies which can be applied to ITS, rather than the ITS applications per se.

- A great deal of its emphasis must be offshore, and ensuring a high-profile Canadian presence (preferably with an industry orientation) at appropriate and selected venues best geared to such functions must be a part of this role.

- Cooperation with other sector interests in Industry Canada's portfolio must be assured.

- Government to government contacts must also form part of this role. Industry Canada has already established good relationships with corresponding US offices with interests in ITS.

Industry Development: Government must work to provide a technology support environment that will help Canadian ITS suppliers to continue to adapt and develop new technologies. Within this function:

- Industry should be offered a continuing opportunity to provide government with direct input on policies and plans which could affect them - particularly those which can impede industry development (such as the crown copyright problem cited in both the GIS and Positioning and Navigation technology assessment studies. ITS Canada may provide one ready means of accomplishing this.

- Coordination with the extensive national network of government laboratories (e.g. NRC, CRC in Ottawa, various National Defence CRAD facilities across the country etc.) and research agencies such as the Transportation Development Centre of Transport Canada (TDC/TC) is essential in order to help assist Canadian industries identify new opportunities and continue development of their current products, as well as assisting the labs to find potential domestic licensing partners for appropriate technologies. Showcasing Canadian technologies must also be an important component of this thrust.

- Industry should be provided assistance in finding information on and accessing partnered R&D funding programs such as Technology Partnerships Canada (TPC), various IRAP programs, NSERC Partnerships and Industry Research Chair funding programs and others.

Standard Setting: Active Canadian participation in international standard setting activities must be coordinated and supported through Transport Canada, Industry Canada and the Communications Research Centre (CRC) - now a special operating agency of the federal government. Recent developments in this area (see Section 3.4.2, page 44) involving both of these federal agencies and ITS Canada, bode well for such an effort in the future. This activity is fundamental to ensuring that Canadian technology suppliers are not excluded by default as new standards for various components of ITS technologies, related communications services, or spatial data mapping are resolved at the international level. Ongoing national-level domestic consultation programs are an obvious adjunct to this thrust. Active industry participation is a must.

As we note above, Transport Canada and Industry Canada are well placed to act as the central points of focus in all of this activity. However, the whole program must build on partnerships between federal departments, industry, academia and other levels of government. The program has to be cooperative, and while the federal government is the only logical party to lead the effort, the program must build on the concept of coordination and cooperation and not direction. ITS Canada can play a critical role in this respect - much in the same manner that ITS America does in the United States. By providing a venue where all parties can meet, discuss and resolve important national issues on a consensus basis, as well as pool resources to work towards common national goals, an independent body such as ITS Canada provides the critical pivot around which government, industry and academia can work together in partnership.

9.2 Stakeholder review

The stakeholders in the ITS arena are extensive in number. We've attempted to compile a list of agencies and groups which have interests in each of the strategic axes of effort discussed in Section 9.1 above. This information is presented in Table 9.1 below.

Table 9.1
ITS Stakeholder Interests

Market Strategies	Technology Intelligence	Industry Development	Standard Setting
• Industry Canada • Transport Canada • Industry • ITS Canada • DFAIT • CIDA • EDC • CCC • Finance Canada • Other levels of gov't • Revenue Canada • Immigration Canada • Economic dev. Groups	• Transport Canada • Industry Canada • Industry • ITS technology users • Universities • DFAIT • NRC • ITS Canada	• Industry Canada • ITS Canada • Transport Canada • Industry • NSERC • NRC • CRC • CRAD • Universities • Prov. research orgs • Geomatics Canada • TPC program	• Transport Canada • Industry Canada • ITS Canada • Industry • CRC • NRC • ITS technology users • CSA • Professional societies of relevance

In essence, each of the four areas identified above represents a strategic thrust, or action area. In an effort to more clearly identify specific actions and roles, we have prepared four "Action Area Summaries", which are intended to provide more specific direction and definition to each of these axes.

With the exception of addressing the question of resource requirements for Industry Canada, we have not attempted to cost the specific initiatives. Many roles - in particular for the supporting agencies - will not engender additional resource requirements, but simply constitute a specific set of actions which would take place in the context of their normal functions and/or administrative structure.

The overall emphasis in the development of these Action Area Summaries, has been on partnership. We see Transport Canada and Industry Canada as playing the lead roles for the federal government. We see ITS Canada as providing the strong industry interface, as well as the environment and structure within which ITS stakeholders can coordinate actions and communicate effectively with one another.

9.3 Market Strategy Action Area

9.3.1 Mission

Market profile and intelligence are fundamental to building a strong industrial base in any field, but particularly in a rapidly evolving one such as ITS. Action plans in this area must focus on: identifying opportunities for Canadian ITS technology suppliers; providing assistance to industry in pursuing such opportunities; fostering showcase opportunities for Canadian ITS expertise; and coordinating and fostering the international profile of Canadian ITS activities through cooperation with other levels of government and industry.

9.3.2 Action Area Lead Agency

Industry Canada

9.3.3 Primary Action Area Supporting Agencies:

Transport Canada, ITS Canada

9.3.4 Action Plans

Action Plan Name	Lead Agency	Supporting Agencies
Identification of international opportunities	Industry Canada	Transport Canada ITS Canada DFAIT CIDA
Assistance to industry to pursue opportunities	Industry Canada	DFAIT CIDA Provincial govt's CCC EDC
Foster/provide showcase opportunities for Canadian industries and expertise	Transport Canada	Industry Canada ITS Canada Revenue Canada Immigration Canada Finance Canada Provincial govt's Municipal govt's
Coordinate / foster international profile of Canadian ITS capabilities	ITS Canada	Industry Canada Transport Canada DFAIT

9.3.5 Comments

Close coordination of the various activities will be essential, and Industry Canada is seen as providing this role through an ITS desk within its current organizational structure. Should such a desk not be created, we would recommend strongly that ITS Canada assume the role of overall coordination, however this will require funding. Partnership funding from government and industry could make such a proposition viable. Organizations such as ITS America currently generate at least part of their revenues through substantial industry sponsorships, conferences and memberships.

9.4 Technology Intelligence Action Area

9.4.1 Mission

Rapidly evolving technology and applications are a hallmark of the ITS marketplace. Standards are still not fixed in many areas, and the potential for shifts in the direction of technology development and application is high in such an environment. Intelligence on the direction of technology development is critical to helping an ITS industrial base develop and flourish in Canada. Action plans in this area should: monitor the evolution of enabling technologies - particularly overseas; foster strong government to government relations - particularly with the United States; ensure internal coordination within government with respect to ITS-related sector interest.

9.4.2 Action Area Lead Agency

Transport Canada

9.4.3 Primary Action Area Supporting Agencies

Industry Canada, ITS Canada

9.4.4 Action Plans

Action Plan Name	Lead Agency	Supporting Agencies
Technology monitoring	Transport Canada	Industry Canada ITS Canada Industry Universities NRC
Promote government to government relations in ITS technical matters	Transport Canada	Industry Canada DFAIT Provincial govt's
Internal coordination within government	Industry Canada	Transport Canada

9.4.5 Comments

Technology intelligence gathering efforts cannot be allowed to take place in an ad-hoc environment. They must be the subject of a closely coordinated effort which involves all stakeholders and which is subject to regular review, analysis and communication to all interested parties. Critical areas of technology development may require detailed technical assessment by experts. In such cases, funding must be available to undertake such work. The identification of such critical investment needs must be carried out in conjunction with the ITS industry - preferably through ITS Canada. Universities and government laboratories can provide valuable resources for carrying out such tasks and should be the first agencies contacted in this respect.

Technology intelligence is constantly being gathered by many departments within the federal government - and particularly within Industry Canada. It is essential that close coordination take place to ensure that critical shifts in technology directions are identified as quickly as possible.

9.5 Industry Development Action Area

9.5.1 Mission

A primary role of government must be to provide a support environment which will help Canadian ITS suppliers to continue to adapt their existing technologies and develop new ones geared to the marketplace. Actions in this area should focus on: providing advice to government on actions needed to continue to foster and encourage the development of the ITS industrial base in this country; providing technology development support and assistance to Canadian industry through partnered research programs; providing technical support and intelligence for product development as well as showcasing support to Canadian industries in their ITS product development efforts.

9.5.2 Action Area Lead Agency

Industry Canada

9.5.3 Primary Action Area Supporting Agencies

Transport Canada, ITS Canada, NSERC, NRC

9.5.4 Action Plans

Action Plan Name	Lead Agency	Supporting Agencies
Advice to government	ITS Canada	Industry Universities Provincial govt's
Partnered research support programs	Industry Canada	Transport Canada Universities NSERC NRC (IRAP) TPC
Technical Support and showcasing	Transport Canada	Industry Canada NRC CRAD TDC/TC Universities Provincial govt's Municipal govt's Federal agencies

9.5.5 Comments

The fostering of industry development will only take place in the context of a closely coordinated and supportive environment which directly involves ITS technology producers, potential funding agencies, and the research community. ITS Canada must play a critical advisory role to government on behalf of industry so that the scarce resources available to help support ITS industry development are properly directed and focused. Partnered research programs such as NRC's IRAP effort, NSERC's Industry Partnerships and Centres of Excellence thrusts, and the new Technology Partnerships Canada (TPC) program must be actively promoted to industry. Showcasing opportunities will be critical to selling Canadian capabilities abroad.

9.6 Standard Setting Action Area

9.6.1 Mission

Active participation in international standards setting exercises is critical to allowing Canadian industries access to the ITS marketplace. Standards will shape the marketplace and the technologies which can survive within it and as such, a meaningful and proactive Canadian presence is essential. Active industry involvement in this area is very important. This action area should address the following areas: advice to government regarding ITS standards; continuing participation in ISO/TC204 activities; and US/Canada cooperation and consultation on ITS related standards setting within the North American context.

9.6.2 Action Area Lead Agency

Transport Canada

9.6.3 Primary Action Area Supporting Agencies

Industry Canada, CRC, Canadian Standards Council (CSC), Industry, ITS Canada

9.6.4 Action Plans

Action Plan Name	Lead Agency	Supporting Agencies
Advice to government	ITS Canada	CSC Industry ITS technology users ITE, CSCE, TAC, CUTA, CTA
International standards setting participation	Transport Canada	CSC Industry Canada Industry CRC NRC ITS Canada
Canada/US coordination & cooperation	Transport Canada	Industry Canada Industry ITS Canada CRC

9.6.5 Comments

Critical issues in this area will involve ensuring active industry participation and involvement in the standards setting process. To date, this has been lacking, however as ITS continues to gain momentum, the need to finalize standards will drive industry interest in other countries. Raising the awareness of industry will be essential and will probably best be led by ITS Canada as part of the advice to government function. Industry should be expected to participate through both intellectual resources and partnering to help underwrite some of the continuing costs of the activity. We expect that investments may be needed in research and resources to help Canada establish and defend its positions at the international standards setting table. Transport Canada and Industry Canada should be prepared to assist in this regard. New momentum has been generated recently in this area by ITS Canada, Industry Canada and Transport Canada. This must continue.

9.7 Industry Canada resource requirements

It would be unrealistic not to recognize this era of financial restraint in which all levels of government must now operate. It is for this reason that we have structured a strategic proposal that focuses on the use of existing resources that are well suited to the tasks at hand. We don't see a need for new major financial investments and/or programs to help the Canadian ITS Industry move ahead. We do see a need for strong coordination and leadership to help industry take advantage of the programs and resources which are in place both in government and elsewhere.

We recommend that Industry Canada create an ITS office either within an existing sector operation - most likely Aerospace and Defence - or as a new sector or desk. We prefer the latter approach simply because it recognizes the multi-disciplinary aspect of ITS and its use of technologies from a wide variety of industry sectors. The office need not be very large, and we recommend a straightforward structure to start with: one senior professional for overall management; one junior support professional; an allocation of about a third of a person-year for administrative support. Further specialist expertise will be required to carry out certain technology intelligence tasks, however we feel that this should be hired as required, since we expect that various types of technical specialist will be required at differing times. Ongoing resources should also be allocated to this desk to allow for the purchase of specialized technology studies (such as the multi-client SRI study), attendance at conferences and trade shows in support of Canadian ITS technology suppliers, and ongoing consultations with various ITS authorities and agencies. The table below summarizes the budget requirements in terms of person years and expenses. Staff costs are estimated only and include an allowance for payroll burden (about 30%), but not for overhead.

Table 9.2
Industry Canada ITS Office Estimated Annual Budget Requirements

Item description	Estimated cost
Senior technical manager	$100,000
Junior technical support person	$ 50,000
Administrative personnel	$ 15,000
Travel, conferences, memberships, publications	$ 30,000
Technology updates, market assessments	$200,000
Standards development	$100,000
Showcase Canadian industry capability at global ITS conferences, trade shows and export missions	$100,000
Total:	$595,000

We recognize that in times of fiscal constraint, finding the new resources to carry out this work will be difficult. Nonetheless, it is our opinion that the potential global market for ITS technologies is of such significance that such an investment is well justified - particularly given that Canadian industries have specific capabilities that are well matched to market demands. Unfortunately, the potential of these capabilities will not be realized unless Canada takes a proactive approach to the world marketplace - primarily because other major players in the global ITS market (US, Europe, Japan etc.) - are all actively supported by their national governments - usually through some sort of partnering arrangement.

Chapter 10: Observations and Recommendations

A brief summary

10.0 Key Observations and Recommendations

Radical changes in technologies which underlie fundamental elements of societal structure inevitably lead to dramatic industrial echoes. These are rare events and represent significant opportunities for those that are ready to take advantage of them. This is the case with Intelligent Transportation Systems. As Koji Kobayashi wrote in his introduction to the Club of Rome publication Information Technology and Civilization:

> *Let us not ask what the future holds in store. It is ours to build.*

The following observations and recommendations are geared to achieving this goal.

10.1 Observations:

10.1.1 General

1. Intelligent Transportation Systems represent a new paradigm in the transportation field. With that new paradigm comes the opportunity to develop the industry base to deploy and serve its technologies.

10.1.2 The Global Marketplace

1. The potential global ITS marketplace is very large. Annual sales could reach almost US$ 19 billion by 2001, US$ 43 billion by 2006, and US$ 66 billion by 2011. Cumulative sales between 1996 and 2011 could exceed US$ 430 billion.

2. Key ITS technology areas which are technologically mature and subject to strong market pull include commercial vehicle operations, electronic toll collection, emergency management and public transportation management. In Japan, advanced traffic management and advanced traveler information systems are moving quickly ahead.

3. Canadian capabilities match these key ITS technology markets extremely well. We have strong and proven skillsets in commercial vehicle operations, electronic payment systems, and public transportation management. Our secondary skillsets in advanced transportation management systems are also well recognized.

10.1.3 Canadian Opportunities

1. Canadian ITS industries could see global annual market sales of over US$ 1.2 billion by 2001, US$ 2.9 billion by 2006, and US$ 4.7 billion by 2011. Canada's cumulative share of global sales between 1996 and 2011 could exceed $US28 billion. This is virtually a 100% export market.

2. The US is a key market area for Canadian ITS technology suppliers. We are well established and recognized there, have a proven track record, and successful alliances in place that help our market penetration.

3. Emerging industrialized countries in the Pacific Rim and Mexico/Latin America are a second major market area for Canadian ITS suppliers - in this case for ETC, ATMS and CVO technologies: all areas of Canadian technology strength.

4. Other already industrialized countries could offer a good potential market, since they generally have characteristics similar to those of the US or Europe and will probably have ITS technology needs that focus on CVO, ETC and public transit applications to begin with. All of these are areas of Canadian strength.

5. Although undetermined in size, niche ITS applications for elderly and handicapped transportation are seen as excellent candidates for Canadian technology suppliers. We have strong skillsets and proven track records in developing these technologies. The demographics of populations in industrialized countries suggest that this market is rapidly increasing in size and could be very lucrative in the next two decades.

10.1.4 Other Market Observations

1. Europe is seen as a secondary market - primarily because of differing technology priorities, but also because of impediments to market entry.

2. The Japanese market is probably closed to Canadian industries except as a minor component supplier of niche technologies.

3. Domestic ITS markets will be very limited in the future - primarily because of the very constrained financial conditions under which most provincial governments are operating. Domestic marketing efforts should be oriented to developing showcase opportunities that can be used as marketing tools for Canadian industries. The highway 407 electronic toll road is a good example of such an application, although it is much larger than any that are expected to proceed in the future.

10.1.5 The Canadian Context

1. Lack of showcase projects is making Canadian industry progress difficult offshore, although we do have world-leading companies in CVO, ETC and APTS technologies.

2. Canadian strengths in communications are world leading. Strong opportunities exist in this area.

3. Canada has good strengths in all of the key enabling technology areas for ITS: GIS, displays, sensors, system integration and software, and

positioning and navigation technologies. However some of our technologies are becoming dated. R&D funding is difficult to find and Canadian company positions in some areas will weaken if steps are not taken to help support them,

4. The weakness of our current ITS coordination efforts in Canada has hampered our ability to compete in the world marketplace. A need exists for such a function. It must be ITS technology industry oriented and must bring together both public and private interests. The combination of the two key federal agencies - Industry Canada and Transport Canada - together with the restructured ITS Canada organization could provide a much stronger force for such coordination.

5. Standards are a key to the ITS marketplace. Although we have succeeded in tracking standards activities, and have participated to some degree, a much more proactive position is needed. Most countries are using standards committees and processes to push their own domestic technologies and shape the marketplace. Our absence from these committees could threaten our market position. Transport Canada and Industry Canada must work cooperatively and strongly in the various international standards committees and venues to ensure that our interests are not only protected, but also promoted. Close cooperation with U.S. efforts at standardization for ITS is also critical.

10.2 Recommendations

10.2.1 Leadership Roles

1. A four-axis strategy is recommended to assist in the development of an ITS industrial base in Canada. The strategy should focus on market development, technology intelligence, industry development and standards setting participation.

2. Industry Canada and Transport Canada must take the lead Federal government roles in supporting Canadian ITS efforts in the future in Canada. Working cooperatively together and with the private sector, these two key agencies should strive to implement the four-axis strategy outlined earlier.

3. ITS Canada - the not-for-profit group established to foster ITS industry development and technology deployment - should play a major role in providing a strong interface between government and the ITS technology industry. The group should be invited to work closely with both Industry Canada and Transport Canada in all aspects of the development of the Canadian ITS industrial base - providing both coordination and advice to the two lead federal ministries.

10.2.2 Implementing the ITS Industry strategy

1. We strongly recommend the establishment of an ITS desk or sector within the current Industry Canada structure. This desk would assume responsibility for implementing portions of the four axis strategy aimed at helping to build our ITS industrial base in this country, with a particular focus on market development (showcasing Canadian capabilities), industry

development and technology intelligence, as well as supporting Transport Canada in key standards setting activity participation. The estimated annual cost for this office is in the order of $595,000.

2. We strongly recommend that Transport Canada take a proactive role in international standard-setting activities for ITS - with a particular focus on close cooperation with US ITS agencies. It should do so in close collaboration with Industry Canada - particularly in respect of communications standards. In addition, Transport Canada should continue its support of industry oriented technology research and development in ITS through its facilities in the Transportation Development Centre.

3. The new Industry Canada ITS desk must play an important and proactive role in helping Canadian ITS industries to build both domestic and offshore alliances. Offshore alliances in particular are usually essential to penetrating local market areas for technology.

4. Other countries have clearly demonstrated that government/industry partnerships are an essential part of developing a strong ITS industrial base. Any future efforts in Canada must take such an approach. The new Industry Canada ITS desk must foster such partnerships as part of its mandate.

5. Existing federal government departments and sectors with responsibilities for international trade and export assistance will have important roles to play within the scope of their current programs in assisting the Industry Canada ITS office in its marketing and business intelligence efforts. The new Industry Canada ITS desk must actively foster and coordinate such a program as part of its mandate.

6. Existing federal government laboratories and technical installations with expertise and technologies applicable to the ITS field could play important roles in supporting continuing ITS industry product RD&D in this country. These facilities will be expected to assist the Industry Canada ITS desk in its efforts to support domestic ITS industry capabilities within the scope of their normal operating programs. The new Industry Canada ITS desk must promote and facilitate such cooperation and support as part of its mandate.

7. Although new funding for ITS RD&D is not recommended, existing sources of funding, including the new TPC program, but also looking at the NSERC research partnerships and Industrial Chair programs and other funds, all must be encouraged to support Canadian ITS industry efforts within the scope of their normal programs. The new Industry Canada ITS desk should assist industry in realistic efforts to take advantage of these programs as part of its mandate. In addition, as noted earlier, Transport Canada should continue to promote, foster and fund ITS-related R&D through the Transportation Development Centre.

8. The Government of Canada crown copyright policies on digital map data should be reviewed and updated to allow greater cost-effective industry access to them. This will help encourage domestic growth in GIS and navigation based ITS application skillsets.

9. High-rate FM subcarrier broadcasting technology should be a high priority for Canadian applications. Related studies have recommended a $2 million field trial of this technology. We strongly support this recommendation.

10. The need for support for technology R&D is an ongoing problem cited by ITS industry participants. Foreign governments have literally spent billions of dollars <u>in partnership with their industries</u> in developing and demonstrating various ITS technologies. Canada must find a way to accomplish the same goal, even if on a much more limited scale. Technical focus will be essential in this respect. ITS Canada - working with both key and supporting federal departments and laboratories - could play an important role in helping to define priorities and thrusts for such efforts.

Chapter 11: Next Steps

We recommend a number of immediate actions which should flow from this study.

1. A national level conference should be held on building Canada's ITS industrial base. Involving all ITS stakeholders (from government, the private sector and academia), this conference should focus on taking the first steps to building a true government/industry partnership focusing on ITS. The conference should be jointly organized by Industry Canada, Transport Canada and ITS Canada.

2. A national level workshop on communications needs and issues related to ITS standards should be sponsored jointly by Industry Canada, Transport Canada and ITS Canada. Its aim should be to provide all ITS stakeholders with intelligence on standards-related activities in ITS over the past two years as well as to raise awareness in the communications sector with respect to the future communications needs of ITS and their significant market potential.

3. In any event, the information gathered and developed in the course of this project and its numerous supporting and related studies should be made available to all Canadian companies, universities and agencies with interests in ITS. One way to facilitate this task would be to carry it out under the aegis of or in cooperation with ITS Canada.

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APPENDIX A

ITS PRIMER

PROGRESS DELIVERABLE

DATE ISSUED: 11/04/96

INTELLIGENT TRANSPORTATION SYSTEMS PRIMER

(revised)

ITS INDUSTRIAL BASE ROAD MAP

AN INDUSTRY CANADA / TRANSPORT CANADA JOINT PROJECT

PREPARED BY: Delphi Systems Inc.

NOTE

This report is one of a series of deliverables produced under the joint Industry Canada / Transport Canada "Study Into a Road Map for the Development of an ITS Industrial Base in Canada". The reports to be produced in this series include:

- ITS Primer: Interim version
- A Bibliography of Canadian ITS Reports: 1990 - 1995
- ITS Primer: Revised Final Version
- Report on Initial Industry Canada consultations: (internal)
- Report on Initial Government consultations: (internal)
- Market Assessment Report
- Draft Action Plan Document
- Draft Final Report
- Final Report

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1.0 INTRODUCTION

Intelligent transportation systems (ITS) represent a group of technologies which are evolving as a result of the need to respond to congestion and safety problems on the world's highway systems. The inital impetus for much of the work in this area has come from the European and Japanese communities, where such problems are demonstrably more severe than in Canada, although in recent years, the United States has also become a leader in the field through its determined efforts to move quickly into the continuing development and implementation of ITS technologies. The primary benefit of intelligent transportation systems their ability to allow us to deal with congestion, safety and transportation efficiency concerns in a more cost effective and environmentally sustainable way than the simple expansion of infrastructure.

The concerns that have stimulated activity in ITS elsewhere, are valid in Canada as well. In 1991 alone, there were 3,700 fatalities and 248,000 people injured on Canadian roads. Estimates by Transport Canada put the total monetary value of these accident losses at over $14 Billion. Even a marginal improvement in safety could thus result in a significant dollar saving to society each year. Unfortunately, current statistics suggest that these problem areas are not likely to diminish in intensity in the future. A 1991 report by the Transportation Association of Canada (TAC) entitled "Highways in Canada" noted that there were over 16.5 million registered motor vehicles, and more than 17.5 million drivers.

These numbers are expected to continue growing. Predictions from another TAC study , "Canada's Highways: The Future" forecast increases of almost 30% and 25% respectively in the number of registered passenger vehicles and licensed drivers, by the year 2001. The same study notes that without significant expansion of the highway system by that time, the number of drivers per kilometre of road will rise from 19.2 to over 24, and the number of vehicles (cars and trucks) per kilometre will increase from just under 19 to over 25. Given these circumstances, it appears unlikely that the problems of safety and congestion on our highways are going to go away.

Safety and congestion problems directly impact on the efficiency of our road transportation system. Increased congestion results in slower travel times and increased costs for the movement of both goods and people. Because transportation costs often represent an important component of the cost of a good, the resultant loss of productivity impacts directly on our ability to be competitive in an increasingly aggressive world market. In addition, the stop and go traffic conditions associated with severe congestion result in increased energy use and vehicle emissions. Both of these effects run counter to current societal values.

Unfortunately, the traditional response to such problems - that of expanding highway infrastructure to accommodate increasing demand - is no longer a viable option in many cases. Decreased budgets and increasing concern by society with respect to the environmental and social costs of new highway construction or existing road expansion, mitigates against infrastructure expansion as the only means of coping with problems on our highway networks. Intelligent Transportation Systems technologies provide us with at least a part of the solution to this problem.

2.0 WHAT IS ITS ?

2.1 Integration - a basic principle:

ITS technologies which allow us to improve the usage and safety of our highway system cannot solve all of our problems, but coupled with demand management techniques and some degree of infrastructure expansion, do appear to provide a practical and available alternative to the traditional way of doing business. The key to ITS is its ability to bring together the road user, the vehicle and the road infrastructure in one communicating system. This integration allows these elements to exchange information in order to allow for better management and use of the resources available.

The principles of ITS have an analog in the military field that is referred to as C^3I - command, control, communications and intelligence. ITS technologies provide these capabilities to the road transport system participants. It is this shift from the provision of a passive road system used by a "remote" and unconnected user, to a single, communicating and carefully controlled system in which all participants have access to information on system conditions, which represents the "Paradigm Shift" that is so often mentioned when people talk about ITS. We are moving from a passive to an interactive road transport system, and it is this ability to provide for interaction that allows the substantive improvements in cost effective use of road resources.

2.2 The "Participants" in ITS:

To get a better idea of how ITS is changing the road transport system,and how technologies can be used to accomplish this, it's useful to look at the potential functions of ITS within each of four key components or "participants" in such a system: the road, the user, the vehicle and the communications system.

ITS technologies allow us to do four different types of things with **the vehicle**: locate, identify, assess, and control. The ability to locate a vehicle within a frame of reference (ie. a map) is a key to successful fleet management and to providing in-vehicle navigation and routing advice. The ability to identify a vehicle without stopping or slowing it could allow us to better enforce regulations, charge tolls, price road use, facilitate border crossings, assess weight-distance taxes, track freight or critical cargo movements and other related functions. Being able to assess vehicles without stopping them is essential to cost effective enforcement of both vehicle size and weight regulations and vehicle-oriented safety rules. Finally, enhanced automated control functions on vehicles could help both improve safety and the efficiency of use of our road networks.

ITS can offer two primary functions with respect to **road users**: navigation, and monitoring. Navigation functions can include in-vehicle navigation, route guidance, and even dynamic route guidance in response to changing conditions on a road system. The ability to monitor driver performance and condition in order to detect fatigue, inattention, or other circumstances which might be of concern could help lead to the provision of a safer and more comfortable driver environment.

ITS offers four primary functions with respect to **the road** : monitoring, detection, control and administration. Monitoring functions can apply to such applications as weather and environmental conditions, as well as to traffic conditions. While monitoring however, certain specific occurrences may have to be noticed - hence the detection function of ITS - which might be applied to the detection of the presence (or absence) of vehicles in certain locations (as we do now at traffic signals etc.), or to the detection of an incident such as an accident, or other non-recurring interruption to traffic flow. Control functions refer to the kinds of activities which are now done with traffic signals and other such devices. Finally, road adminstration could be thought of as functions relating to regulatory enforcement or toll/road pricing collection.

Communications is what makes ITS work. The ability to move information around between the three "participants" in the system provides the necessary linkage to allow for the gathering of data which can be processed to become intelligence, and which can then used to determine and take appropriate command and control actions.

3.0 ITS PRODUCTS AND SERVICES

3.1 A Historical Footnote on Terminology:

Like any rapidly evolving area, ITS has a lexicon that is changing as quickly as the technology evolves. Originally termed IVHS - for Intelligent Vehicle Highway Systems - the new ITS term was coined to incorporate the obvious concerns for intermodality and interaction with other modes. European organizations favoured the terms "Road Transport Informatics" (RTI) and "Advanced Transport Telematics" (ATT), and most recently, the Japanese have turned to the term Vehicle, Road and Traffic Intelligence Systems (VERTIS). All of these designate the same set of technologies that we refer to in this primer as ITS.

As ITS first evolved in North America, the domain was divided into six functional areas as noted in the table below.

Initial ITS Functional Areas Designations

DESIGNATION	FUNCTIONAL AREA NAME
ATMS	Advanced traffic management systems
ATIS	Advanced traveler information systems
AVCS	Advanced vehicle control systems
CVO/AFMS	Commercial vehicle operations / Advanced fleet management systems
APTS	Advanced public transit systems
ARTS	Advanced rural transportation systems

These functional areas have now evolved into what American ITS authorities have termed in their National Program Plan - seven "Service Bundles" comprised of 29 distinct "user services" - or ITS products. The table on the page following summarizes these bundles and their constituent user services. Each of these bundles and their services are described briefly below. Regardless of the terminology used - they provide a good means of classifying and grouping the kinds of actual products and services which are now beginning to appear in the ITS world. A brief discussion of each of the "bundles" is provided below.

3.2 Travel and Transportation Management:

The services provided under this heading collect and process real-time information about the surface transportation system and use this both for providing commands to traffic control devices, and for disseminating intelligence regarding road and other conditions within the system to the traveller. They may take their inputs from detectors (in the road or on masts) which indicate such things as the presence of vehicles, their speeds, headways, and other parameters that permit a determination of how efficiently traffic is moving. Existing signal installations are also capable of providing data on vehicle presence and flow, and recent experiments have shown that vehicles moving in the traffic stream can also transmit information regarding speeds and delay back to a central control centre. Closed circuit television (CCTV) cameras may also be used to provide direct visual information to control centre operators.

USER SERVICES BUNDLES

Bundle	User Services
Travel and transportation management	• Enroute driver information • Route guidance • Traveller services information • Traffic control • Incident management • Emissions testing and mitigation
Travel demand management	• Demand management and operations • Pre-trip travel information • Ride-matching and reservations
Public transportation operations	• Public transportation management • Enroute transit information • Personalized public transit • Public travel security
Electronic payment	• Electronic payment services
Commercial vehicle operations	• Commercial vehicle electronic clearance • Automated roadside safety inspection • On-board safety monitoring • Commercial vehicle administrative processes • Hazardous materials incident response • Freight mobility
Emergency management	• Emergency notification and personal security • Emergency vehicle management
Advanced Vehicle Control and Safety Systems	• Longitudinal collision avoidance • Lateral collision avoidance • intersection collision avoidance • Vision enhancement for crash avoidance • Safety readiness • Pre-crash restraint deployment • Automated highway system

Real-time data collection and surveillance are primary characteristics of the services provided in this bundle. In this way, corrective actions can be taken in time to provide the efficiencies of capacity use that are sought. The integration of various subsystems is also important, enabling many different data inputs to be brought together to provide a better overall picture of network conditions. While the means to provide the linkage between the driver and the control centre exists using conventional means (traffic signals etc.) more and more emphasis is being placed on providing advice to the driver regarding conditions in order that they may take the actions that they deem most appropriate for their situation.

The user services provided under this bundle are described below:

- ***Enroute driver information:*** provides driver advisories and in-vehicle signing for convenience and safety.
- ***Route guidance:*** provides travelers with simple instructions on how to best reach their destinations.
- ***Traveller services information:*** provides a "business directory" or "yellow pages" of service information.
- ***Traffic control:*** manages the movement of traffic on streets and highways
- ***incident management:*** helps public and private organizations quickly identify incidents and implement a response to minimize their effects on traffic.
- ***Emissions testing and mitigation:*** Provides information for monitoring air quality and developing air quality improvements strategies.

3.3 Travel Demand Management:

This bundle of services is intended to support policies and strategies that are aimed at reducing vehicle demand by developing and encouraging modes of travel other than the single occupancy vehicle. Building on information collected and processed by the Travel and Transportation Management services and the Public Transportation operations services, this set of services achieves its goal by providing information required to implement effective demand management strategies at the operational level, by providing pre-trip information on multiple modes of travel to individuals before they undertake their trip, and by helping travelers find ride-sharing opportunities.

The user services provided under this bundle are:

- ***Demand management and operations:*** supports policies and regulations designed to mitigate the environmental and social impacts of traffic congestion.
- ***Pre-trip travel information:*** provides information to travelers for selecting the best transportation mode, departure time and route.
- ***Ride matching and reservation:*** makes ride-sharing easier and more convenient by assisting both users and service providers in maximizing the use of their vehicles.

3.4 Public Transportation Operations:

These services are intended to help improve both the service and efficiency of public transit companies. By providing improved information to public transit users both at the pre-trip planning stage, and during the trip itself they can help improve the reliability and attractiveness of public transit as a travel mode.

They can also help enable specialized paratransit services which render transportation systems more widely accessible. From a management standpoint, the services will provide improved monitoring of bus usage, vehicle location and driver performance measures - tools which can help public transit fleet managers plan and carry out their work more effectively. The services will rely on a variety of technologies, including AVI (automatic vehicle identification), GPS (for vehicle location), information display technologies, and cashless payment technologies such as smart cards.

Public transit operations services have several key characteristics. Like the travel and transportation management bundle they require real-time information for many of their functions if the systems are to be useful to passengers. Data links with a centralized control centre are essential to vehicle positioning, routing and scheduling. Traveller information of relevance offered under the services of this bundle might include: automated next-stop information on vehicles; transfer point and times information; routing and scheduling information at stations; real-time "next vehicle" information at stations.

The services included under the Public transportation operations heading include:

- *Public transportation management:* automates operations, planning and management functions of public transit systems.
- *Enroute transit information:* provides information to travellers using public transportation after they begin their trips.
- *Personalized public transit:* provides flexibly-routed transit vehicles to offer more convenient and more accessible customer service.
- *Public travel security:* creates a secure environment for public transportation patrons and operators.

3.5 Electronic Payment:

This single-service bundle supports the deployment of many other services - both inside and outside the transportation domain. Both public and private sectors will take advantage of the systems included in this service. Electronic payment will help to promote intermodal travel by providing a common electronic payment medium for a wide variety of transportation services including: tolls; transit fares; and parking. A number of technologies are available to support this service - including the current leading contender - "smart cards". It is highly likely (and has been demonstrated in Europe) that such systems could be expanded to include a much wider range of consumer goods and services, and in fact could provide a real alternative to today's credit/bank cards.

- *Electronic payment services:* allows travelers to pay for transportation services electronically.

3.6 Commercial Vehicle Operations:

The purpose of the CVO bundle of services is to improve the safety and efficiency of commercial vehicle operations. They offer these benefits through two distinct mechanisms; improvements in fleet management tools and techniques for the carriers themselves; and improved and more efficient regulatory enforcement techniques for government agencies. Already, fleet management tools involving satellite-based fleet tracking, centralized computer-aided dispatching, and in-vehicle voice/data links between trucks and their home offices have allowed trucking companies to progress substantially in terms of making better use of their available fleet and dispatch resources. At the regulatory level, pilot programs such as the Heavy Vehicle Electronic License Plate (HELP) have demonstrated the practicality of such technologies as automatic vehicle identification (AVI) and weigh-in-motion (WIM) for the purposes of enforcing truck size and weight regulations without having to make vehicles stop. Communications technologies obviously play a central role in such applications.

Some of the applications involve the use of in-vehicle sensors to monitor both vehicle functions (engine conditions and use, speeds, distances etc.) and driver alertness (eye movements etc). Electronic identification tags (Transponders) allow individual identification of vehicles and roadside/vehicle communication of that and other relevant regulatory information. Data links are obviously also an essential element, as are voice communications.

Deployment of ITS technologies is already well underway in this domain, in particular with respect to the fleet management and dispatch functions which are critical to the effective management of resources. The user services foreseen under this bundle are:

- ***Commercial vehicle electronic clearance:*** facilitates domestic and international border clearance, minimizing stops.
- ***Automated roadside safety inspection:*** facilitates roadside inspections.
- ***On-board safety monitoring:*** senses the safety status of a commercial vehicle, cargo and driver.
- ***Commercial vehicle administrative processes:*** provides electronic purchasing of credentials and automated mileage and fuel reporting and auditing.
- ***Hazardous material incident response:*** provides immediate description of hazardous materials to emergency reponders.
- ***Freight mobility:*** provides communication between drivers, dispatchers, and intermodal transportation providers.

3.7 Emergency management:

Emergency services such as police, fire and specialized rescue operations can use the services under this bundle to improve both response time and management of resources under their control. The primary characteristics of the applications in this bundle include knowledge of vehicle location, communications, and response. The services include:

- ***Emergency notification and personal security:*** provides immediate notification of an incident and an immediate request for assistance. Incidents can include both driver/personal security requests and automatic collision notification. Both services generally involve the provision of vehicle location automatically with the signal. In the case of collisions, the nature and severity of the crash may also be provided to responding personnel.
- ***Emergency vehicle management:*** reduces the time it takes for a vehicle to get to an incident through such techniques as more effective fleet tracking and management, route guidance, and signal priority/pre-emption for emergency vehicles.

3.8 Advanced Vehicle Control and Safety Systems:

The common goal of these services is to improve vehicle safety. In the near-term, all of the services (excepting the automated highway application) depend in autonomous in-vehicle technologies to do their jobs. Ultimately, infrastructure-based sensors will probably be used to supplement and improve many of these systems. In fact, these systems can be thought of as generally progressing through 3 stages or levels of development: autonomous systems, cooperative driving systems, and automated functions. In an autonomous system, the devices depend on no external communications or control signals to accomplish their tasks. In cooperative driving however, they act as an "automated copilot" which can, on occasion, warn the driver of impending situations, or supplement the driver's actions to a degree. Finally in fully automated systems, vehicle control may be relinquished by the driver to the system entirely at certain times, or the systems may take over control completely automatically under appropriate conditions. Advanced vehicle control and safety systems will normally require sophisticated in-vehicle sensors and electro-mechanical control systems, in addition to vehicle to vehicle and roadside to vehicle two-way communications capabilities.

The services incorporated under this bundle include:

- ***Longitudinal collision avoidance:*** helps prevent head-on, rear-end or backing collisions between vehicles, or between vehicles and other objects or pedestrians.
- ***Lateral collision avoidance:*** helps prevent collisions when vehicles leave their lane of travel.
- ***Intersection collision avoidance:*** helps prevent collisions at intersections.
- ***Vision enhancement for crash avoidance:*** improves the driver's ability to see the roadway and objects that are on or along the roadway.
- ***Safety readiness:*** provides warnings about the condition of the driver, the vehicle and the roadway.
- ***Pre-crash restraint deployment:*** anticipates an imminent collision and activates passenger safety systems before the collision occurs, or much earlier in the crash event than is currently feasible.
- ***Automated highway system:*** provides a fully automated, "hands-off" operating environment.

4.0 WHERE ARE WE NOW ?

ITS is here now. It is not a revolutionary new breakthrough, but represents an evolution of traffic management technology that has been used since the 1960's. The section below provides a brief overview of where ITS deployment stands in North America at the present time.

4.1 Travel and transportation management:

Traffic monitoring and management is relatively common throughout North America. An outgrowth of conventional traffic control technology, the use of loop detectors, video-based detection systems, video cameras etc. are all used to help monitor and adjust traffic control devices - most commonly traffic signals. Many municipalities are using centralized traffic control systems, and adaptive, real-time traffic control systems such as SCOOT are now appearing in cities such as Halifax, Red Deer, and Toronto. Freeway management systems involving multiple data inputs, control centres, variable message signing and highway advisory radio can be found in both Canada (COMPASS, in Toronto) and in many cities in the United States.

Commercial traffic reporting by radio and television is common. While experiments are ongoing in methods to deliver dynamic traffic information to users in vehicles exploiting technologies such as digital cellular telephone, paging systems, portable personal communications devices, in-vehicle sub-carrier radio, and palm-top computers, none of these have led to widespread application of travel information services. Static route guidance systems are available as options on some vehicles, in rental cars and as personal computer packages - primarily in the United States, since

Canadian maps- although plentiful in government hands - have not been made commercially available at cost effective prices. Dynamic route guidance is not yet commercially available.

4.2 Travel Demand Management:

Still not widely exploited, current efforts in this area tend to be more oriented to public transportation services, with increasing numbers of transit agencies providing dial-up or kiosk based pre-trip information services to prospective passengers. Multi-modal pre-trip travel information services , and demand management and operations services are not yet in place. Ride matching and reservation services tend to be present only within agencies or groups of employers and are run as private systems for employees, rather than being open to broader participation.

4.3 Public Transportation Operations:

Virtually all large and medium-sized transit operations use scheduling and run-cutting software for route planning and resource allocation services. A number of agencies in Canada such as Metro Transit (Halifax), and OC-Transpo (Ottawa-Carleton) are using automatic vehicle location and tracking systems to help monitor resource distribution and schedule compliance. Demand-responsive trip routing and scheduling software has become widespread, particularly to increase the accessibility of public transit services to all travelers. A number of systems maintain automated dial-up route information and schedule services for public access, as well as kiosk-based route information services in transit stations and other public locations.

4.4 Electronic Payment:

Still limited in its application, electronic payment systems are nonetheless beginning to make inroads in both the road tolling and public transit systems. Some systems have been extended to both parking facilities and telephone usage. In 1995, the U.S. reported electronic payment systems being planned or deployed at 20 toll facilities in the U.S. The public/private sector partnership Highway 407 project in Toronto is being designed as an electronic tolling (ETC) application and a number of provincial governments in Canada (New Brunswick, Nova Scotia, and British Columbia among others) are all contemplating tolled facilities in which ETC would piay a role. Interoperability questions and a lack of standards in this technology area are inhibiting factors which could still influence the spread of this technology in the near-term future.

4.5 Commercial Vehicle Operations:

The fastest growing application area, this domain is definitely the subject of a major "market-pull" - particularly from the highly competitive commercial freight carriers. Over half of North American truck fleets have deployed some form of fleet management system - most frequently to facilitate dispatching, vehicle location and fleet resource allocation in response to changing customer demands. Truck and driver condition monitoring systems are also being deployed, and intermodal operations are being facilitated through the electronic identification of containers and vehicles.

At the administrative level, as noted earlier, both weigh-in-motion (WIM) and automatic vehicle identification (AVI) technologies are being used to gather information on truck weights and vehicle credentials. The HELP Inc. project is now operational and is using electronic clearing services to permit safe and legal trucks equipped with transponders to bypass weigh stations and state ports-of-entry at highway speeds. Advantage I-75 - which will incorporate portions of Highway 401, in Ontario, will soon be implemented as an operational test of similar technologies. Other corridor applications are also planned.

4.6 Emergency Management:

In the U.S. in 1995, 24 emergency management systems were equipped with automatic vehicle location systems and a further 104 were moving forward with plans to implement. Exact figures are not available for Canada, but informal surveys indicate that the trend is similar. Commercial in-vehicle "mayday" systems (with monitoring services) are expected to be optional in some high-end passenger vehicles in the near future.

4.7 Advanced Vehicle Control and Safety Systems:

A few longitudinal and lateral collision warning systems are available on the market and are being deployed - primarily by commercial bus and truck operators. All of the major automobile manufacturers are working on intelligent cruise control systems - systems designed to maintain constant vehicle headways - and are expected to bring operational technologies to market within 3 to 5 years.

5.0 INTERNATIONAL EFFORTS IN ITS

5.1 Investment Overview:

ITS developments are currently moving most rapidly in Europe, Japan and the United States. Driven by the imperative of severe traffic congestion and safety problems, both Europe and Japan have had significant programs of research, development and demonstration (RDD) underway since the mid 1980's, although work was proceeding in this area even before that time - particularly in Japan. The table below provides a summary of centrally provided public funding for ITS programs in each of these locations.

CENTRALLY PROVIDED PUBLIC FUNDING FOR ITS PROGRAMS

Europe	United States	Japan
• PROMETHEUS: spending planned for 1987 - 1993: $770M • DRIVE budget for 1988-91: $70M • DRIVE II budget for 1991-94: $160M • DRIVE III budget (est) for 1995-98: $275M • EC DGVII (Transport Directorate) RTI/ITS under Framework IV: $25M	Federal government R&D: • 1989: $2M • 1990: $13M • 1991: $24M • 1992: $234M • 1993: $143M • 1994: $203M • 1995 through 1997: $231M/yr (estimated)	1973 - 1979: • $180M for CACS R&D 1985 - 1992: for R&D • $1.9M (NPA & MOT) • $5.0M (MOC) • $5.4M (MITI) 1985 - 1992: for deployment • $1.875Billion (NPA) • $519.5M (MOC) • $17.9M (MOT)

source: International Program Assessment, Kan Chen. Paper prepared for ITS America BEC Committee

The **European program of Road Transport Informatics** (RTI) or Advanced Transport Telematics (ATT) as ITS is called in Europe, has had two primary elements: Prometheus and

Drive. Investments by both government and the private sector to date in both research and demonstration projects, has exceeded $1 billion (US)since 1987. It is interesting to note that both are taking place at the European Union level, with multiple country participation and the need to coordinate a broad range of activities within a very complex interjurisdictional environment.

PROMETHEUS, working under the aegis of the European artificial intelligence and high technology initiative EUREKA, is primarily a private sector effort. It began in 1986, and ran until 1994, was vehicle oriented, and had an investment level in the order of $770 million (US). It was aimed at the development of technologies for active driver support, cooperative driving, and traffic management.

The **DRIVE** program, now entering its third phase, focuses on road infrastructure technologies in the area of demand management, traveller information systems, traffic management, fleet management, and other areas. In Phase 1 of the program which started in 1988 and ran until 1991, over $140 million (US) was invested by government and industry in 72 projects which were essentially pre-competitive research. In phase II, the DRIVE program had 56 projects - primarily of a field trial nature, and a combined public/private sector investment level of $300 million (US). Phase III of the DRIVE program is only just getting underway.

Japanese efforts in ITS began in the 1970's and early 1980's,however, the program of work crystallized in the 1980's around two major efforts: **the road Automobile Communications System (RACS)** and **the Advanced Mobile Traffic Information and Communications System (AMTICS).** Both were concerned with traffic management and traveller information systems - notably navigation and traffic information dissemination. Where RACS was oriented to expressway traffic, AMTICS dealt primarily with arterial street systems, and both were sponsored by different ministries within the country. By the 1990's however, both programs had been completed, and their successor program **the Vehicle Information and Communication System (VICS),** aims at complete system integration with real-time traffic management and route guidance as the primary objectives. The Japanese efforts are probably the most advanced in the world in terms of putting down fully operational infrastructure for drivers across the country. Forecasts by some experts predict that they will have this task complete by the turn of the century. If so, the Japanese will be the first to accomplish this. As can be seen in the table, the vast majority of public money has been invested in providing public infrastructure to support the ITS applications developed in their R&D program.

The **United States** is a relative latecomer to the ITS arena, however the public sector commitment of the early 1990's as set out in the provisions of the 1991 **Intermodal Surface Transportation Efficiency Act (ISTEA)** allowed for funding of $660 million from the federal government for ITS related projects. All of this will not necessarily be appropriated however, and there is some doubt as to the commitment of the federal government to its leadership role in the area. Nonetheless, at present, the program still appears to be on solid ground, although decision makers are beginning to look for positive results and returns from their investment. The work program is application oriented, and of course the federal investments only represent one part of the funding picture, since states, cities, and the private sector will also be required to invest in moving ITS forward quickly in that country. Several corridor projects and technology areas already involve joint U.S-Canada participation and it can be expected that developments in that country will strongly influence what is to be done in Canada.

5.2 Technical Perspective:

In comparing the efforts of the three leading ITS investment communities, there are definite differences in the strengths of each, as well as the approach being taken in each area. In general, The United States has in place a strong coordinating organization, with a top-down planning approach and an orientation to operational testing and demonstration projects. In terms of technical deployment, America leads in the ETC and CVO areas.

Japan on the other hand, with a stronger investment from the private sector, and a heavy public input into ITS infrastructure for traffic management and driver information, holds a definite lead in both of these areas. Experts have suggested that Japan will be the first country in the world to deploy traffic and traveller information services nationwide - probably by the turn of the century.

Europe's more broadly-based R&D program has provided it with a solid base upon which to build applications in the future. Because of their extensive involvement in ITS application through the PROMETHEUS program, European car manufacturers appear to have an advantage in the vehicle control and safety area.

6.0 CONCLUDING THOUGHTS

There is no one mechanism that can be prescribed for a country that wants to develop its ITS capabilities in order to both take advantage of the benefits of the technology as well as to promote its industrial development. In most cases, the mechanisms that will work depend to a significant extent on the constitutional structure of the country and the traditional mechanisms that have been put in place to foster cooperation in the past.

In the European case, the international cooperation required has been fostered to a significant degree by the European Union effort and the structures already in place. In Japan, the tradition of managed competition run through such agencies as MITI, has allowed that country to advance the development of its technologies in a structured and managed fashion, minimizing waste, and exploiting the strengths of the Japanese technology industry.

The United States has used ISTEA as the cornerstone of its ITS efforts from a financial standpoint. However, the creation of ITS America as a body which could bring together all of the parties interested in ITS to discuss, exchange information, and provide advice to the federal government on technical and policy issues has strengthened the ability of the various communities to work together.

The mechanisms differ from country to country, however the key ingredients are the same wherever ITS is moving ahead quickly:

- There is a national coordinating (not dictating) mechanism
- All sectors are involved: public, private, and academia
- Catalytic funding is available to help promote activities
- International cooperation and coordination are seen as keys to opening new market opportunities for national industries .
- There is a heavy emphasis on demonstration projects - re-iterating the need for ITS to prove its worth through the demonstration of benefits.
- Government and private sector cooperation are seen as essential.

John B.L. Robinson
11/04/96

APPENDIX B

TECHNOLOGY EVALUATION PARAMETER SCORES

SHORT TERM PROSPECTS: Present to 3 years

Criteria	Traffic Management			Fleet Management				Driver Info. & Trip Plan.			Vehicle Safety & Control				
Criteria	Traffic	ITMS	ATC	AVLT	Driv. A&I	Transit	Freight	PTI	IV Nav	ER Info	Col Avoid	HazWarn	AVC	SSM	Mayday
Technology	5.0	5.0	7.0	7.0	8.0	7.0	4.0	5.0	-5.0	-7.0	5.0	3.0	-3.0	-5.0	7.0
Efficiency	-5.0	-7.0	9.0	9.0	9.0	5.0	5.0	-3.0	-3.0	-7.0	-3.0	0.0	0.0	-3.0	5.0
Utility	-5.0	-7.0	9.0	3.0	5.0	5.0	5.0	3.0	3.0	-3.0	3.0	-7.0	-5.0	-3.0	7.0
Reliability	-5.0	-7.0	9.0	7.0	7.0	0.0	7.0	-5.0	-5.0	-5.0	-3.0	0.0	-5.0	-5.0	3.0
Interoper.	-5.0	-7.0	-5.0	-3.0	-3.0	-3.0	-3.0	-5.0	-5.0	-7.0	0.0	0.0	0.0	0.0	0.0
Cost	-5.0	-7.0	7.0	-5.0	-5.0	-3.0	0.0	3.0	-5.0	-7.0	-7.0	-3.0	-3.0	-3.0	-3.0
Complexity	0.0	-3.0	0.0	3.0	3.0	0.0	-3.0	0.0	-5.0	-5.0	0.0	0.0	-7.0	-5.0	0.0
Standards	-3.0	-9.0	-5.0	0.0	0.0	0.0	2.0	0.0	0.0	3.0	-3.0	0.0	0.0	-5.0	3.0
Inst. Issues	-3.0	-9.0	0.0	-3.0	-3.0	-3.0	0.0	0.0	-3.0	-5.0	-7.0	-3.0	-7.0	-7.0	3.0
Next Gen.	-3.0	0.0	3.0	5.0	5.0	3.0	3.0	-3.0	-3.0	-5.0	5.0	0.0	-3.0	0.0	5.0
Ave. Score	**-2.9**	**-5.1**	**3.4**	**2.3**	**2.6**	**1.1**	**2.0**	**-0.5**	**-3.1**	**-4.8**	**-1.0**	**-1.0**	**-3.3**	**-3.6**	**3.0**

LONG TERM PROSPECTS: 4 to 10 years

Criteria	Traffic Management			Fleet Management				Driver Info. & Trip Plan.			Vehicle Safety & Control				
	Traffic	ITMS	ATC	AVLT	Driv. A&I	Transit	Freight	PTI	IV Nav	ER Info	Col Avoid	HazWarn	AVC	SSM	Mayday
Technology	7.0	7.0	9.0	8.0	9.0	9.0	10.0	5.0	3.0	0.0	7.0	5.0	3.0	0.0	7.0
Efficiency	5.0	3.0	9.0	9.0	9.0	8.0	9.0	3.0	3.0	3.0	3.0	0.0	0.0	-3.0	7.0
Utility	5.0	3.0	9.0	7.0	9.0	5.0	9.0	3.0	5.0	3.0	3.0	-7.0	-3.0	-3.0	7.0
Reliability	3.0	3.0	9.0	8.0	9.0	3.0	7.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	7.0
Interoper.	-3.0	-5.0	-1.0	0.0	3.0	0.0	3.0	0.0	-3.0	0.0	0.0	0.0	0.0	0.0	5.0
Cost	5.0	-7.0	9.0	3.0	3.0	-3.0	5.0	-3.0	0.0	-3.0	0.0	0.0	-3.0	-3.0	0.0
Complexity	0.0	-3.0	0.0	3.0	3.0	0.0	0.0	0.0	-3.0	0.0	0.0	0.0	-3.0	-3.0	0.0
Standards	0.0	-5.0	-1.0	0.0	3.0	0.0	3.0	0.0	0.0	-3.0	0.0	0.0	0.0	-3.0	3.0
Inst. Issues	-3.0	-7.0	0.0	3.0	0.0	-3.0	0.0	0.0	0.0	0.0	-3.0	-3.0	-7.0	-3.0	5.0
Next Gen.	0.0	0.0	5.0	5.0	3.0	3.0	5.0	3.0	3.0	5.0	5.0	0.0	0.0	3.0	3.0
Ave. Score	**1.9**	**-1.1**	**4.8**	**4.6**	**5.1**	**2.2**	**5.1**	**1.4**	**1.1**	**0.5**	**1.5**	**-0.5**	**-1.3**	**-1.5**	**4.4**

RATING SCALE

Score	Criteria	Potential
10	Proven	Mandated
7	Significant Advantage	Excellent
5	Advantage	Very Good
3	Minor Advantage	Good
0	Neutral	Fair
-3	Minor Shortfall	Poor
-5	Shortfall	Very Poor
-7	Significant Shortfall	Insufficient
-10	Intractable	Intractable

APPENDIX C

ITS MARKET CATEGORY BREAKDOWNS

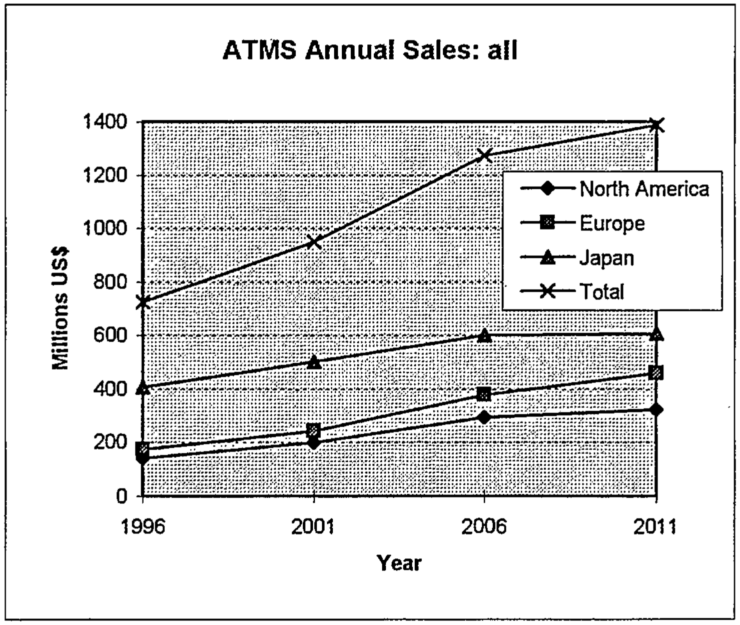
Source: SRI Consulting, ITS Market Forecasts: Report #2

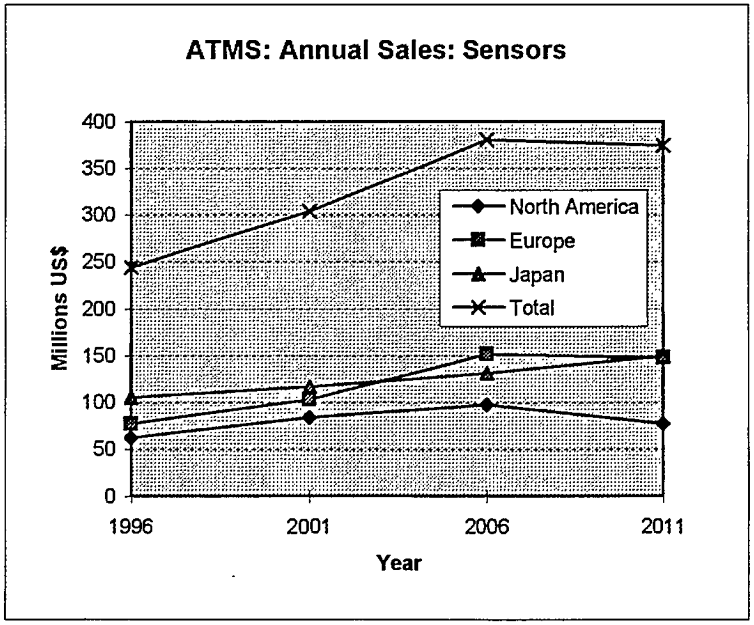
ATMS ANNUAL SALES: TOTAL SYSTEMS (REALISTIC)

	1996	2001	2006	2011
	Millions of US$			
North America	142	202	295	322
Europe	175	245	378	460
Japan	408	503	600	607
Total	725	950	1273	1389

ATMS ANNUAL SALES: SENSORS (REALISTIC)

	1996	2001	2006	2011
	Millions of US$			
North America	62	84	98	77
Europe	77	103	152	148
Japan	105	117	131	150
Total	244	304	381	375



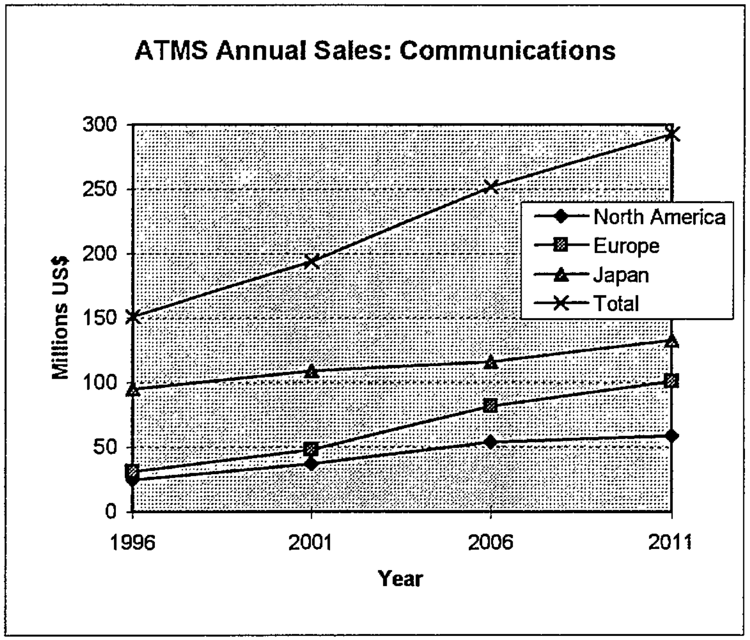


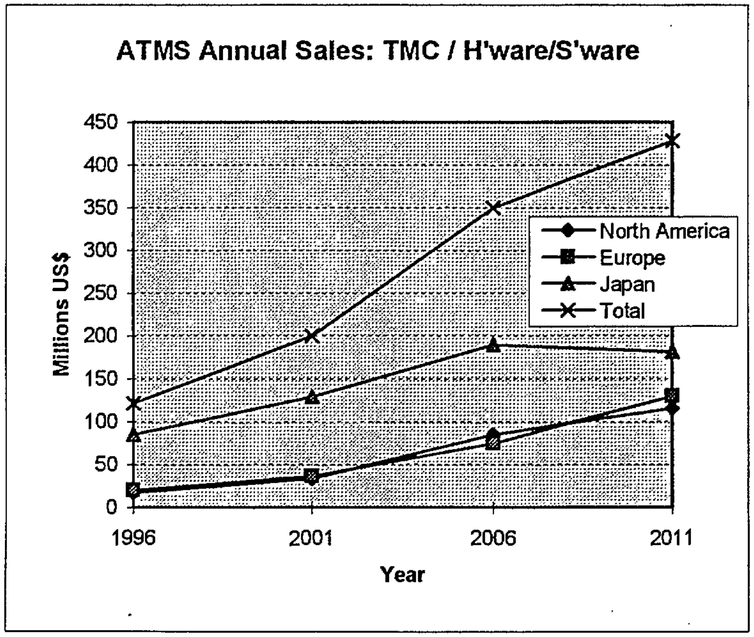
ATMS ANNUAL SALES: COMMUNICATIONS (REALISTIC)

	1996	2001	2006	2011
	Millions of US$			
North America	25	37	54	59
Europe	31	48	82	101
Japan	95	109	116	133
Total	151	194	252	293

ATMS ANNUAL SALES: TMC / H'WARE/S'WARE (REALISTIC)

	1996	2001	2006	2011
	Millions of US$			
North America	17	34	85	116
Europe	20	37	75	130
Japan	85	129	190	182
Total	122	200	350	428



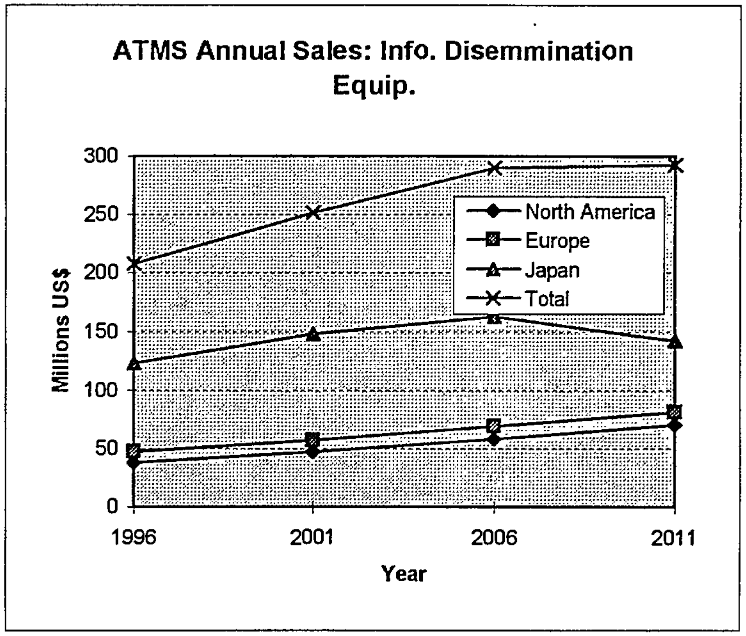


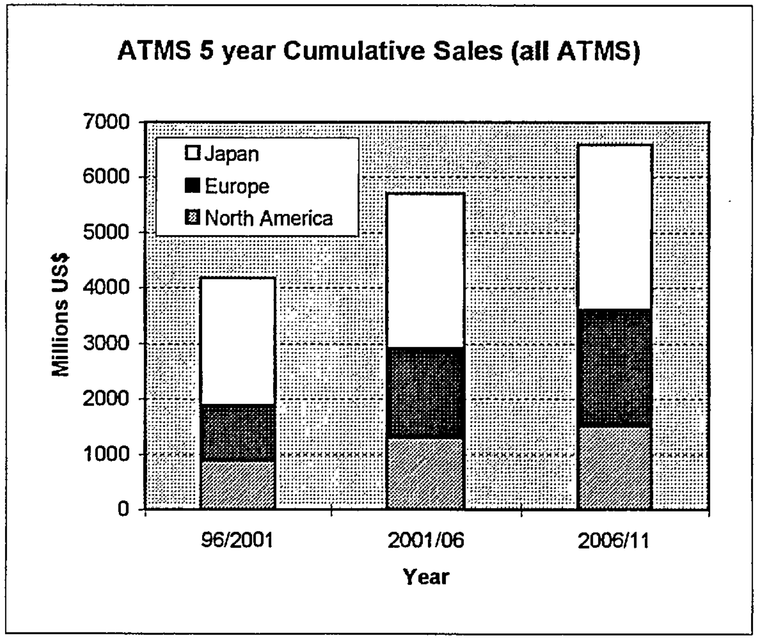
ATMS ANNUAL SALES: INFO DISSEM. EQUIP. (REALISTIC)

	1996	2001	2006	2011
	Millions of US$			
North America	38	47	58	70
Europe	47	57	69	81
Japan	123	148	163	142
Total	208	252	290	293

ATMS CUMULATIVE SALES: ALL (REALISTIC)

For each of the 5 year periods indicated				
	96/2001	2001/06	2006/11	
	Millions of US$			
North America	880	1300	1500	
Europe	1000	1600	2100	
Japan	2300	2800	3000	TOTAL
Total	4180	5700	6600	16480



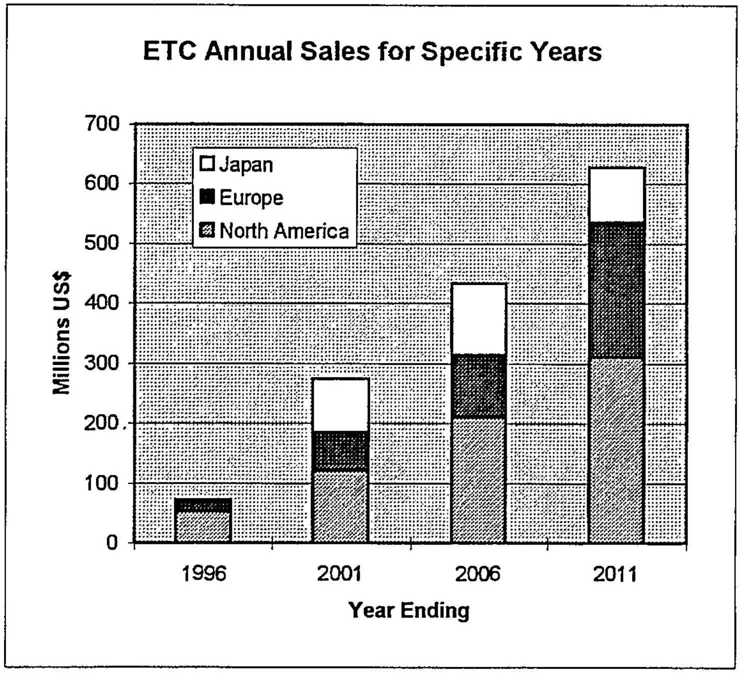


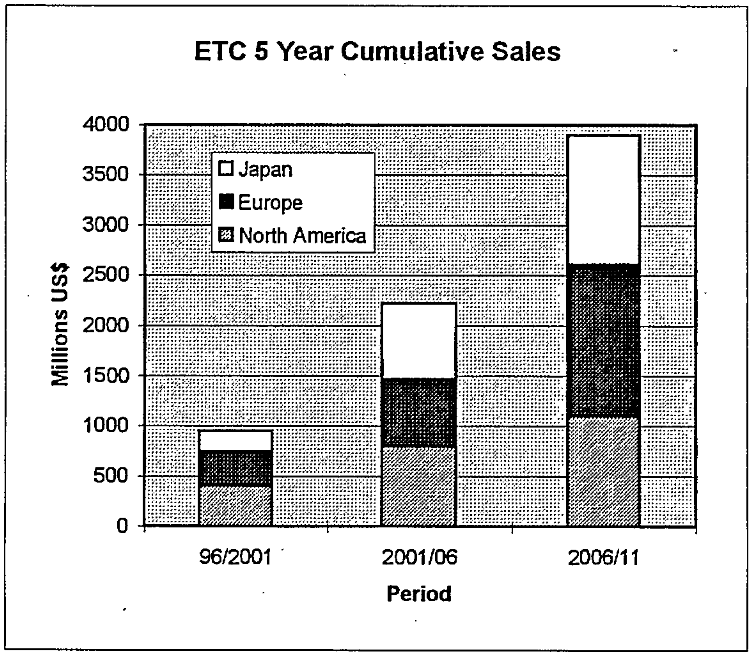
ETC ANNUAL SALES (REALISTIC)

	1996	2001	2006	2011
	Millions of US$			
North America	52	120	210	310
Europe	21	64	104	225
Japan	0	90	120	93
Total	73	274	434	628

ITS CUMULATIVE SALES: ALL (REALISTIC)

For each of the 5 year periods indicated				
	96/2001	2001/06	2006/11	
	Millions of US$			
North America	400	800	1100	
Europe	343	660	1500	
Japan	210	762	1300	TOTAL
Total	953	2222	3900	7075



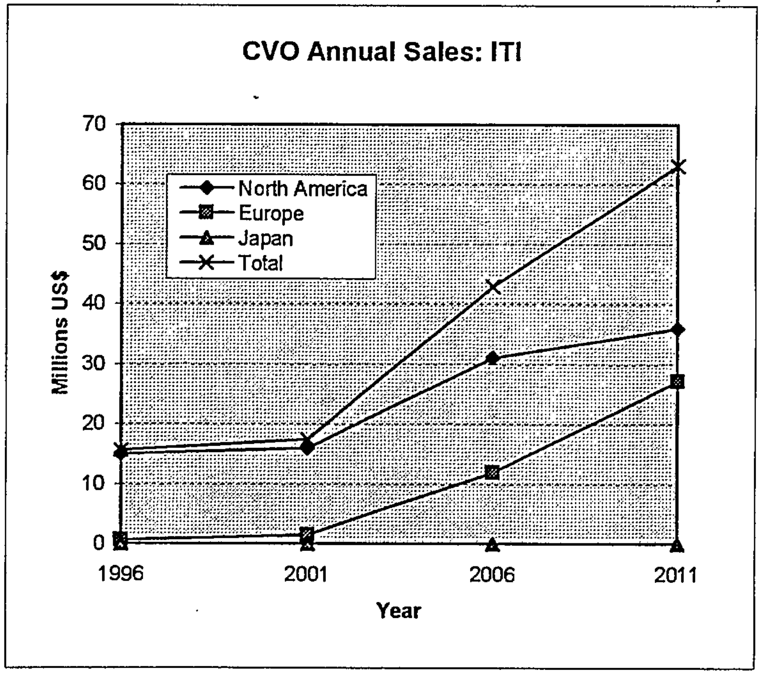


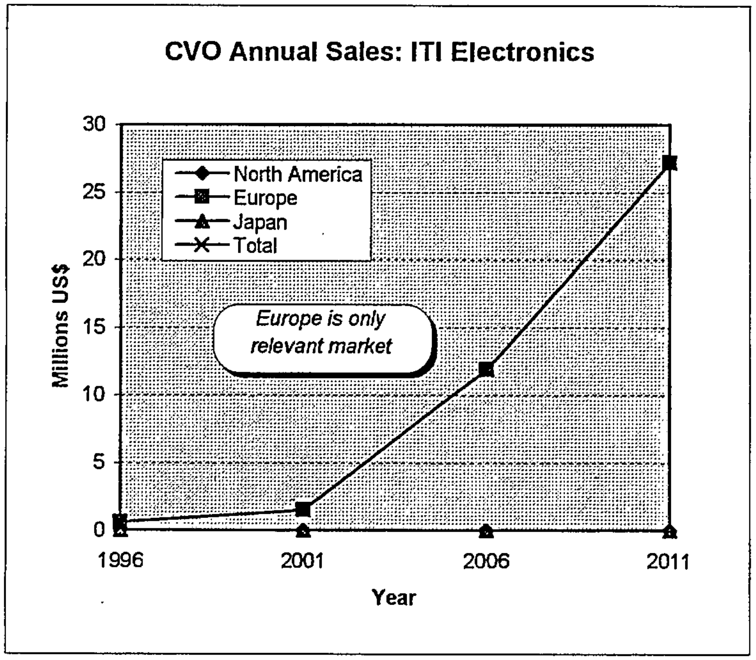
CVO ANNUAL SALES: ITI (REALISTIC)

	1996	2001	2006	2011
	Millions of US$			
North America	15	16	31	36
Europe	0.6	1.5	11.9	27.2
Japan	0	0	0	0
Total	15.6	17.5	42.9	63.2

CVO ANNUAL SALES: ELECTRONICS (REALISTIC)

	1996	2001	2006	2011
	Millions of US$			
North America	0	0	0	0
Europe	0.6	1.5	11.9	27.2
Japan	0	0	0	0
Total	0.6	1.5	11.9	27.2



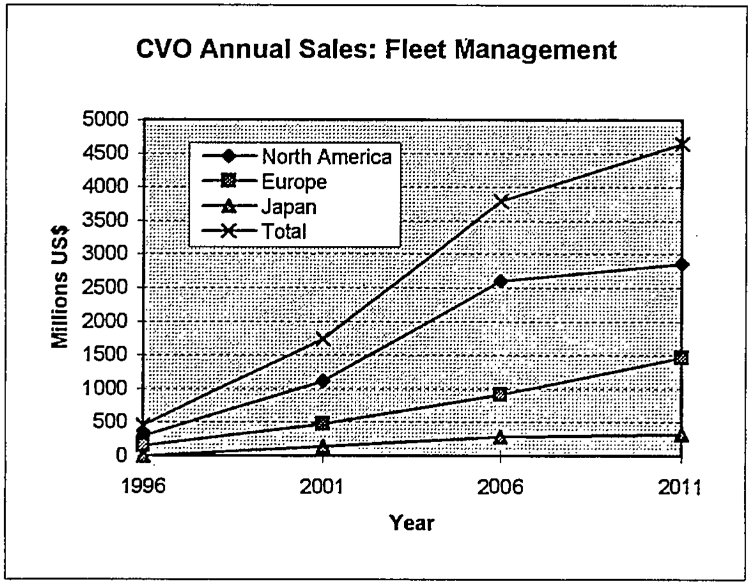


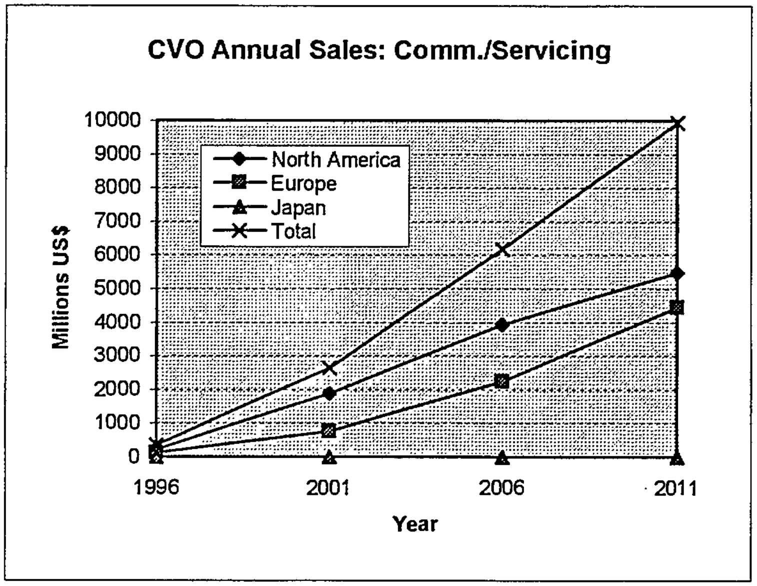
CVO ANNUAL SALES: FLEET MANAGEMENT (REALISTIC)

	1996	2001	2006	2011
	Millions of US$			
North America	299	1116	2600	2857
Europe	154	476	911	1467
Japan	2.8	147	284	323
Total	455.8	1739	3795	4647

CVO ANNUAL SALES: COMM. / SERVICING (REALISTIC)

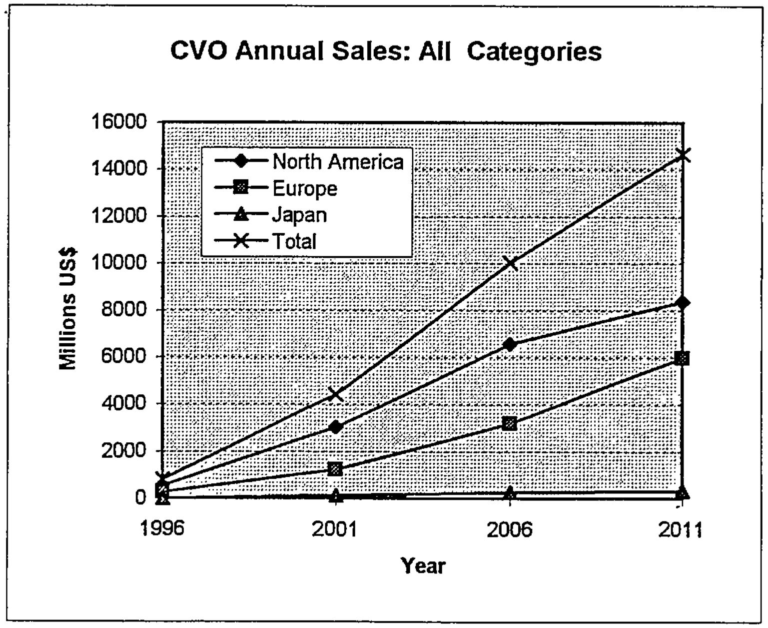
	1996	2001	2006	2011
	Millions of US$			
North America	233	1885	3927	5481
Europe	126	760	2250	4458
Japan	0	0	0	0
Total	359	2645	6177	9939





TOTAL CVO SALES

	1996	2001	2006	2011
	Millions of US$			
North America	547	3017	6558	8374
Europe	281	1239	3185	5979
Japan	3	147	284	323
Total	831	4403	10027	14676

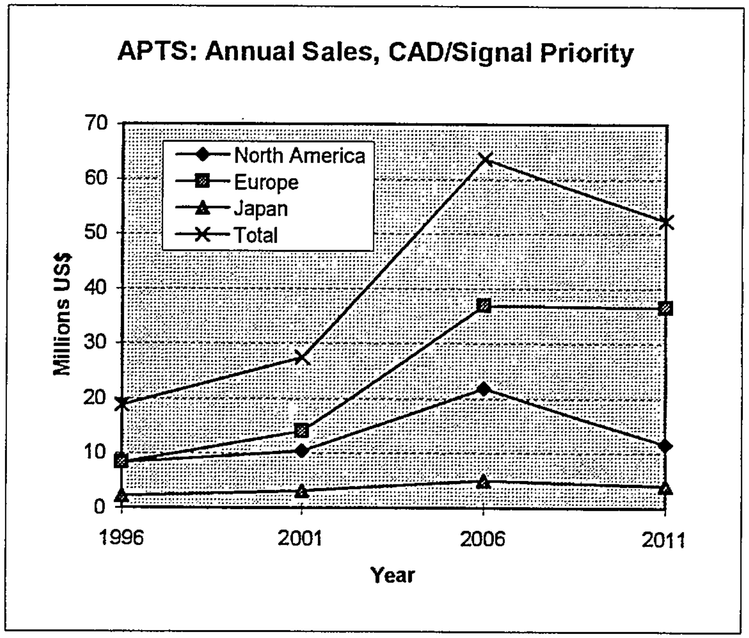


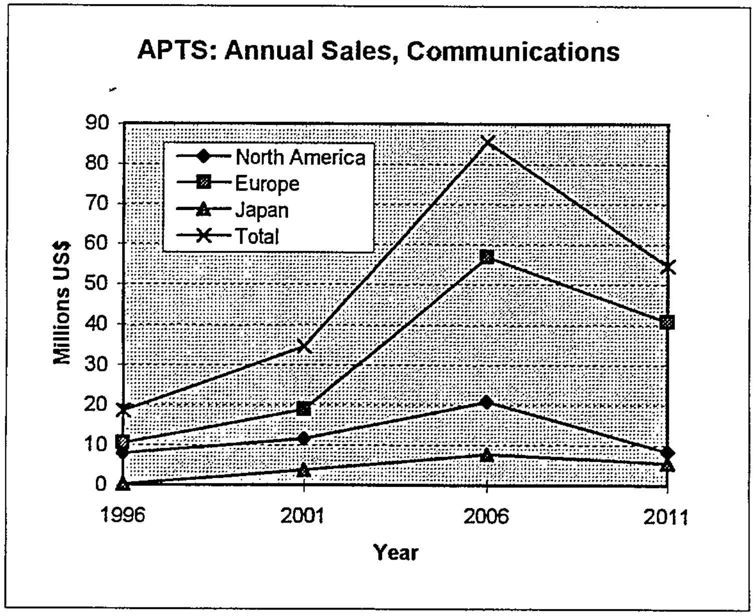
APTS: CAD/SIGNAL PRIORITY (REALISTIC)

	1996	2001	2006	2011
	Millions of US$			
North America	8.3	10.4	21.8	11.6
Europe	8.3	14	36.9	36.6
Japan	2.2	3.1	5	4.1
Total	18.8	27.5	63.7	52.3

APTS: COMMUNICATIONS (REALISTIC)

	1996	2001	2006	2011
	Millions of US$			
North America	7.9	11.7	20.8	8.5
Europe	10.5	19	56.9	40.7
Japan	0.3	3.8	7.8	5.5
Total	18.7	34.5	85.5	54.7



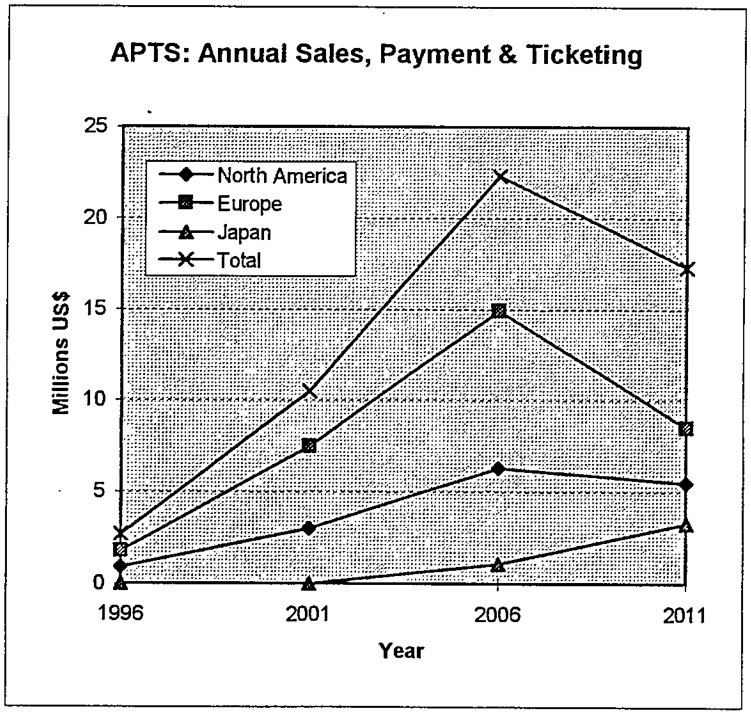


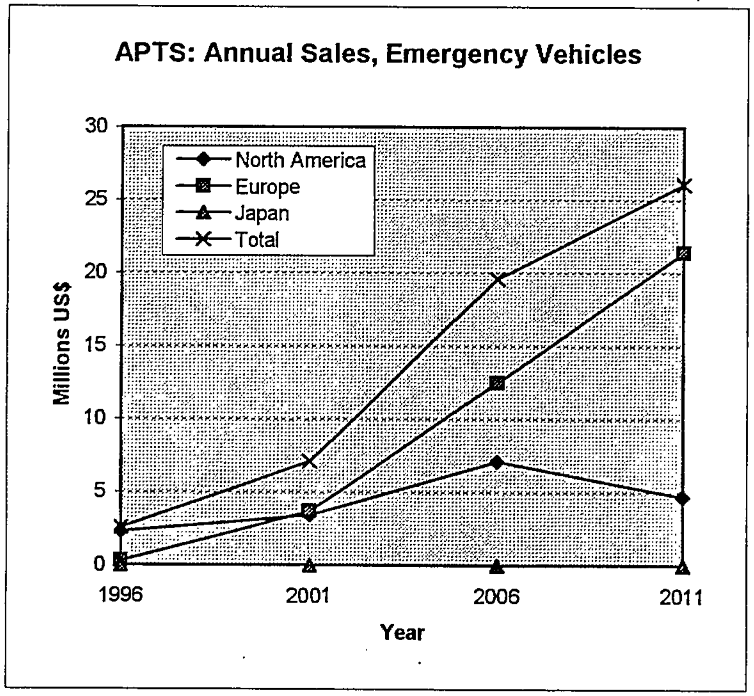
APTS: PAYMENT/TICKETING (REALISTIC)

	1996	2001	2006	2011
	Millions of US$			
North America	0.9	3	6.3	5.5
Europe	1.8	7.5	14.9	8.5
Japan	0	0	1.1	3.3
Total	2.7	10.5	22.3	17.3

APTS: EMERGENCY VEHICLES (REALISTIC)

	1996	2001	2006	2011
	Millions of US$			
North America	2.3	3.4	7.1	4.7
Europe	0.3	3.7	12.5	21.4
Japan	0	0	0	0
Total	2.6	7.1	19.6	26.1





APTS: All technologies

	1996	2001	2006	2011
	Millions of US$			
North America	19.4	28.5	56	30.3
Europe	20.9	44.2	121.2	107.2
Japan	2.5	6.9	13.9	12.9
Total	42.8	79.6	191.1	150.4