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ASSESSMENT OF DISPLAY TECHNOLOGIES FOR ITS

FINAL REPORT

MARCH 1996

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REPORT DOCUMENTATION FORM

1. Transport Canada Report No. Industry Canada Report No.	2. Recipient's Catalogue No.
3. Title and Subtitle Assessment of Display Technologies for ITS	4. Report Date March 1996
	5. Performing Organization Report No. TO-5266
6. Author(s) Mr. K. Bebenek and Ms. A. Dybka	7. Industry Canada File No. 126-9506-4-5
8. Performing Organization Name and Address IBI Group 230 Richmond Street West, 5th Floor Toronto, Ontario M5V 1V6	9. DSS File No.
	10. Industry Canada Control No. 67HAB-5-0143
11. Sponsoring Agency Names and Addresses Industry Canada, Aerospace & Defence Branch 6 East, 235 Queen Street Ottawa, Ontario K1A 0H5 Transport Canada, Research & Development Directorate 26B, Tower C 330 Sparks Street Ottawa, Ontario K1A 0N5	12. Type of Report and Period Covered Final
	13. Sponsoring Agency Code
14. Supplementary Notes	15. Project Manager Mr. Arjan Chandan

16. Abstract

The report defines the various roadside, control room, and in-vehicle displays applications required to support Intelligent Transportation Systems (ITS) functions. Each display application is defined in terms of functional requirements, architecture, examples, and applicable standards. An outreach to selected industry contacts has resulted in a profile of the current and expected future state of technology for display applications. An assessment of domestic and foreign industry activity has yielded recommendations for Canadian industry pursuing ITS display markets.

17. Key Words: ITS, Displays, Variable Message Signs		18. Distribution Statement: Limited number of copies available from Industry Canada	
19. Security Classification (of this report) Unclassified	20. Security Classification (of this page) Unclassified	21. No. of Pages 47	22. Price No charge

FORMULE DE DONNÉES POUR PUBLICATION

1. N° de la publication de Transport Canada N° de la publication de Industry Canada	2. N° de catalogue du destinataire
3. Titre et sous-titre Estimation de Technologies d'Affichage pour STI	4. Date de la publication Mars 1996
	5. N° de document de l'organisme TO-5266
6. Auteur(s) M. K. Bebenek et Mlle. A. Dybka	7. N° de dossier de l'Industrie Canada 126-9506-4-5
9. Nom et adresse de l'organisme exécutant IBI Group 230 rue Richmond Ouest, 5e étage, Toronto, Ontario, M5V 1V6	9. N° de dossier - ASC
	10. N° de contrat - l'Industrie Canada 67HAB-5-0143
11. Nom et adresse des Organismes parrain Industries Canada, Succursale d'Aéronautique et Défense 6 E, 235 rue Queen Ottawa, Ontario K1A 0H5 Transport Canada, Groupe de sûrété et sécurite, La du direction Recherche et Développement 26B, Édifice C 330 rue Sparks Ottawa, Ontario K1A 0N5	12. Genre de publication et période visée Finale
	13. Code de l'organisme parrain
14. Remarque additionnelles	15. Gestionnaire Arjan Chandan

16. Résumé

Ce rapport défine les différents applications des moyens d'affichage au bord de la route, en chambre de contrôle et sur véhicule qui doivent supporter les fonctions des Systèmes de Transport Intelligent (STI). Chaque moyen d'affichage est caractérisé en termes de demandes fonctionnelles, architecture, exemples et standards applicables. Une enquête sur le sujet s'est concrétisée dans un profile de l'état présent et futur de la technologie d'affichage. Une estimation de l'activité dans le domaine s'est ensuivie de recommandations pour l'industrie Canadienne sur les marchés de moyens d'affichage STI.

17. Mots-clés: STI, d'affichage		18. Diffusion: Des copies sont disponibles de Transports Canada	
19. Classification de sécurité (de cette publication) non-classifié	20. Classification de sécurité (de cette page) non-classifié	21. Nombre de pages 47	22. Prix Gratuit

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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 Research and Development Directorate of Transport Canada, or the Aerospace and Defence Branch of Industry Canada.

ACKNOWLEDGEMENTS

IBI Group and the authors wish to sincerely acknowledge the helpful guidance provided by Mr. Arjan Chandan, Senior Advisor, ITS, of the Industry Canada Aerospace & Defence Branch, who managed this project and served as Chairman of the Steering Committee for the ITS Industrial Base Development Program of Industry Canada.

IBI Group and the authors wish to thank all who provided comments on the technical memoranda and presentations provided throughout the course of the project. These constructive comments helped to provide a comprehensive and useful final product. Individuals assisting in this capacity include:

Arjan Chandan	Aerospace & Defence, Industry Canada
Barbara-Anne Brown	Spectrum Engineering, Industry Canada
Michel Gaudreau	Spectrum Management, Industry Canada
Gerry Chan	Spectrum Engineering, Industry Canada
Gilles Gagnon	Automotive Branch, Industry Canada
Alan Jones	Service Industries Branch, Industry Canada
Joanne St-Onge	Marketing & Promotion Services, Industry Canada
Luc Fournier	Communications Development, Industry Canada
William Johnson	Transportation Development Centre, Transport Canada
Michael Ball	Research & Development, Transport Canada
Brian Hicks	Highways, Transport Canada
Ghislain Blanchard	Special Infrastructure Project, Transport Canada
Gus Pokotylo	Research & Development, Transport Canada
Gaetan Deschamps	Canada Post Corporation
John Robinson	Delphi Systems Inc.
Sultan Akhtar	Aerospace/Defense Robotics, Industry Canada
Norman Yanafsky	Policy - Science Strategy, Industry Canada
Dave Benson	SRI California
Peter Trau	Aerospace & Defence, Industry Canada
Guy Gallant	Aerospace & Defence, Industry Canada
Denis Lachance	Transportation Industries Branch, Industry Canada

The market for transit passenger information is better developed in Japan and the EU as compared to North American uncertainties over transit priorities. Canadian industry provides a broad range of display hardware and software; alliances to market integrated solutions should help to further penetrate U.S. and European markets.

Industry Canada and Transport Canada should consider mechanisms aimed at:

- fostering the development of industry alliances to facilitate product development, marketing, manufacturing and support for the international market for roadway and transit displays;
- showcasing Canadian ITS expertise, including display applications;
- inducing ITS display research and development activities in Canada;
- participation in foreign ITS programs and standards initiatives.

Table of Contents

1. INTRODUCTION

This report presents an assessment of the current state of technology and industry activity associated with various display applications as required to support Intelligent Transportation Systems (ITS). This work forms part of a broader program sponsored by Industry Canada and Transport Canada to assess the technology and worldwide markets for enabling technologies for ITS. The primary objective of the overall program is to identify ways by which Canadian industry can compete successfully in foreign and domestic ITS markets.

Most ITS functions require display technologies to interface with system users and operators. This report addresses visual and aural ITS displays as follows:

- Definition of the various ITS display applications in terms of functional requirements, system architecture, example applications, relevant standards/protocols and issues related to ITS compatibility and interoperability.
- An assessment of candidate technologies for each display application in order to identify relative performance costs, and market potential.
- A commentary on Canadian and foreign industry participation, including an assessment of barriers to accessing foreign markets, and recommendations for positioning Canadian industry in meeting the Canadian needs and to compete in the international marketplace for ITS.

Industry participants contacted and/or referenced in the report have been profiled in a standard format to support the development of on-line ITS industry listings.

2. SYSTEM DEFINITION

ITS applications for display technologies are categorized as follows:

- roadway displays;
- control centre displays;
- in-vehicle displays;
- transit passenger information displays.

The role of each of the above applications have a common element in that they represent a method of disseminating information to the users and operators of transportation systems.

This section discusses display applications in terms of the functional requirements and technologies currently in use and under development with examples of existing applications. The discussion is supported by physical and logical system architecture diagrams that provide an understanding of the interaction between the various system components, applicable standards, protocols and interfaces associated with the various ITS applications.

2.1 ROADWAY DISPLAYS

Roadway display applications are categorized according to their functional characteristics and intended use. Accordingly, roadway displays are defined as either full-function variable message signs (VMS) or limited-function variable message signs (VMS).

A full-function VMS provides maximum flexibility in disseminating information to motorists. The display typically includes a large continuous matrix or a combination of discrete character matrix elements. These signs are generally installed overhead or roadside mounted in a freeway or arterial traffic management environment.

Limited-function variable message signs typically provide local advisory or regulatory information along arterials. These signs support a limited number of pre-defined messages.

2.1.1 Functional Requirements

A full-function VMS should fulfil the following functionality:

- the VMS should be capable of displaying messages comprised of any combination of numerals and characters, with limited graphic capabilities such as arrows. Sequencing and flashing of messages should be supported;
- the VMS should incorporate default and fail safe message functions and automatically re-boot following power or communications failure;
- the field installations should provide a status feedback to central;
- the field installations should not require more than two routine field visits per year for inspection/maintenance.

A limited-function VMS should fulfil the following functionality:

- the sign should be capable of displaying any one of two, three, or four pre-defined messages, including blank-out state where applicable;
- the sign should incorporate default and fail safe messages;

- the signs should be activated in response to commands from field processor outputs, or other field devices and provide status feedback to the field processor;
- the field installations should not require more than two routine maintenance field visits per year.

2.1.2 System Architecture

Exhibit 2-1 depicts the physical and logical system architectures for both the full-function and limited-function variable message signs. VMS subsystems typically incorporate a head-end or master processor that communicates to field controllers via the communications subsystem. Several variable message signs may be controlled remotely or locally through a single field controller. Local control is generally achieved via a portable laptop for maintenance/service purposes.

2.1.3 Technologies and Applications

The following is an introduction to the enabling technologies for VMS, identifying key distinguishing characteristics.

LED

Light Emitting Diode (LED) displays use pixels comprised of clusters of high intensity LEDs. Each LED is recessed in a black cylinder to minimize the impact from direct sunlight. The main characteristics of LED VMS are:

- solid state construction with availability of multiple colours for a broad range of applications;
- higher power consumption and heat generation relative to other VMS technologies;
- low routine maintenance requirements;
- potential for long term degradation of LED output;
- rapid pace of technological development and improvement.

LED signs are gaining widespread acceptance and are predicted to become the standard technology of the future for VMS. At present, the installed base includes selected sites in North America and Europe, and widespread deployment in Japan.

Shuttered Fibre Optic

Fibre optic technology is based on quartz halogen lamps which illuminate an array of display pixels via bundled fibre strands. Fibre ends are electro-magnetically shuttered to control the display of pixels.

Lamp assemblies can be fitted with coloured lenses to tailor display colour. The main characteristics of this technology are:

- proven and reliable technology;
- moving parts (shutters) and lamp replacement dictate a regular maintenance schedule;
- visual impact under direct sunlight poses visibility problems.

This technology has been used extensively for many years, particularly in Europe.

Hybrid Signs

There are two types of hybrid signs: Fibre/Flip Disk and LED/Flip Disk. Fibre/Flip Disk signs employ reflective flip disks with each disk having a small opening to expose the end of an illuminated fibre strand. The disk employs a shield which blocks the fibre end when the disk is blank. Hybrid LED/Flip disks employ a similar configuration with disk openings exposing an LED pixel. The main characteristics of these technologies are:

- improved visibility over conventional LED and fibre displays when display is exposed to direct sunlight;
- uninterrupted operation in the event of power failure (if desired);
- potentially high maintenance requirements associated with degradation of moving parts and reflective disks.

Liquid Crystal Displays

Liquid Crystal Display (LCD) technology has been traditionally used for a wide variety of indoor signing applications. LCDs are usually used as solid-state shutters with fluorescent tubes being used as the back light source. However, the light passed through an LCD in its "light transmission mode" is insufficient for outdoor applications and the technology has not developed to the point where it can be used with confidence in the outdoor roadway environment. Introducing reflective material to the LCD to reflect more light through it in its "light transmission mode" improves outdoor performance. These so-called transreflective LCDs have been applied to shuttering light emitted from fibre optics, but this requires two LCDs in series to effectively interrupt the light. In addition, the LCDs have a high attenuation thus demanding greater light source power. Other major obstacles to the

use of LCDs for roadway applications are insufficient contrast ratios and operating temperature restrictions.

In recent years, there have been extensive amounts of research initiated to increase contrast ratio thus, increasing visibility. There are several characteristics that make LCD's attractive for VMS applications:

- completely solid state;
- compact design;
- wide viewing angle.

LCD may emerge as a viable VMS technology over the next five years.

Incandescent Bulbs

Incandescent bulbs displays are used extensively in the advertising industry. Some traffic management installations in the state of California utilized this technology. However, due to high power consumption and intensive routine maintenance efforts associated with bulb replacement, its use in roadway display applications is decreasing.

Electro-Mechanical Rotating Prism

Electromechanical signs are commonly used in limited-function VMS applications to provide a limited number of messages. They are characterized by simple design with rugged construction accommodating standard luminescent traffic signage. This technology is well-suited to incorporation of variable message panels into static sign boards. However, moving parts can be a long term maintenance issue.

Applications

There is considerable experience with full-function VMS implementation in North America and Japan. In Europe, use of limited-function VMS is wide-spread, with increasing deployment of full-function motorway VMS.

The following example applications represent agencies that have worked with a variety of VMS display applications and technologies:

- Ministry of Transportation of Ontario - LED, Fibre/Disk, Fibre Optic and Reflective Flip Disk - 20 signs;
- Arizona DOT - Fibre Optic, LED, Fibre/Disk - 10 signs;

- Department of Transport, U.K. - Fibre Optic, Fibre/Disk, LED, Rotating Drum limited state VMS - 19 signs.

2.1.4 Standards and Interoperability

There are two primary considerations when addressing standards for roadside displays:

- message content/presentation format;
- communications interface between the display controller and the traffic management system.

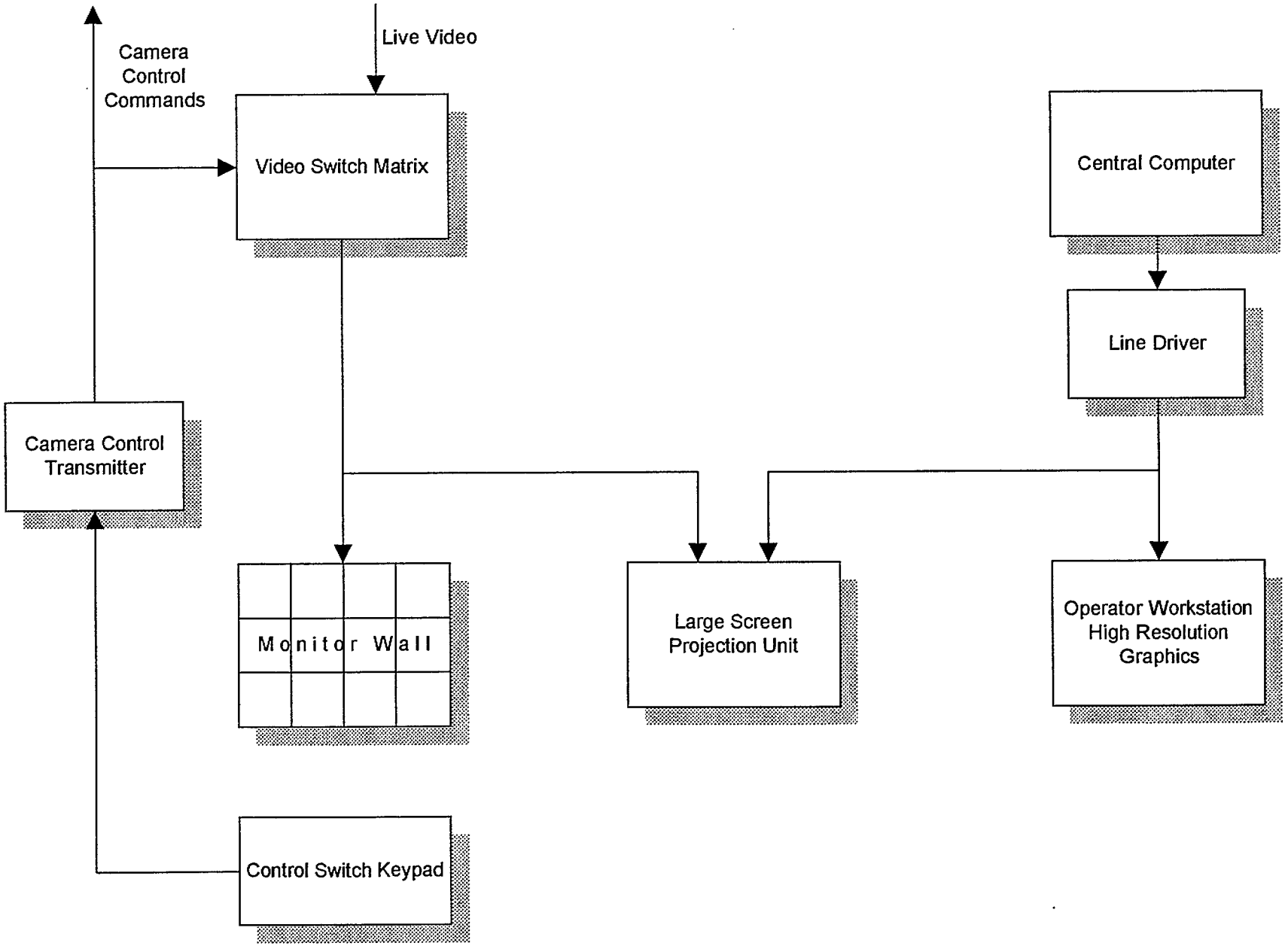
To date there are no international industry standards addressing the format of information presented to motorists using variable message signs. As the accompanying table indicates, the tendency in North American systems has been to use text messages to define traffic events and provide indications of levels of congestion and suggested diversions.

MOTORIST INFORMATION MESSAGE FORMAT
Regional Preferences

North America	• text • limited graphics (such as arrows)
Europe	• text • pictograms
Japan	• limited text • graphic images (such as schematics)

In the multilingual environment characteristic of the EU, there is a greater reliance on pictograms to supplement text messaging. In Japan, the tendency is to provide simplified graphic maps/diagrams to indicate locations of incidents and congestion. These regional preferences have impacted the VMS industry in that each region has spawned a discrete supplier base. In order for manufacturers to develop VMS products which are transportable among regions, their hardware and software technologies must be flexible to adapt to differing character sets and levels of graphic capability. For example, the graphical approach used in Japan dictates the use of LED technologies and hence the hybrid fibre optic/reflective flip disk technology which is widely used in North America is not competitive. Any efforts at developing standard message formats are intra-regional and hence it is unlikely that international compatibility would be achieved in the foreseeable future. With respect to regional efforts at standardization, it is noteworthy that

EXHIBIT 2-2
CONTROL CENTRE DISPLAY ARCHITECTURE



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in North America efforts are underway to incorporate VMS messages into the Manual of Uniform Traffic Control Devices.

With respect to standards and interoperability issues at the communications interface level, most VMS applications incorporate a separate display unit and microprocessor based controller. The communications driver protocols between the display and controller are proprietary and unique to each manufacturer. From the standpoint of overall ITS architecture, the display and controller can be considered one functioning unit and hence the interface issue exists between the display controller and the overall system architecture.

To date, the typical approach for integrating VMS subsystems is to have dedicated trunk communications channels between central system and the outlying VMS. The central system must incorporate custom or proprietary host software in order to communicate with the field sites. In the case of Toronto's Gardiner-Lake Shore CTMS, the central system incorporates custom software which accommodates VMS communications protocols for four VMS suppliers.

The current trend for communications with VMS, and in fact all ATMS devices, is towards an open systems architecture compliant with the Open Systems Interconnect (OSI) 7 layer model developed by the International Standards Organization (ISO). The most notable efforts to date in this regard lie within the U.S. ITS program in the form of the National Transportation Communications for ITS protocol (NTCIP). The accompanying table summarizes the proposed communications profile for each OSI layer. This standard, and in particular the data link layer and physical layer, will facilitate interoperability among subscribing ATMS central systems, communications architecture, and field controllers for all ITS applications. This standard is presently under development, and working papers are available from the NTCIP Steering Group.

For Canadian VMS manufacturers to remain competitive, it is imperative that they participate and subscribe to this process. At present, it is not clear whether NTCIP will be adopted elsewhere in the world, however compliance with the OSI model supports this transportability.

THE NTICP PROTOCOL

OSI Model Layer	Communication Profile
Application Layer	Simple Mail Transfer Protocol (SMTP) & Simple Network Management Protocol (SNMP) OR File Transfer Protocol (FTP)
Presentation Layer	None
Session Layer	None
Transport Layer	Transmission Control Protocol (TCP) OR User Datagram Protocol (UDP) (optional)
Network Layer	Internet Protocol (optional)
Data Link Layer	High-Level Data Link Control (HDLC)
Physical Layer	RS232 OR Frequency Shift Keying (FSK)

Source: NTCIP Steering Group http://www-atms.volpe.dot.gov/ntcip/

The VMS industry is still largely a build-to-spec industry, with each operating authority using unique specifications. While the required display dimensions/format may vary from one agency to another, there is a large degree of commonality in the enabling technology performance specifications (i.e. parameters such as pixel output environmental requirements, power consumption, etc.). Operating agencies recognize this and there are some regional movements towards the development of standard specifications for VMS. In the EU, there is presently a draft European standard for use by all member transportation authorities, however the UK DOT has experienced some dissatisfaction with the current draft and has embarked upon a UK revision. In North America, a recently announced $15 million multi-agency initiative is targeting the development of standards for all ITS components. The Institute of Transportation Engineers is charged with the responsibility for the development of standard specifications for traffic management field components, including VMS.

2.2 CONTROL CENTRE DISPLAYS

ITS Control Centre displays include:

- CCTV monitors;
- large screen projection units;
- high-resolution graphics monitors.

2.2.1 Functional Requirements

The CCTV monitors and large screen projection units are the focal point of a control room for presentation of desired information. Therefore, it should be ensured that the type of display, display size, placement and orientation are such that control room operators and viewers have easy access to video and graphic images. To achieve this, the display system must satisfy a number of functional requirements as follows:

- display units should be compatible with the video and graphic images generated by related subsystems. Parameters include resolution, and video/graphics image standard formats;
- display units should be appropriately sized and characterized by horizontal and vertical viewing angles that are compatible with the control room ergonomics;
- the display system configuration should provide flexibility for expansion and upgrade.

2.2.2 System Architecture

Exhibit 2-2 identifies the physical and logical system architectures for control centre video/graphic displays. Typically, a video switch matrix distributes the video images from the field to the various display devices (i.e., monitors, projection screens, etc.) located in a control room. Operators have the capability of switching any image(s) to any available display device via a control switch keypad or video switch keypad. The graphics images generated by the central computer are routed to high resolution workstation monitors or large screen projection units.

2.2.3 Technologies and Applications

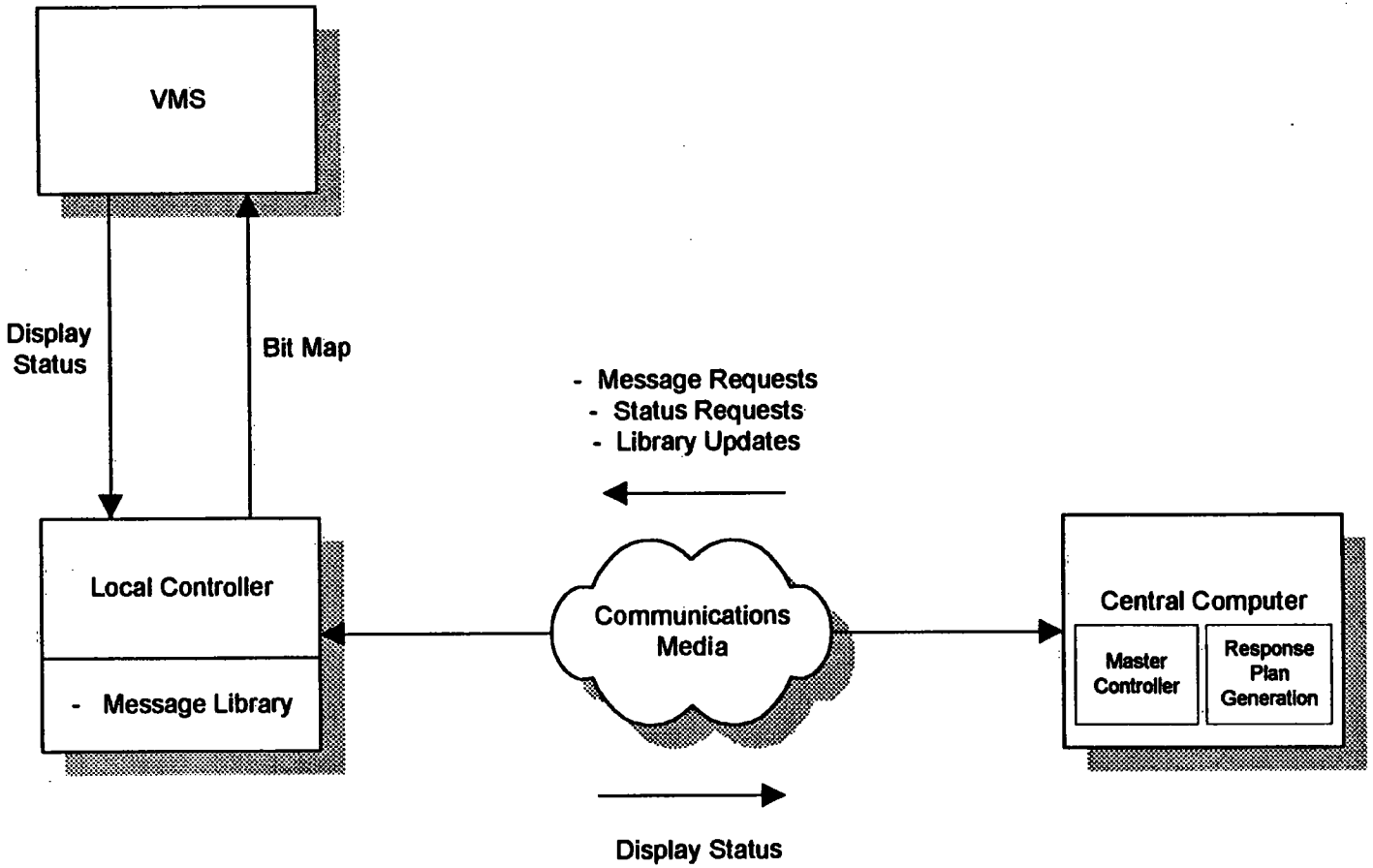
The following is a brief discussion of the various control centre large format display technologies.

Front Projection - CRT Based

Front projection consists of a projection screen and a ceiling mounted video projector. Units are used to display live video or high resolution computer graphics over a large display area. Some attributes of a front projection are:

- low capital cost;
- ability to support high resolution graphics;
- poor image quality under office environment ambient illumination levels.

EXHIBIT 2-1
ROADWAY DISPLAY ARCHITECTURE



Rear Projection - CRT Based

In rear projection units, the projector and screen are enclosed in a single unit. A rear projection display system usually employs a fresnel-lenticular image surface which acts as a lens to narrow the path of the light from the projection device as it passes through the image surface material. The result is an effective increase, or gain, in the brightness of the image making the retro-projection system more useful in higher ambient light conditions. Stand-alone systems are currently available in a variety of image surface sizes ranging from 760 mm high by 1,020 mm wide to 1,900 mm high by 2,550 mm wide. These systems can also provide an image resolution of 1,280 (H) by 1,024 (V) pixels.

Rear projection rooms can be custom configured to provide a full wall display. The image surface can be specified to be any size and aspect ratio (width:height) which offers the potential of making better use of the display wall area. Other attributes of rear projection are:

- higher capital cost and space requirements due to additional structural supports and internal reflective components;
- ability to support high resolution graphics;
- improved image quality as compared to front projection.

Liquid Light Valve Projection

Liquid light value is a proven technology that has been refined over the years. It operates in a manner that is analogous to that of a standard film projector. A high intensity projection lamp produces light which is directed through the light valve assembly which modulates the projected light in to the desired image. The modulated light emerging from the light valve is focused onto the projection screen using a single optical lens.

These projectors were originally designed for showing NTSC and PAL standard television images and not high resolution graphics.

LCD Light Valve Projection

This projection technology is similar in concept to the liquid light valve technology, the fundamental difference being the use of a liquid-crystal-diode (LCD) panel to modulate the light from the projection lamp into a colour image for display on the screen. These units are currently available in the consumer and industrial markets from a number of manufacturers with Sharp Electronics being pre-eminent. Such units are relatively inexpensive and are easy to set up and use.

Some attributes of light valve projection are:

- increased reliability due to solid state components;
- single image produced provides inherent stable alignment characteristics;
- commercially available units are designed solely for the projection of NTSC or PAL video and are therefore not suitable for the projection of high resolution graphic images;
- susceptibility to image degradation in high ambient light conditions due to limited output image intensity.

Projector Cube

This technology consists of a fully enclosed video projector and a relatively small (450mm high and 600mm wide) rear projection screen. Because of the small size of the screen, no mirrors are required to fold the optical path. Instead, the projector is oriented directly onto the rear of the screen.

These units are in the order of 900 to 1,200 mm deep and are designed to be stacked beside and on top of one another in order to create a large display surface. These units are designed to work at normal television scan rates which are comparable to VGA computer graphics. Other system attributes are:

- suitable for office ambient light conditions;
- high quantity of graphics driver cards required to generate the images on the high quantity of display units;
- colour quality may vary between individual units;
- higher costs associated with the controller system and software required to integrate the individual display devices.

Projection Wall

This display technology is very similar to projection cube. The significant difference is that the individual projection devices are not enclosed in a housing with their respective rear projection screens; rather, all of the screens and all of the projection devices are housed in a purpose built structure. Generally, the individual screen elements are slightly larger than those in projection cube and therefore, require that

the projection devices be located a greater distance away. Some characteristics of this system are:

- high capital cost;
- computer controlled video switching system required to route video to individual display devices;
- highly custom integrated structure of the display system dictates a rigidity in terms of integration into control centre environment.

Monitor Wall

This type of display technology consists of assembling a group of individual CRT monitors to form a "wall" of monitors. Although similar in concept to the Projector Cube type of display system, the function of the monitors is primarily the display of individual CCTV pictures, not overall graphics images.

A number of manufacturers (e.g. Hanatrex of Italy; Barco of Belgium) produce monitors for this purpose which are interlocking and are designed with minimal cabinetry around the CRT. This type of monitor therefore takes up less space, does not require special mounting hardware of shelving and presents a neat, clean finished appearance from the front. Processors are available to allow the monitor wall to display a single video image across a matrix of multiple individual monitors.

Applications

The following are some of the example applications that are currently in operation or under development:

- San Antonio, Texas - the new Traffic Control Centre as constructed by Allied Signal is representative of a new control centre facility, custom configured with rear projection walls, monitor banks, and high resolution graphics operator workstations;
- Toronto, Ontario - the Integrated Traffic Control Centre is representative of a retrofit of Advanced Display Technologies into an existing building envelope. The control room utilizes compact standalone rear projection units, combined with video monitor wall and high resolution graphic operator workstations.

2.2.4 Standards and Interoperability

The following is a brief description of the applicable industry standards, protocols and interfaces with regards to control centre displays:

- NTSC format - the National Television System Committee defines video characteristics in North America, Japan, the Philippines and much of South America. Overall bandwidth is 6MHz utilizing an interlaced scanning system that show 30 frames a second, each frame having 525 lines of resolution;

- PAL and SECAM formats - are also interlaced scanning systems that show 25 frames per second with each frame having 625 lines resolution. PAL and SECAM systems have an overall bandwidth of 8MHz and are used in Europe, mainland Asia, Africa and parts of South America.

The above formats are suitable for standard video displays, however control centre display applications often incorporate high resolution computer graphics and text displays. More bandwidth and faster electronics are required for these display systems and are currently governed by both computer and television formats.

The prevailing standard for computer graphics is 1,280 x 1,024 or 1,600 x 1,280 pixel resolution. The graphics quality is also characterized by horizontal and vertical frequency which is proprietary to manufacturers. Other standards include Macintosh, Unix and PS/2.

Currently, many transportation agencies operate independently of one another and as a result Control Centre display systems are tailored for the individual agency's specific needs and physical environment. The trend toward open systems, compatibility and interoperability between agencies will impact the application of control centre displays, as agencies share video and graphics information. The advent of Integrated Services Digital Networks (ISDN) from North American communications service providers is a catalyst for ITS control centre interoperability. Facilities can now share digital video, graphics, and data on demand without incurring the cost of dedicated communications infrastructure.

2.3 IN-VEHICLE DISPLAYS

In-vehicle displays provide information services such as en-route driver information, route guidance and traveller information to the motorist within the vehicle.

Within the scope of ITS, a variety of application areas such as Advanced Traveller Information Systems (ATIS), Commercial Vehicle Operations (CVO) and Advanced Vehicle Control Systems (AVCS) utilize an assortment of available in-vehicle display technology.

2.3.1 Functional Requirements

In-vehicle displays should be capable of fulfilling the following functionality:

- the displays should not pose a distraction to vehicle operators and consequently should adhere to safety standards;
- the display systems should be flexible in order to support new user services such as en-route driver information (driver advisory, in-vehicle signing), route guidance and traveller services information, as they become available;
- the display systems should be able to interface to a variety of mobile communication media (low power radio beacons, microwave, infra-red, AM/FM broadcast, sideband mobile cellular, satellite).

2.3.2 System Architecture

Exhibit 2-3 identifies the physical and logical system architecture indicative of systems that support in-vehicle displays. Dependant on the nature of the in-vehicle application, the motorist display and associated processor may interface to a variety of devices. Some applications such as CD ROM navigation systems are a standalone on-board application that do not incorporate external interfaces. Most ITS programs are aimed at integrating on-board systems with vehicle-to-roadside communications to provide real-time, location/direction specific information to the motorist.

2.3.3 Technologies and Applications

The in-vehicle display technologies include: Liquid Crystal Displays (LCD), CRT, heads-up-display (HUD) and digitized/synthesized voice.

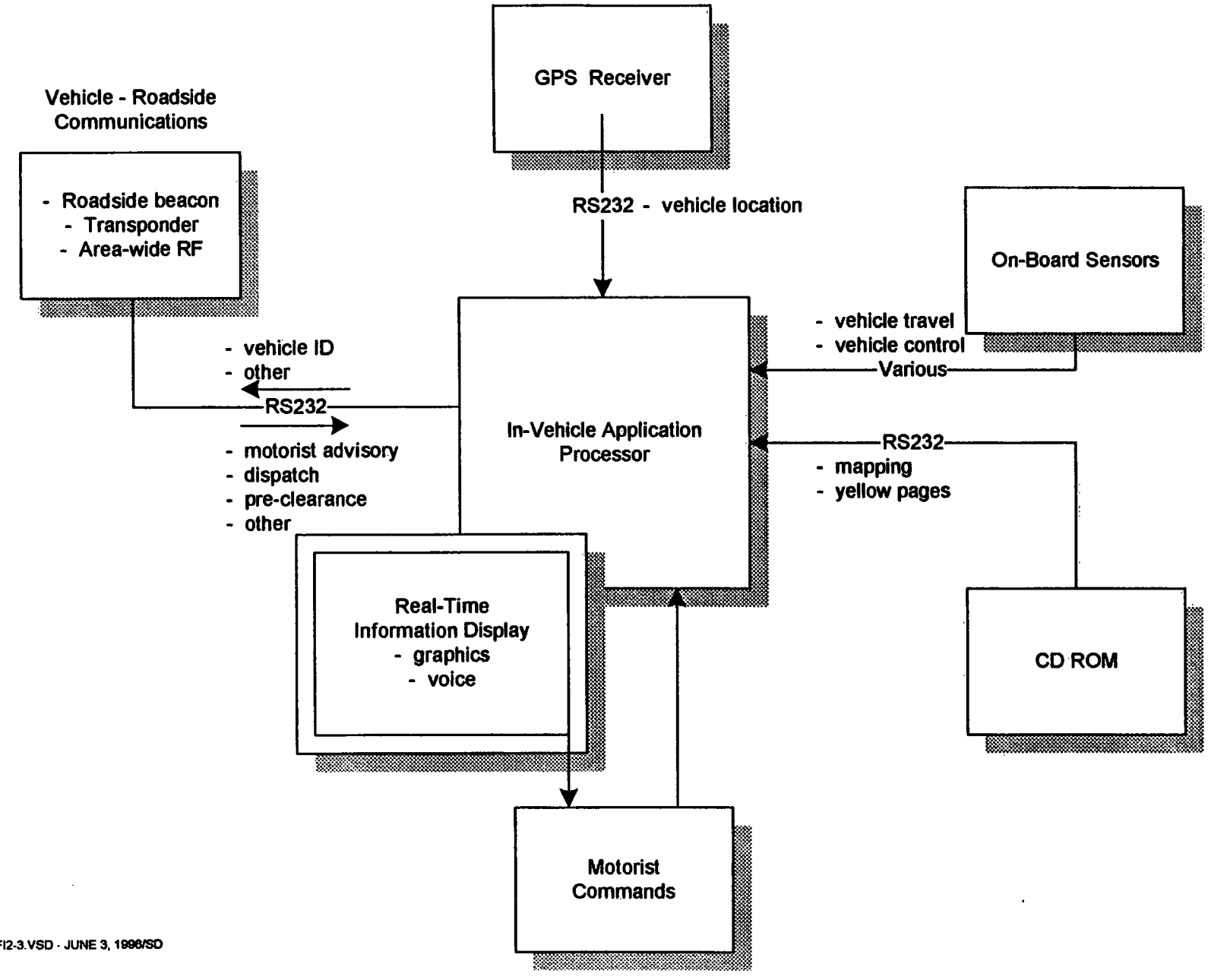
LCD

LCD displays are compact and characterized by low power consumption. For in-vehicle applications, LCD displays are typically used to provide alphanumeric messaging for fleet management, or simplified map display and directional indications for route guidance.

CRT

CRT displays are capable of displaying high resolution graphics information and as such are well suited to presentation of detailed navigation maps. CRT technology has also been used in providing a touch screen interface to support multiple on-board processor functions.

EXHIBIT 2-3
IN-VEHICLE DISPLAYS - ARCHITECTURE DIAGRAM



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HUD

Heads Up Displays (HUD) employs technology adopted from the military aircraft industry to project selected information onto the windscreen. At present, this technology has typically been employed to display key vehicle operating information, namely speed.

Voice

Utilization of voice technology in the vehicle offers the advantage of minimal distraction to the driver. Voice advisory can be provided in a variety of formats including the widespread use of two-way voice communications for fleet management and motorist advisory via cellular telephone access. Voice has also been employed to compliment in-vehicle navigation/guidance graphic displays through instructional commands.

Applications

The following are some examples of in-vehicle display technologies currently on the market:

- in Japan, Sony has achieved an installed base of over 5,000 in-vehicle navigation systems employing CD ROM map technology and CRT displays;
- in the U.S., General Motors offers an optional heads-up display of vehicle speed on select models;
- in Europe, the Siemens Euroscout route guidance system uses LCD display technology to provide direction instructions to the motorist;
- in the U.K., the Trafficmaster system uses a liquid crystal display to show a simplified representation of portions of the motorway network, highlighting areas of congestion.

2.3.4 Standards and Interoperability

As with the roadside displays, in-vehicle display standards can be expressed in terms of:

- message format;
- equipment interfaces.

With a variety of emerging in-vehicle applications and associated display technologies, there are no prevalent standards for providing information to the motorist in the vehicle. Furthermore, the market is characterized by regional preferences. For example, in Japan there

appears to be a preference for detailed colour map displays, whereas in Europe, Siemens has been a promoter of providing a more instructional approach to route guidance on the basis that it is less distracting to the motorist.

With respect to equipment interfaces, in-vehicle displays are typically bundled with one or more application processors, such as in-vehicle navigation, and audio entertainment. Typically, the interface between the processor(s) and the motorist display is standard RGB. Considerable effort has been expended towards the development of standards for high speed serial communications interfaces among vehicle application processors. The Society of Automotive Engineers (SAE) J-bus initiative represents a series of Recommended Practice specifications governing high speed serial communications within the vehicle. This ongoing international standards development process has been underway for several years and supports the interoperability among original equipment and after-market vehicle electronics components. This standards process has been effective in facilitating the globalization of automakers and automotive components industry. The J Series specifications provide design parameters focusing on the physical layer, data link layer, and application layer of the OSI model.

2.4 TRANSIT PASSENGER INFORMATION DISPLAYS

Transit passenger displays provide information related to operation of transit vehicles or emergency information. During the time when there is no transit information to report, the displays may be utilized as advertising boards, thus generating revenue for transit authority. Displays may be located on-board of transit vehicles, i.e. buses, train cars; in transit shelters or stations. Within the scope of ITS, these applications are utilized by Advanced Public Transit Systems (APTS).

2.4.1 Functional Requirements

Passenger information displays should be capable of fulfilling the following functionality:

- the display should be at least capable of displaying messages that are combination of text and numerals. Graphics capabilities will add to the value of display broadening the flexibility especially to support advertising. Flashing messages should also be supported;
- the display should incorporate a library of messages and support real time data;
- the on-board side mounted displays should have wide viewing angle to allow viewing from front and back of transit vehicle;
- the display system should incorporate a small display for the vehicle driver to verify message content;

- the display should be readable in all ambient light conditions.

2.4.2 System Architecture

Exhibit 2-4 identifies the physical and logical system architecture for a system that supports on-board displays. The display processor contains a library of messages, usually advertising or weather, which may be overridden by real-time transit or emergency messages or messages entered by operator of the vehicle. The display is interconnected with vehicle public announcement system which supplement displays with voice messages. The vehicle-to-roadside communications provide real-time message display capabilities and sends vehicle location data to central control centre.

2.4.3 Technologies and Applications

The enabling technologies for transit displays include: LED, LCD, electromagnetic reflective flip dot displays and digitized/synthesized voice and CRT.

LED displays have high visual impact and are well suited for displaying text based messages and limited graphics capabilities. They are capable of supporting multi-colour displays. Older LED displays utilize matrix of holes with individual LEDs mounted in the holes. Newer solutions employ flat top cavities in a solid matrix which improves luminosity and greatly increases viewing angle.

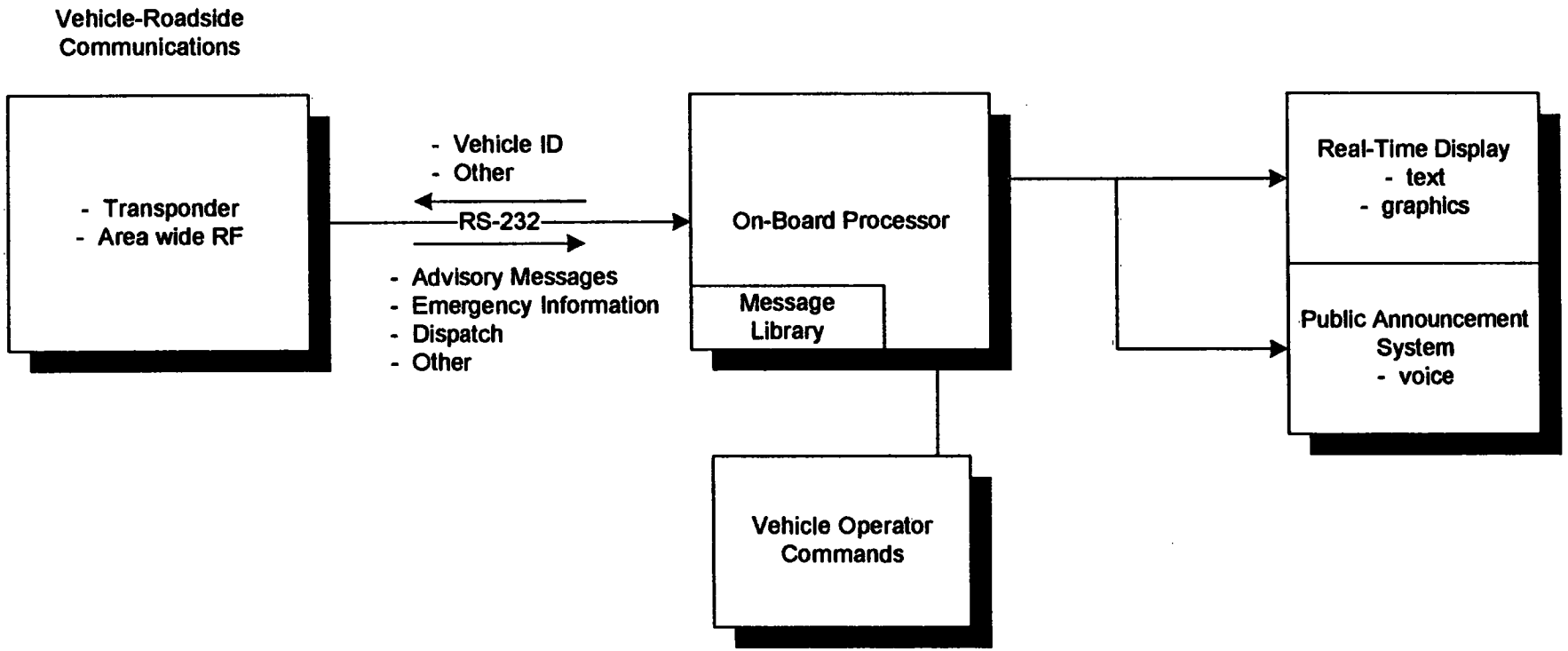
LCDs are monochrome displays with much lesser visual impact than LED. Ambient lighting conditions have impact on legibility of the display, hence current applications are concentrated in transit stations. Colour LCDs for this type of application are under development.

Electromagnetic flip dot technology has been used for many years for route displays on buses. They employ reflective flip dot technology internally illuminated with fluorescent lighting. The functionality of the processor may be limited to preset library of messages or accept real-time data. The technology is also used as large size transit station displays.

Voice systems may utilize either synthesized or digitized technology. The on-board voice processor is usually interconnected to the public announcement system. The message database may be downloaded either at the time of vehicle departure or in real-time.

CRT monitor displays are mainly overhead or kiosk mounted at transit stations. They display transit schedule information and other general information. They may also display traffic messages if the transit station is a Park'N Ride type facility.

EXHIBIT 2-4
TRANSIT INFORMATION ON-BOARD DISPLAYS



C:\WP51\5266\DISFI2-4.VSD - JUNE 3, 1996/SD

Applications

Transit passenger information displays are most commonly used at transit stations as schedule displays. The transit shelter and on-board applications are in their prototype stage in North America. A number of transit authorities are in the process of implementing their first on-board displays. Some existing implementations include:

- Osaka, Japan - operational bus and bus shelter display system;
- City of Montreal subway - 846 real-time LED/voice displays inside subway vehicles and on platforms;
- New Jersey Transit - initial deployment of on-board displays for buses to be in place in 1997.

2.4.4 Standards and Interoperability

As with other information displays transit display standards may be expressed in terms of two layers:

- message format and content;
- communications interface.

Message format and content for transit display system is generated as a function of what scheduling information is available. There are no established standards with respect to how information is presented; the format is defined as a function of the display media. For example on-board information dissemination primarily utilizes aural or alphanumeric character displays. Fixed displays, such as information kiosks in transit facilities tend to utilize graphical, interactive display media.

With respect to equipment interfaces, the discussion of standards and interoperability under Sections 2.1.4 and 2.2.4 apply to fixed transit facility display systems. Regarding in-vehicle displays, the discussion under Section 2.3.4 applies. SAE specifications which specifically address high speed serial communications for heavy duty vehicles include J1708, and J1939.

3. TECHNOLOGY REVIEW

The objective of the technology review is to assess the current state of the ITS display industry and observe the industry trends in terms of market strategies and new technological developments.

ITS displays encompass a wide range of applications. Within each application there are manufacturers, distributors, system integrators, owners/operators, and users. In assembling a list of 20 survey contacts, the intent is to reach a wide spectrum of technologies and organization types. The following is a summary of criteria considered:

- cross-section of manufacturers, research bodies/Universities, suppliers/distributors, agencies and authorities;
- representation from Canadian firms active in ITS;
- input from defence/aerospace industry;
- input from industry with new technical developments;
- global content.

In an effort to obtain a uniform responses, a set of survey questions was prepared covering three main areas:

- general information about the organization and level of their involvement in ITS;
- details on currently manufactured/used ITS display technology and any future developments;
- domestic and international marketing issues.

The survey was tailored according to the type of application (i.e. roadway displays or in-vehicle displays) and the type of organization. Copies of the survey question sheets are included as Appendix A.

The questionnaires were faxed to all contacts and followed up with a phone call several days later. Some respondents chose to fax their answers. Of the 20 contacts, 12 agencies responded with useful input to the study. It is estimated that 200-250 manufacturers participate in the worldwide market for ITS display applications. A list of industry contacts in the ITS Yellow Pages format is included as Appendix B.

3.1 ROADWAY DISPLAYS

Roadway VMS displays have traditionally employed reflective technologies which offered poor legibility under varying ambient light conditions. The growth in the market has resulted in a new generation of light emitting displays specifically for the traffic market. The main technologies developed and manufactured for roadway applications are:

- Light emitting diodes (LED);
- Shuttered Fibre Optic;
- Hybrid Signs;
- Liquid crystal displays (LCD).

Exhibit 3-1 presents a comparative assessment of each of the technologies. Exhibit 3-2 graphically represents current and predicted level of market penetration for each technology, based upon IBI Group's subjective interpretation. Currently, LEDs, shuttered fibre optic and fibre optic hybrid signs dominate the market. Hybrid fibre-optic flip disk technology offers a competitive cost/performance relationship and is gaining wide-spread deployment in North America. LED displays, used widely in Japan, are steadily improving in performance and costs will approach costs of competing technologies. Similarly, LCD is evolving rapidly and promises to be viable roadway variable message sign (VMS) technology.

Light Emitting Diodes

LED offers excellent visual impact in all ambient light conditions and the fully solid state construction results in better reliability than other sign technologies. In VMS applications, LEDs are favoured by majority of manufacturers and research activities are focused in this area.

First generation LEDs produced amber colour by combination of red and green diodes in one cluster. Uneven degradation of differing diodes caused changes in pixel colour from amber to red or green. Current LED signs employ high output amber diodes, which should significantly reduce the problem of pixel output degradation. (The long term performance of the current generation of LED's has yet to be proven.) Additional developments are expected in colour availability (blue diodes) which would increase flexibility of displays with colour messages and graphics.

Steady improvements in LED technology have increased the light output of individual diodes, thus allowing manufacturers to reduce the number of diodes per cluster and to increase emitter luminance. The potential remains to further reduce the heat generated by LED signs. Any new developments in this area will reduce power requirements and improve reliability by reducing LED operating temperatures.

A major breakthrough in LED has been made recently with new semiconductor material called AlInGaP (Aluminium, Indium, Gallium, Phosphide). The use of this technology generates efficiencies (lumens/Watt) equal to halogen light sources. The latest version of AlInGaP technology generates 20 lm/W whereas conventional LED semiconductor materials generate efficiencies up to 2 lm/W. The light output from AlInGaP LEDs makes them suitable for applications where conventional LEDs would not operate, such as high ambient light conditions. AlInGaP technology is being manufactured by Hewlett-Packard of U.S. and Toshiba of Japan.

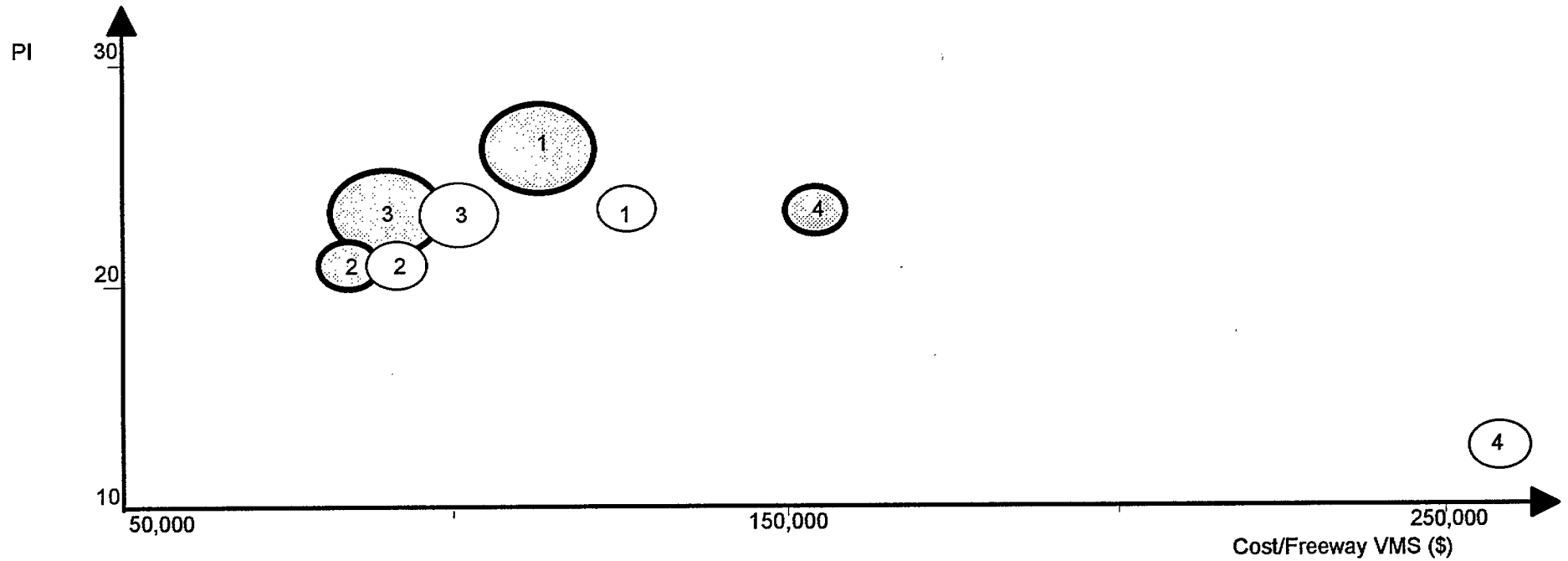
EXHIBIT 3-1
ITS ROADWAY DISPLAYS
TECHNOLOGY ASSESSMENT

	Performance Index (PI)**			
Evaluation Criteria	**LED**	**Shuttered FO**	**Hybrid**	**LCD**
Functional Capabilities	4	3	4	1*
Performance/Accuracy	5	3	4	1*
Reliability	3*	4	4	3*
Routine Maintenance	4	3	3	4
Connectivity	4	4	4	4
Physical Integration	3*	4	4	2*
Total Performance Index (PI)	23	21	23	15
Comments	- fully solid state construction - relatively high power consumption and heat generation - long term LED output degradation has been an issue - rapid pace of technical evolution	- proven technology - regular lamp replacement and shutter maintenance required - poor visibility under direct sunlight - not adversely affected by high/low ambient temperatures	- proven technology - regular lamp replacement and shutter maintenance required	- not yet a viable technology - cold weather performance is an issue - visibility over a wide range of ambient lighting is an issue - fully solid state construction - low power consumption - multiple colours - wide viewing angle - rapid pace of technical evolution

* Areas where improvements are anticipated.

** Performance Index Ranking
1 ... 3 ... 5
Poor Average Excellent

EXHIBIT 3-2
ITS ROADWAY DISPLAYS
TECHNOLOGY ASSESSMENT



Key		
1	LED	- Ledstar
2	Shuttered FO	- SES
		- Dambach
3	Hybrid	- Telespot
		- Mark IV
4	LCD	- Vultron

Year

1996

2001

Installed Base

< 500

500-1,000

> 1,000

LEDs in multi-colour configuration are predominant technology for VMS in Japan (approximately 75% of the market). The interesting aspect of Japanese VMS is use of colour coded simplified road diagrams to indicate areas of congestion, which convey large amount of information in a very concise manner.

Fibre Optic

Compared with LEDs, fibre optic represents a more developed and stable technology. The main developments in fibre optic signs involve increased efficiency and longer life of light sources, and improved reliability of the shuttering mechanism. Recent improvements in shuttering technology have increased reliability. A potential development area exists in LCD shutters which offer possibility of a solid state shutter.

Plastic optical fibres have been introduced in recent years by Austrian manufacturer Fabrik für Elektrotechnik and Maschinenbau. Their advantage over glass fibres are: more uniform light output, lower light loss, lower susceptibility to breakage and lower weight. However, the long term performance of plastic fibres is yet to be assessed.

Remotely lamped signs are under development, incorporating a light source located in a roadside cabinet and long fibre strands or other suitable light transmission media used to transmit the light to the sign display. The major advantage of a remote light source is the ease of access for bulb replacement and maintenance. The disadvantages of this technology include light loss over the length of fibre (which limits the length of fibres) and colour shift towards the reddish-yellow part of the spectrum which is directly related to the length of the fibre run. This is relatively new and evolving technology and the cost is expected to be high.

LCD

LCD technology is evolving rapidly. In order for the LCD to become viable as a VMS technology research and development efforts must address:

- display performance over a wide range of ambient temperatures;
- display legibility over a wide range of ambient light conditions.

Future Trends

Transportation authorities are demanding increasing levels of optical performance and multi-colour graphic capabilities for VMS applications. This is in large part due to the motivation to display recognizable traffic signing symbols such as used to designate parking facilities or roadwork. The technologies which are best suited to fulfil these requirements are the solid state technologies, namely LED and LCD. LED technology is presently achieving market leadership resulting from recent advancements in high output with lower power consumption and heat generation. High LED output facilitates the use of smaller pixels which provides the opportunity to develop display configurations with higher resolution as compared to shuttered fibre optic technologies. The current state of LED development provides adequate yellow, green and red display capabilities; blue is presently becoming available. Based on discussions with LED suppliers, it is anticipated that over the next 2 to 3 years development efforts will yield blue LED with suitably high outputs to provide full colour display capabilities. Costs of LED VMS continue to decline such that they can compete with other technologies. Large outdoor LED displays are gaining widespread acceptance for other applications such as advertising, and scoreboards, thereby further improving production economies of scale and reducing VMS costs.

While LCD is not presently considered a viable outdoor VMS technology, industry suppliers suggest that ongoing research and development with LCD technology should yield the appropriate size, environmental robustness, and display resolution and output for small scale outdoor VMS.

Shuttered fibre optic display technologies are still widely used for VMS applications focusing on alphanumeric messages and limited pictograms. As operating agencies demand more graphic capabilities in terms of variety of colours and resolution, shuttered fibre optic technologies will assume less of a role in the market.

In summary, it is expected that LED will be the predominant enabling VMS technology in the marketplace in the years to come. LED has been the technology of choice in the past in Japan, and will continue to be applied in order to meet the increasingly graphics oriented VMS display requirements of operating authorities worldwide.

3.2 CONTROL CENTRE DISPLAYS

There is a wide range of related industries that use control centre displays suitable for ITS. Examples include telecommunications, defence, fleet management, network management, advertising, sports stadia and conference rooms. The size of the market drives the size of manufacturing base and results in wide range of products and competitive prices.

The main technologies used in control centre applications are:

- Front projection (CRT or LCD Light Valve);
- Rear Projection (CRT, or LCD Light Valve);
- LED flat screen displays;
- Rear Projection Cube;
- Monitor Wall;
- High Resolution Graphics Monitors.

Exhibits 3-3 and 3-4 present a comparative assessment and graphical representation of current and future costs and levels of market penetration for large ITS control room applications, based upon IBI Group's subjective interpretation.

The choice of technology and size of display are usually driven by the required functionality, i.e. what type of signal the display is to accept, composite video or RGB; available space (area and vertical clearance) and budget. Typical applications combine more than one technology type, i.e monitor wall, large screen projector and high resolution graphics monitors. Some Japanese traffic management centres combine as many as five large screen display media.

Front projection technology, such as marketed by Electrohome, has found a limited implementation in ITS control centre applications. It does not provide adequate picture quality in office levels of illumination. In addition, a projector unit hanging from the ceiling may obstruct view of operators or other staff involved. New technology developed jointly by Hughes Aircraft and JVC Technology offers significant improvement in picture quality. The Light Image Amplifier is an example of military technology adopted to commercial market. The projector, which utilizes reflective LCD technology, is capable of displaying full motion video and computer generated graphics.

Rear project technology is widely used to display high resolution graphics and live video images. The technology is configurable in the sense that it is available in a variety of forms including:

- stand-alone pedestal mounted units marketed as standard products;
- standard products stackable rear-projection cubes which can be configured to suit custom display requirements;

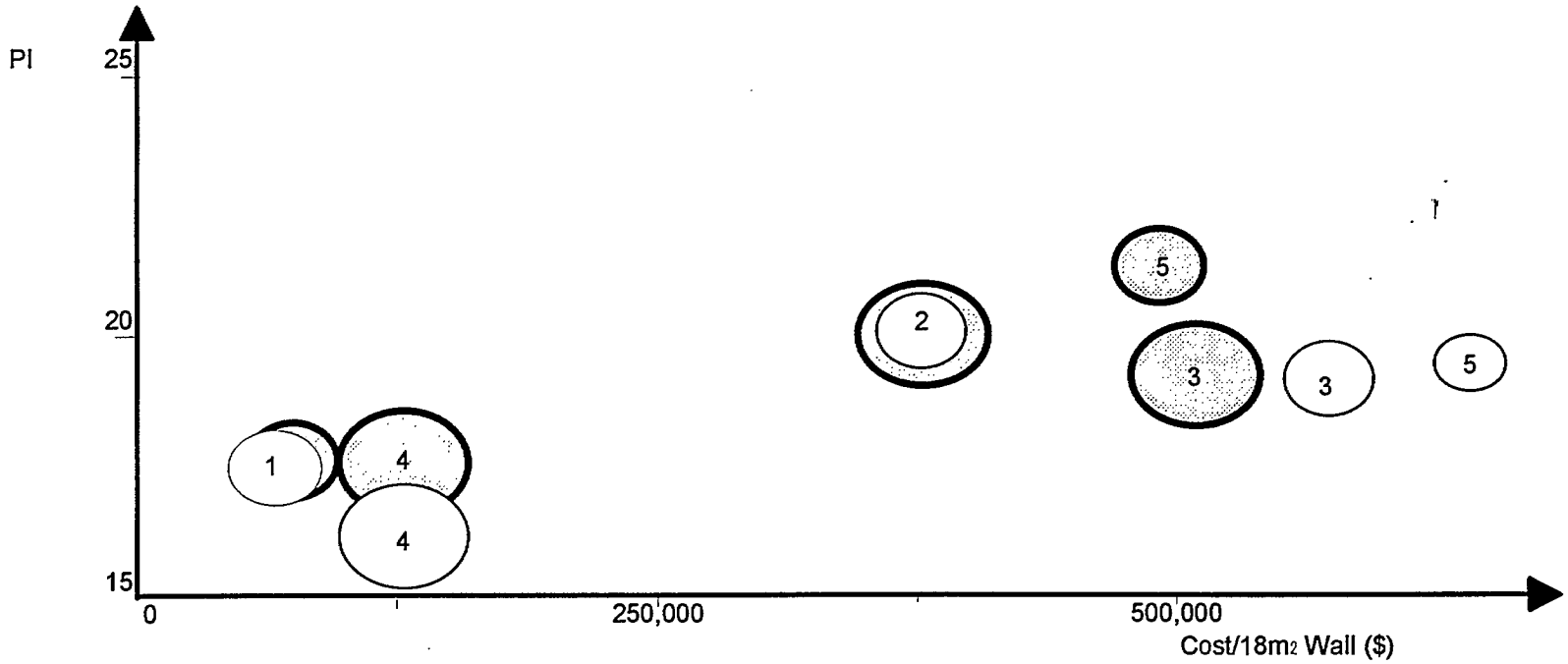
EXHIBIT 3-3
ITS CONTROL CENTRE WALL DISPLAYS
TECHNOLOGY ASSESSMENT

	Performance Index (PI)**				
Evaluation Criteria	**Overhead Project (CRT or Light Valve Projection)**	**Rear Projection Wall (CRT or Light Valve Projection)**	**Projector Cube**	**Monitor Wall**	**LED Flat Panel Displays**
Functional Capabilities	4	4	4	1*	2*
Performance/Quality	1	4	4	3	2*
Reliability	3	3	3	4	3
Routine Maintenance	3	3	2	3	5
Connectivity	4	4	3	2	4
Physical Integration	2	2	3	3	4
Total Performance Index (PI)	17	20	19	16	20
Comments	- poor visual impact under office illumination levels - projection unit can obstruct sightlines	- requires space for rear projection room - proven technology	- compact, configurable - thin margins between cubes - requires software to partition	- limited graphics capability - wide margins between monitors	- only red and green available - can accommodate composite video and low resolution graphics - 10 cm deep panel

* Areas where improvements are anticipated.

** Performance Index Ranking
1 ... 3 ... 5
Poor Average Excellent

EXHIBIT 3-4
ITS CONTROL CENTRE WALL DISPLAYS
TECHNOLOGY ASSESSMENT



Key		
1	Overhead Projection	- Electrohome
2	Rear Projection Wall	- Electrohome
		- Barco
		- Sony
		- M3i
3	Projection Cube	- Philips
		- M3i
4	Monitor Wall	- Hanatrex
		- Barco
5	LED	- Ideal Visuel

Year

1996

2001

Installed Base

< 100

100-500

> 500

- custom-built rear-projection wall using standard projector components built into the facility.

CRT or light valve based rear-projection technology is proven, widely available and provides suitable intensity in office level illumination. The primary drawback for this technology is the space requirements to accommodate rear-projection systems. The stackable rear-projection cubes address this, but at increased costs. Furthermore, custom software may be required to partition graphic images between projectors; M3i is a Canadian company which is an industry leader in this area. Their portfolio of experience includes participation in major traffic management system control room development in Japan.

Traditional ITS control room applications incorporate banks of monitors, or monitor walls to display live video images from surveillance cameras. The primary drawback of this display media is the inability to display large high resolution graphic images across a wall of monitors.

Ideal Visuel International of France has developed a LED based, flat, overview display system which is only 10 cm deep. The display supports RGB and composite video signal. Currently, only red and green LEDs are available but the company representative indicated that full RGB displays will be available later this year.

Future Trends

ITS control centres will maintain the need to display integrated live video and computer generated information in varying configurations. Accordingly, the industry trend is toward media walls which are user definable as a function of time-of-day, traffic operations, staffing, etc. The requirements for media wall capabilities are certainly not unique to the ITS arena; other applications include entertainment/casinos, network operations centres for various utilities, and fleet management control rooms such as that operated by Canada Post. ITS control centres will continue to draw upon the wider market of developing and proven media wall display technologies. The trade-offs facing ITS applications are similar to those of other industries (i.e. how to maximize functional capabilities while minimizing cost and space requirements). The industry-wide trend is toward the solid state applications including LCD based rear-projection, and LED panels. Ultimately the industry may develop modular large screen liquid crystal displays.

3.3 IN-VEHICLE DISPLAYS

In-vehicle display systems utilize display technologies that are already developed and widely used in other applications, such as:

- LCD;

- CRT;
- synthesized or digitized voice;
- Heads Up Display (HUD).

Refer to Exhibits 3-5 and 3-6 for comparative assessment of the technologies and current and predicted level of market penetration, based upon IBI Group's subjective interpretation.

The adaptation of display technologies for the vehicle requires production of displays of size suitable for the in-vehicle environment, robust and resistant to vibrations, and able to interface with the required in-vehicle processors.

Visual driver displays are usually small in size (10 - 15 cm screen) to fit within the vehicle's dashboard. Currently, the prevailing technology is LCD. Its main advantages are compact size and quality of display. CRT displays are less favoured for in-vehicle use because they require more space. Their advantages include better image quality, visibility and viewing angle.

Some authorities, particularly in the EU, are not supportive of graphic displays which draw attention away from the road. In-vehicle voice displays employ speech recognition and speech synthesis to provide step-by-step information to the driver. The driver can retrieve information while keeping hands on the wheel and eyes on the road. One commercial speech driven system, based on in-vehicle CD-ROM is AudioNav from Amerigon, Inc. of Burbank, California.

HUD's are another safety-driven in-vehicle display application. Firms such as GM/Hughes and Allied Signal are applying military research and development efforts for automotive heads-up displays to include night vision enhancement in addition to projecting vehicle controls on windshield.

Future Trends

Looking to the future, it is anticipated that ITS in-vehicle features such as dynamic route guidance will be bundled with other in-vehicle information processing applications such as audio, television, and external communications. As the SRI ITS Report 1 notes, Clarion Corporation is already marketing a product which integrates CD-ROM in-vehicle navigation with car audio systems. This type of integration of value-added in-vehicle features will be critical to the marketing success of ITS features such as dynamic route guidance. Furthermore, it provides the opportunity to distribute the costs of the in-vehicle display component across a variety of functions. The costs of the display can

EXHIBIT 3-5
ITS IN-VEHICLE DISPLAYS
TECHNOLOGY ASSESSMENT

	Performance Index (PI)**			
Evaluation Criteria	**LCD**	**CRT**	**Audio Displays**	**HUD**
Functional Capabilities	3*	4	2*	2*
Performance/Accuracy	4	4	3	3
Reliability	4	4	3*	4
Routine Maintenance	5	5	5	5
Connectivity	4	4	3*	3
Physical Integration	4	1	5	3*
Total Performance Index (PI)	24	22	21	20
Comments	- colour LCDs available - technology of choice for in-vehicle applications	- may employ touch screen option - size is an obstacle for in-vehicle applications	- safer alternative to visual displays - speech recognition needs more research	- enhance road safety - limited information content - infrared night vision displays under development

* Areas where improvements are anticipated.

** Performance Index Ranking
1 ... 3 ... 5
Poor Average Excellent

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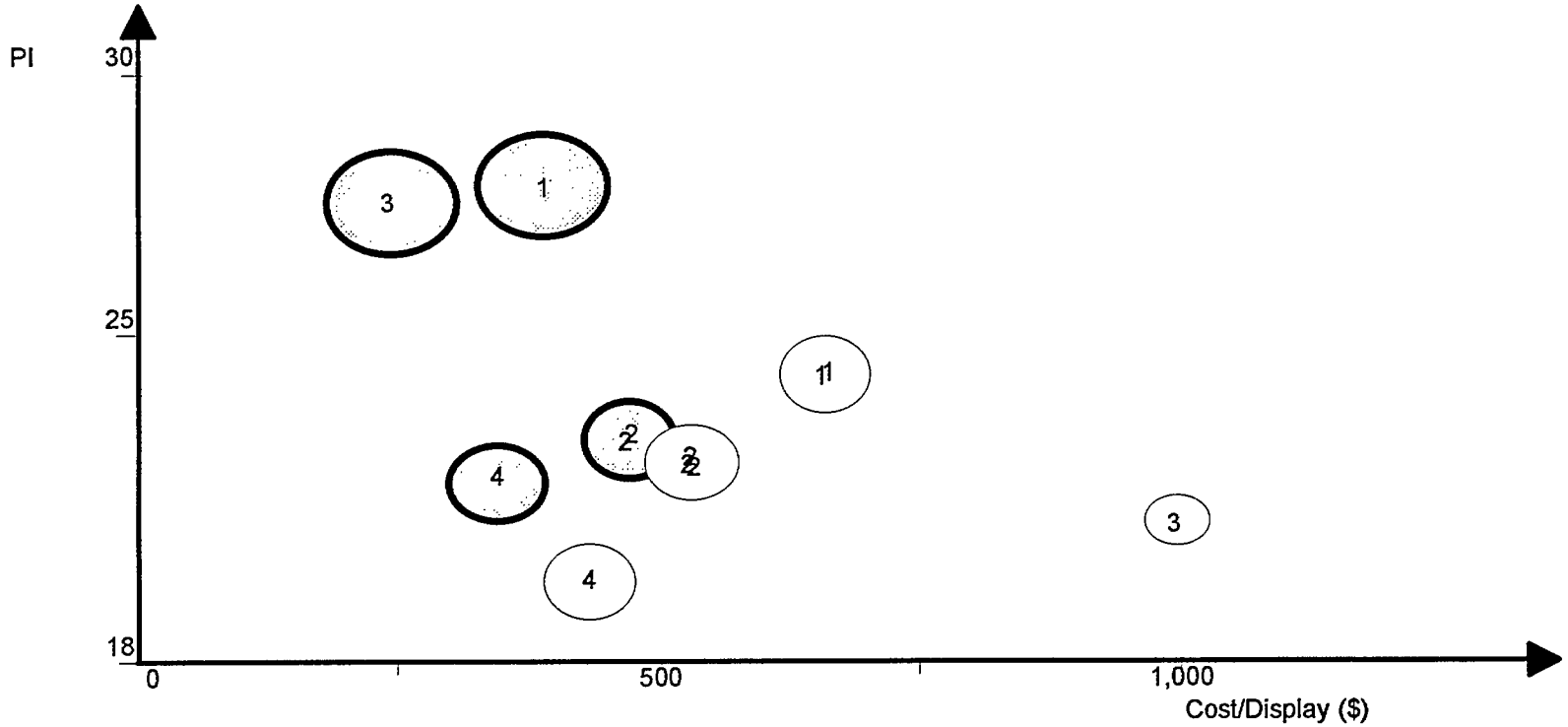
EXHIBIT 3-6
ITS IN-VEHICLE DISPLAYS
TECHNOLOGY ASSESSMENT



Key		
1	LCD	- Sony
		- Pioneer
		- Sanyo
		- Sharp
		- Mitsubishi
2	CRT	- Sony
3	Voice	- Amerigon
		- Pioneer
		- Blaupunkt
4	HUD	- Delco
		- Allied Signal

Year

- 1996
- 2001

Installed Base

- Prototype
- < 2,000,000
- > 2,000,000

C:\WP51\5266\DISFI3-6.XLS - 6/3/96/SD

represent up to 50% of the total cost of an in-vehicle navigation system equipped with 6" colour LCD display.

Also critical to the market acceptance of ITS in-vehicle functions (and the associated display components) will be the ability to interface these systems to the local information infrastructure. This will provide the opportunity to update the in-vehicle systems with current traffic information, revised yellow pages/map data, special event information, etc. To date, there have been a variety of working prototypes for use in short range RF or infrared communications or area-wide digital broadcast to establish these communications links to the vehicle. Over the years to come, the industry faces the challenge of developing a standardized approach in this regard both in terms of the physical communications link and the data format/protocols.

The Clarion Corporation example is also noteworthy because it integrates the aforementioned AudioNav voice guidance system from Amerigon. Future in-vehicle systems will place emphasis on voice synthesis and voice recognition in order to optimize safety.

Heads-up displays for vehicle speed are available now as optional equipment, most notably on some GM models. It is anticipated that public awareness, acceptance, and demand for this feature will grow, likely to the extent where it becomes standard equipment on many models in the near future. Future development of this application will include other vehicle operating information and motorist warnings from other advanced vehicle functions such as collision avoidance.

3.4 TRANSIT PASSENGER INFORMATION DISPLAYS

Passenger information displays encompass on-board displays and stationary kiosks with information related to public transit operations and route information. Some forms of intelligent displays in transit operations have been employed for a number of years. These include exterior route information, on-board public announcement systems and station displays. More recent applications include on-board and transit stop information displays, displaying distance to specific location, waiting time or emergency information.

Public transit passenger on-board displays are larger in size than driver information displays, to provide adequate visibility to all passengers in a public transit vehicle.

Technologies used for these applications are:

- LCD;
- LED;
- electromagnetic reflective flip dot signs;

- voice information systems;
- CRT.

Exhibit 3-7 presents a comparative summary of these technologies in transit applications. Exhibit 3-8 presents graphical representation of the current and predicted level of market penetration for this application, based upon IBI Group's subjective interpretation.

The appropriate enabling technology for transit passenger information is dictated by the physical environment and the information to be conveyed. On-board applications typically employ pixel-board display technologies (LED, LCD, flip-dot) or voice systems. Transit facilities may employ some combination of these technologies, as well as CRT-based information kiosks.

The visual on-board displays are usually mounted in the front of the vehicle (behind the driver) or in the middle of the vehicle, just above windows on both sides. The preferred technology for on-board applications is LED because of the strong visual impact. The controlled lighting environment characteristic of transit vehicles also facilitates the use of LCD technology. To date implementation of on board displays has been limited. Japan is the world's leader in transit passenger displays. Sumitomo Electric Industries offers a range of displays for on-board and transit stop applications.

Voice information systems are usually tied to the vehicle or station public announcement systems utilizing digitized voice or synthesized voice technology. In vehicle/train systems, voice data is downloaded either prior to trip or real-time through RF communications. These systems are very cost effective because they utilize infrastructure already in place.

In some jurisdictions, both the visual displays and audio displays are required to provide equal opportunity for persons with visual and hearing impairments. In the United States this requirement is legislated through the American with Disabilities Act (ADA) which transit authorities are required to honour.

Displays at transit stations are very common all over the world and deployment and capabilities will continue to expand. Schedule displays on every bus stop have some major barriers. One is enormous cost for wide spread implementation; another is vandalism.

Future Trends

Transit passenger information systems largely draw upon a stable of display media used in a number of industry applications. The focus

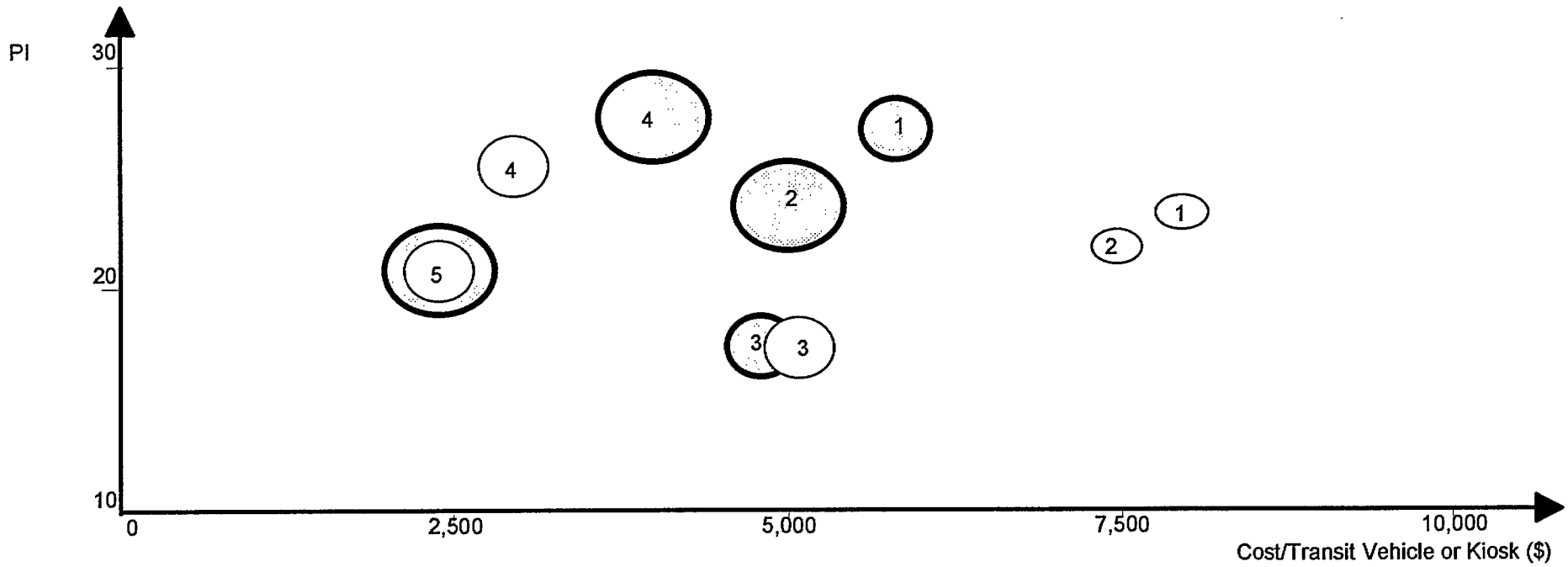
EXHIBIT 3-7
ITS PUBLIC TRANSIT DISPLAYS
TECHNOLOGY ASSESSMENT

	Performance Index**				
Evaluation Criteria	**LCD**	**LED**	**Flip Dot**	**Voice**	**CRT**
Functional Capabilities	4	3*	3	4	4
Performance/Accuracy	3*	4	3	4	4
Reliability	4	4	3	4	4
Routine Maintenance	4	4	2	4	4
Connectivity	4	4	4	2*	4
Physical Integration	4	3	2	4	1
Total Performance Index (PI)	23	22	17	26	21
Comments	- adversely impacted by varied ambient light and temperature - low maintenance requirements	- low resolution - high intensity - adversely impacted by varied ambient light - low maintenance requirements	- widely used for route displays and transit stations - relatively inexpensive - requires regular maintenance of fluorescent bulbs	- integrated with vehicle/train P/A system flexible and inexpensi	- flexible to display high resolution graphics; live video - close range viewing only

* Areas where improvements are anticipated.

** Performance Index Ranking
1 ... 3 ... 5
Poor Average Excellent

EXHIBIT 3-8
ITS PUBLIC TRANSIT PASSENGER DISPLAYS
TECHNOLOGY ASSESSMENT



Key		
1	LCD	- Sumitomo
2	LED	- Mobitec
3	Flip Dot	- Mobitec
4	Voice	- Interalia
5	CRT	- Sony

Year

1996
2001

Installed Base

< 10,000
10,000-100,000
> 100,000

EXHIBIT 4-1
ITS DISPLAY TECHNOLOGY
INDUSTRY ASSESSMENT

Applications	*Key Industry Participants*				
	U.S.	*E.U.*	*Japan*	*Canada*	*Related Canadian Companies*
1. Roadway Displays	Addco Manufacturing C. J. Hood Skyline Lake Technologies Daktronics Fibre Optic Display Systems Vultron Advanced Display Systems	Rolls-Royce Industrial Controls Dambach Zelisko Alta-Route SES Neuhaus SA	Kyosan Electric Sumitomo Mitsubishi Koito Industries Nagoya Electric	Ledstar Infocite Group Mark IV Tele-spot	
2. Control Centre	Hughes - JVC Technology	Electrosonic Ideal Visuel International Hantarex Phillips Electronics	Sony Mitsubishi	Electrohome M3i	Litton Computing Devices
3. In-Vehicle Displays	Delco Electronics Amerigon Clarion	Delphi Automotive Indikta Display Systems Philips Electronics Blaupunkt Bosch	Sony Pioneer Sanyo Sharp Mitsubishi		Litton CAE Electronics CDL Systems Allied Signal
4. Passenger Transit	Clever Devices Digital Recorders	Mobitec Peek Traffic	Sumitomo Electric Industries Sony Fujitsu Ten	Telecite Interalia	

identifiable cost component of a traffic management field implementation.

There is limited opportunity in roadway display applications to provide a standard off-the-shelf product. Each implementation involves significant level of custom manufacture to the client specifications. This creates a tendency for manufacturers to lobby with authorities to influence the formation of standards. As a result there are regional market leaders who, having established relationships with authorities, are pre-approved for supply of displays. Examples of such regional market leaders are Mark IV in the U.S. and Canada, Dambach in Europe and Sumitomo in Japan. The number of companies involved in production of displays is already significant and newcomers to the industry may find it difficult to compete without establishment of alliances with existing suppliers.

The U.S. is a relatively large market for roadway displays and there is a well developed manufacturing base which originated from billboard advertising. In addition, all Canadian display fabricators are very active in the U.S. market. In fact, a significant proportion of the VMS installed in the U.S. are manufactured in Ontario and Quebec.

There is a long history of VMS deployment in the U.S., dating back large scale deployments in the early 1980's, such as the Long Island INFORM System. Many of these initial installations have reached their lifecycle and provide retrofit opportunities for manufacturers. The U.S. market is also characterized by a large degree of activity on the part of toll authorities migrating to electronic toll collection and commercial vehicle operations initiatives such as weigh station and border crossing preclearance. These are major growth areas within ITS that are self funding and require variable message signing.

The initial ITS initiatives in Europe undertaken since 1987 through DRIVE and PROMETHEUS programs have been criticized for not being deployment oriented. In recent years, the deployment of ITS systems and roadway displays have been expanding with United Kingdom, France, and Germany being the leaders. There are a number of strong manufacturing companies producing ITS roadway displays. Leading suppliers include Dambach, R-R Industrial Controls and Altaroute.

As a densely populated country with high levels of traffic congestion, Japan has recognised the importance of traffic control and information systems. Constant public support in research, development, and deployment activities since early 1970's have resulted in extensive Advanced Traffic Management System deployment. The Japanese roadway display market in Japan is virtually closed to outside suppliers. The leading manufacturers include Koito Industries, Nagoya Electric,

Unlike roadway display market, the in-vehicle displays and systems market is less dependent on public sector funding. SRI Consulting predicts that the world-wide long term market prognosis for in-vehicle systems (and associated displays) is good. The primary barriers to wide-spread deployment are lack of real-time information, current unit costs and the perception that the systems are a luxury tag.

The in-vehicle systems in the U.S. are still largely in their development and planning stage. To date, marketing of in-vehicle systems as an option in vehicles has been mostly unsuccessful. The prototype systems that exist typically use U.S. produced digital maps and software and Japanese hardware (Sony of America has recently purchased Etak, a California pioneer in digital mapping databases). A notable exception to Japan hardware dominance is Delco Electronics' Telepath System. Selected car rental companies (Avis, Hertz and National) offer path finding in-vehicle systems from Delco, Zexel (U.S.) or Sony (Japan) for a nominal daily fee.

There is much U.S. federal agency support in this area, expressed through significant number of demonstration projects aimed at defining scope and format of the in-vehicle information. Also, the use of different hardware like pagers, message watches and handheld computers to display real-time traffic and route guidance information is being tested.

Regarding heads-up displays, some GM car models currently offer limited function Delco HUD options that project vehicle speed on the windshield. HUD features will likely become commonplace in the U.S. automotive market over the years to come.

In-vehicle navigation systems have their difficulties in Europe because of language, mapping and cultural differences. Systems developed in one country may not be easily transferred to another. A number of operational trials and private funded ventures for en route information systems are underway with some failures on record, such as the Siemens-led Copilot initiative. The European community's preference seems to be directed to voice systems which keep driver's attention on the road. This has been reflected in implementation of FM-based TMC-RDS road traffic information service which provides traffic messages through car radios.

Japan has outranked the world in development and manufacturing of visual in-vehicle displays. In-vehicle navigation systems are offered by over 30 manufacturers led by Sony and Pioneer, with some manufacturers releasing their second or third generation products. Japan is the only country that has had a notable commercial success with marketing of in-vehicle navigation systems. SRI Consulting reports a current installed base of over one million units.

Transit Passenger Information Displays

The objective of transit displays is to improve level of service to passengers and make public transit a more desirable mode of transportation. This will be achieved only if scheduling information provided through displays is supported by well operating transit system. As a result, market opportunities for transit displays are greater in countries that already have strong public transit systems like Japan and Europe.

The market for transit displays depends largely on public sector funding. Private sector sponsorship of displays in return for advertising rights has been used to effect costs.

In North America, the priority for transit funding is generally uncertain. Over the longer term, major urban centres will have to place more of an emphasis on transit systems to mitigate urban congestion. There may be an opportunity for Canadian firms to service the U.S. market, based on the experience with transit systems in major Canadian centres, which are exemplary by North American standards.

The well developed transit systems in Europe and Japan provide an opportunity for the implementation of Advanced Public Transit Systems and information displays. Automatic Vehicle Location systems with shelter and on-board displays are already operational in several cities in Japan including Osaka and Nagoya.

4.2 CANADIAN INDUSTRY PARTICIPATION

This section presents a short overview of Canadian manufacturers active in ITS market. The manufacturers were considered as Canadian if their manufacturing base is in Canada, regardless of corporate ownership.

With the exception of in-vehicle displays, Canadian manufacturers are well represented in the ITS display industry. The following is a short overview of their activities.

Roadway Displays

Infocite Electric Display Systems based in Montreal manufactures LED displays for ITS, sports and advertising applications. The company has been operating since late 1970's and is active on Canadian and U.S. markets.

Ledstar Incorporated of Downsview, Ontario is marketing LED displays. Thirteen Ledstar VMS were installed on Highway 401 in 1991. The company is also present on the U.S. market.

Mark IV of Mississauga, Ontario is a Canadian division of Mark IV Industries of Amherst, New York. The company manufactures fibre optic flip disk and hybrid signs for the Canadian and U.S. markets.

Tele-Spot Systems has been marketing motorist information displays since 1970. The current technology is LYNX, a fibre optic reflective flip disk VMS. The company is based in Bolton, Ontario with offices in Victoria, BC and U.S. In addition to Canadian and U.S. the company is active in French and U.K. markets.

Control Centre Displays

Control centre displays are manufactured by two large Canadian companies. Electrohome Limited based in Kitchener, Ontario specializes in CRT large screen projectors. M3i Systems Inc. of Longueuil, Quebec is a leader in providing partitioning software for monitor wall displays. Both companies are large and well established with international market penetration.

Transit Passenger Information Displays

Telecite of Montreal, Quebec is a company focused in development, manufacture and service of audio and visual passenger information displays. Founded in 1986, the company originated as communications consultant and transitioned to transit displays manufacturer in early 1990's. Telecite have supplied displays for Montreal subway, New York City Transit Authority and Amtrak Penn Station in New York. The company is currently negotiating supply of LED displays for Paris Subway.

Interalia, a Calgary based firm is a designer and manufacturer of Digital Voice Announcement Systems. The company has international sales base and has sold their product worldwide. The most recent contracts include project in Norway for design and installation of intelligent train announcement system.

Related Industries

Many of the roadway display manufacturers originated from billboard and advertising display industry. As roadway display market emerged and developed these companies were first to modify their products to suit the new requirements. Currently a number of advertising display companies are developing products for ITS market.

ITS type displays for in-vehicle and control centre applications have been manufactured for military and aerospace markets for many years. Many of these technologies could be either directly applicable to ITS or could be adapted to suit ITS requirements.

The prevailing trends in ITS focusing on solid state technologies such as LED and LCD or voice synthesis present opportunities for companies that offer this expertise for other markets, such as Litton or CAE Electronics.

4.3 THREATS TO CANADIAN INDUSTRY

There are a number of threats to the Canadian ITS display industry which arise from activities in foreign countries, summarized as follows:

Government Programs

ITS programs in other countries or regions are better organized and better funded than in Canada. Of particular relevance to Canadian industry, the U.S. program is particularly well organized/funded. Originating in 1991 under the Intermodal Surface Transportation Efficiency Act (ISTEA) the federal U.S. ITS program has been allocated $200-$300 million U.S. annually to ITS initiatives, with contributing funds at the state level. The program includes specific initiatives to foster research, development, productization and showcasing of ITS component technologies. Display systems typically are not discretely identified in these programs but rather are integral to many of the ITS solutions being developed and deployed. Specific components of the U.S. federal program include:

- **ITS IDEA** (Innovations Deserving Exploratory Analysis) is a program which fosters the transfer of technologies from other industries to develop ITS products. Funding for successful proposals ranges up to $250,000 U.S.

- **Research Projects.** Tens of million dollars are devoted to research and development annually, primarily involving the U.S. federal government laboratory such as Oakridge and Volpe as well as large automotive and defense interests, such as Rockwell. As an example, a $24 million U.S. contract was recently awarded to TRW to develop an advanced driving simulator. Obviously a project this nature would have advanced display requirements and Canadian firms such as CAE bring relevant experience in simulation environments. Canadian firms must position themselves to access these U.S. R&D programs because the order of magnitude federal direct investment simply cannot be achieved within Canada.

- **Research Centres of Excellence (RCE).** Partnerships between the federal government, academia, and private sector interests have yielded RCE's devoted to ITS. The program is sponsored by the Joint Program Office of the U.S. Department of Transport and includes University of Michigan, Texas A&M, Virginia Tech and the University of

Minnesota. Some initiatives involving advanced display systems includes human factors assessment for commercial vehicle in-cab displays, and human factors assessment and development of guidelines for variable message signs.

- **Operational Tests.** Proof of concept for new and emerging ITS applications and components are provided through selected field deployment and operational evaluation initiatives. The largest of these is a $70 million U.S. project in Oakland County Michigan, known as FAST-TRAC. One component of this operational test is the Siemens Ali-Scout in-vehicle driver information system.

- **Model Deployment.** Most recently, under the Intelligent Transportation Infrastructure initiative, three model deployment sites will be selected to feature a broad range of ITS applications across an entire urban area. The objective is to create a showcase of ITS features and benefits intended to serve as models for other cities and build public awareness/support.

In Japan, the ITS program is extremely centralized, involving some five central government ministries. This centralized approach gives the Japanese tight control over institutional issues, standards, system architecture, etc. which has yielded a program which is considered quite closed to foreign industry. Furthermore, the Japanese are positioned to market exemplary full scale ITS deployment solutions in other parts of the world, with a particular presence in Asia-Pacific emerging markets.

Private Sector Funding from Abroad

ITS programs in Japan, Europe and the U.S. are designed to emphasize public/private partnerships. Typically large automotive and defense interests are well represented in terms of project participation and investment. In the case of the European DRIVE programs, often these partnerships are designed to foster unity among EU nations by incorporating a cross-section of public and private agencies from member countries. In the U.S., a good example of private sector investment of resources is the National Automated Highway System Consortium incorporating:

- Bechtel;
- California Department of Transportation;
- Carnegy Mellon University;
- Delco Electronics;

- General Motors;
- Hughes Aircraft;
- Lockheed Martin;
- Parsons Brinckerhoff;
- University of California PATH Program;
- Federal Highway Administration.

Clearly with this core participation, it is unlikely that other firms are going to be well positioned to compete with Hughes/Delco in providing in-vehicle display components. In effect, the corporate research and development investment will shut out competing interests, particularly from foreign countries.

Foreign Industry Organizations

Again, looking to the U.S. example, ITS America has done an unrivalled job of bringing together various industry interests promoting ITS and providing a forum for information exchange. While the organization invites participation from the world, it is largely populated with U.S. industry interests.

Regional Standards

The European and U.S. programs are actively pursuing the implementation of standards for technical specifications and information exchange. Canadian industry must participate and subscribe to these processes or risk exclusion from future deployment.

Public Sector Funding

Deployment of VMS and ITS control centres relies heavily upon public sector funding. Current indications are that public sector budgets here in Canada and internationally are coming under scrutiny and decreasing. This could threaten the rate of ITS deployment.

Lack of Presence Within the In-Vehicle Market

Canadian industry is not well represented in the market for in-vehicle display systems. Accordingly, Canadian industry may not be able to access the future growth and private sector funding characteristic of the long term in-vehicle systems market.

Off-Shore Manufacturing

The assembly of large VMS displays is labour intensive; firms with manufacturing bases such as Taiwan, Malaysia, and ultimately China will be more cost competitive as compared to current North American manufacturing operations.

4.4 BARRIERS TO ACCESSING INTERNATIONAL MARKETS

The experiences to date of the Canadian ITS industry have reflected the fact that display systems manufacturers must export in order to remain in business. Accordingly, manufacturers must respect and attempt to address the barriers associated with doing business internationally.

Lack of Standards

As discussed in preceding sections, the application of displays at the roadside, in-vehicle and in control room environments are characterized by a lack of standards in terms of how information is conveyed and in terms of technical specification of components and interfaces. This hinders the transportability of technologies among various nations and renders it difficult for any one manufacturer to build a product for the worldwide market.

Build to Specification

As a symptom of the lack of standards, each roads authority, transit authority or in-vehicle systems integrator has specific and often unique technical requirements/specifications. Therefore in order for a manufacturer to, for example, supply VMS into Thailand, the particular manufacturer must be intimate with local approaches to driver information, character fonts, system architecture, and technical specifications.

Local Presence

The build to specification environment has traditionally resulted in a stable of regional suppliers manufacturers require that the local/regional presence in order to be intimate with specifications. Furthermore, there is typically a large degree of lobbying and liaison with government agencies in order to influence and anticipate specifications prior to the tender process.

Local presence is also a consideration at the time of manufacture of VMS or custom rear projection display systems. Purchasers typically want to be involved in the quality assurance process throughout manufacturing, including witnessing of tests at the point of manufacture.

Industry Alliances

As suggested in the preceding section, the development and operational testing of new ITS applications typically involves alliances of private or private and public sector organizations. For example, virtually every major automaker leads some form of multi-organization team in the prototyping of advanced vehicle control applications such as obstacle detection and vision enhancement. Canadian firms that have relevant display technology expertise risk being shut out of the market if they are not participating within industry alliances early in the product development cycle.

5. SUMMARY AND RECOMMEND-ATIONS

5.1 SUMMARY OF FINDINGS

Roadway Displays

LED will continue to be the predominant enabling VMS technology in the marketplace in the years to come. Other solid state technologies, namely LCD, are also expected to emerge as viable variable message sign technologies over the longer term.

The worldwide market for VMS is expected to continue to grow, and will benefit from the emerging regional standards and expanded deployment of ITS information gathering features. The market will increasingly rely upon revenue generating applications (i.e. toll roads and commercial vehicle preclearance). A particular area of growth will be the emerging economies of the Asia-Pacific region.

Canadian Industry is well represented in the manufacture of variable message signs. Infocite, Ledstar, Mark IV, and Tele-Spot Systems manufacture displays in Ontario and Quebec for the North American market. The challenge for this existing manufacturing base will be to remain competitive in the face of a number of threats including the high level of federal research and development funding and operational tests in the United States. While standards are emerging, the industry is expected to remain very much a built-to-spec environment. Canadian manufacturers are not well positioned to access major markets outside of North America, namely Europe, Japan, and the emerging markets of Asia-Pacific. In order to compete in these markets, manufacturers will need to establish a local presence for business intelligence and some degree of local manufacturing. Industry alliances will be a key strategy in order to compete in the overseas markets, and to access U.S. programs.

Control Centre Displays

ITS control centres draw upon a broader market of enabling technologies to incorporate media walls with integrated live video and computer graphics. The industry-wide trend is toward solid state applications including LCD based rear projection and LED panels.

The size of the ITS control centre display market is limited and manufacturers do not tend to solely target this market. Market opportunities will exist in the retrofit of older generation facilities.

Canadian industry is represented in the control centre display systems market, notably by Electrohome and M3i Systems. The latter maintains a worldwide reputation for niche role in providing the software solutions to partition images across a series of displays.

In order to access U.S. and overseas markets, control centre display system providers must typically align themselves with turnkey system integrators and contractors such as Allied Signal, TRW, Alcatel, etc.

In-Vehicle Displays

Colour LCD displays ranging in size from 10cm to 15cm will continue to be the technology of choice for visual in-vehicle displays. Increasing emphasis is being directed upon the development of voice synthesis/recognition technology to provide aural motorist interface.

The long term market prospects are good for in-vehicle display applications. There is growing emphasis on the integration of a variety of functions such as car audio, television, in-vehicle navigation, etc. to utilize a single display. The market outlook is also quite positive for heads-up displays for vehicle speed and other operating information, currently emerging as optional equipment in the U.S. market.

The LCD panel display market is currently dominated by Japanese manufacturers, and in particular Sony, Pioneer, and Toshiba. Canadian industry is not well represented in this market. In order to compete, Canadian industry will have to look to niche opportunities based on the existing hardware market, such as multi-function interface application software. With respect to HUD, there is some Canadian expertise in related industries, such as with Allied Signal, which could be transferrable to the ITS arena.

Transit Display Systems

Transit passenger information systems draw upon a variety of technologies as discussed for the preceding applications. It is expected that transit authorities will continue to develop custom approaches to

real-time information systems based on the characteristics of their fleets, facilities, and information available.

In general, the North American market for transit applications is less advanced than the more densely populated regions of Japan and Europe. However, there are some Canadian interests and applications which are market leaders as compared to the United States. Firms such as Telecité and Interalia have been successful at marketing their audio and visual passenger information products in the U.S., and worldwide.

While priority for transit funding in North America is generally uncertain, there could be long term market growth potential and corresponding opportunities for Canadian firms. Furthermore, strengths in related Canadian industries, most notably Bombardier, could provide opportunities to access the worldwide market through alliances.

5.2 CANADIAN INDUSTRY STRENGTHS AND WEAKNESSES

Roadway Displays

Canada, and in particular Southern Ontario and the Montreal region, is a strong manufacturing base for large pixel displays for freeway applications. The relative low value of the Canadian dollar has helped these firms become major suppliers in the U.S. market. In the earlier part of the 1990's, Ledstar was an industry leader in the application of LED technology.

The current industrial base is characterized by a number of weaknesses which need to be addressed in order to maintain competitiveness. These include:

- a large degree of reliance on shuttered fibre optic technology which is expected to become out-moded;
- a lack of a steady backlog of LED applications to maintain technical leadership;
- poor representation in the Japanese, European and Asia-Pacific markets, the latter two which are expected to provide the primary future areas of growth.

Control Centre Displays

Canada has demonstrated successes in the application of CRT projection technology and is a worldwide leader in the application software for partitioning of images among multiple projectors. Also, LED manufacturers such as Ledstar are developing large indoor LED media wall applications for other applications (notably casinos) which could be transferrable to the ITS arena. Another strength of Canadian

industry is the system integration role which focuses on the scoping of the application, specification, commissioning and integration of various control room display media.

Canada does not compete with Japanese and European suppliers of high resolution monitors and stand-alone rear projection systems. Furthermore, we are not technical leaders in the application of LCD light valve technology which is rapidly replacing CRT based projection systems.

In-Vehicle Displays

Canadian industry is not well positioned in the in-vehicle display market, and Canada is generally under represented in ongoing development of in-vehicle applications spearheaded by the world's automakers.

There are some applications in related industries which could help Canadian industry to establish presence in the in-vehicle market. These include research and development into heads-up displays and the development of voice interface products. In addition, Canada in general has a well developed software industry for graphics applications which could present opportunities for niche participation in the in-vehicle market.

Transit Passenger Information Systems

Canada has a number of demonstrated successes relevant to delivery of integrated passenger information systems. These include overall turnkey transit systems delivery/integration (e.g. Bombardier), LED display manufacturers (e.g. Telecité, Ledstar), transit voice announcement systems (Interalia), and transit scheduling/information system software (Teleride Sage).

With key enabling components well represented, the primary weakness in this area of the industry is lack of an integrated approach to marketing, particularly in the U.S. and in Europe.

5.3 OPPORTUNITIES FOR CANADIAN INDUSTRY

Niche opportunities which could be exploited by Canadian industry are summarized herein.

Canadian industry has demonstrated market leadership in LED variable message signs. Through continued research and development and application opportunities, Canada could maintain technical dominance in this market which would be instrumental in accessing growth markets in Asia-Pacific region. Canadian manufacturers could concentrate their efforts on development and manufacture of the display pixels, drivers, controllers, and related software which would be incorporated into

locally fabricated enclosures. At present, the industry alliances to market and manufacture displays for Asia and Europe along this model are not in place.

Canada maintains an existing niche in application software for large screen display technology. M3i has demonstrated an ability to access international markets, including Japan, through alliance with display system hardware vendors.

Canada's strength in ITS integration can come to bear in the development of control centre display systems and transit passenger information systems. Both applications typically require custom design and integration services in order to draw upon a stable of technologies to meet the customers specific requirements. More formal relationships between system integrators, software providers, and display system providers (foreign and domestic) could enhance the ability to access international markets.

Heads-up displays for the automotive market could be an area where Canadian aerospace and defense research can be brought to bear. The mechanism to do so would involve alliance with one of the automakers or a major automotive electronics supplier.

Regarding other in-vehicle display applications, Canadian industry can focus on software applications which provide multi-function motorist interfaces integrated onto a common display. This type of application would be of interest to a broad range of suppliers of in-vehicle navigation and entertainment systems. Furthermore the experience of foreign firms such as Amerigon indicate that there are niche opportunities for expertise in the areas of voice recognition/synthesis, applications which are transportable among a variety of products.

5.4 RECOMMENDATIONS AND PROPOSED COURSE OF ACTION

The following section presents recommendations for each stakeholder for the advancement of an ITS display industry in Canada. Each recommendation is supported by candidate measures which could be undertaken in order to address the recommendation.

Industry Canada and Transport Canada

1. **Foster the development of industry alliances to facilitate product development, marketing, manufacturing, and support for the international market for roadway and transit system displays.** This study has identified a number of Canadian interests with expertise in LED displays, transit voice annunciation, etc. These resources should be better aligned in order to address Asian and European markets for applications such as roadway variable message signs, and transit passenger information systems. These alliances would include Canadian firms in related industries and

local partners overseas. Specific measures which should be considered include:

- use the Strategis Website as a forum for exchanging information on ITS display system capabilities and market opportunities;
- represent Canada's ITS capabilities in trade missions to the Asia-Pacific region;
- introduce ITS industry participants to targeted high technology firms that are actively targeting emerging markets (e.g. Nortel);
- use embassies to gather information on upcoming projects and potential local partners including sign fabricators, electrical contractors, telecommunications industry, and system integrators.

2. **Provide a showcase for Canadian ITS expertise, including display components.** The experience with the Ministry of Transportation of Ontario COMPASS program suggests that state-of-the-art ITS applications can be deployed to meet Canadian needs and also serve as a showcase to the world market, generating significant export benefits. In the case of the COMPASS example, export revenues are estimated to be at least three times the original investment in the system deployment. The showcase, or "model deployment", is the current thrust of the U.S. program and provides the opportunity to bring together the various ITS industry strengths and demonstrate interoperability and operational benefits. Examples in the Canadian ITS arena could include an ATMS/ATIS for Vancouver or a Canada-wide commercial vehicle pre-clearance program. Specific measures which should be considered include:

   - work with targeted provincial, regional, and/or municipal levels of government to promote model deployment;
   - provide funding for model deployment, possibly through direct assignment of fuel tax revenues or the development of an information technology infrastructure program.

3. **Provide incentives for ITS display research and development in Canada.** Targeted areas would be further development of LED and LCD displays for roadway, control centre and transit applications, as well as development/integration of in-vehicle

display systems. Faced with intensive levels of public and private sector R&D funding under foreign programs, domestic programs must focus on specific niches with demonstrated market opportunities. Specific measures would include:

- use monetary incentives such as R&D tax breaks and access to Canadian research facilities to encourage automakers to increase their levels of research and development within Canada;
- fund research, development and productization through NSERC, NRC and IRAP programs;
- discretely identify ITS as a target area within the Technology Partnerships Canada Program to encourage public/private partnerships for research, development and productization;
- establish a program similar to the U.S. ITS IDEA Program which encourages the transfer of technologies from related applications to the ITS arena;
- spearhead the development of a research centre of excellence along the lines of the U.S. model drawing upon the ITS expertise at University of Calgary, McMaster University, and Queen's University.

4. **Participate in foreign ITS programs and standards initiatives in order to help facilitate access by Canadian industry.** For example, Transport Canada and the Ministry of Transportation of Ontario participate in the Enterprise consortium of U.S. state departments of transport. This provides the opportunity for Ontario ITS firms to participate in, or have access to, Enterprise-sponsored research and development activities. Specific measures to be considered include:

   - assume a more active role in proposing, funding, and directing R&D initiatives within the Enterprise consortium;
   - use the Strategis Website as a gateway to provide access to other online databases sponsored by the U.S. DOT, federal laboratories such as Turner-Fairbanks, and U.S. research centres of excellence;

- actively participate in standards processes including U.S. national ITS architecture, U.S. DOT Joint Program Office standards for ITS, and the EU DRIVE programs.

5. **Update this review of technology on a regular basis.** This report identifies various enabling technologies supporting a range of ITS display applications. Some emerging technologies such as LED are developing very rapidly. Periodic (e.g. annual) update bulletins to amend the contents of this report will help to keep this report useful as a reference tool for Industry Canada and the Canadian industrial base.

6. **Create an ITS Office within Industry Canada.** An ITS Office would serve as a national ITS industry focal point in order to:

   - track the progress of foreign and domestic ITS activities;
   - ensure that the recommendations as set forth herein are acted upon;
   - foster cooperation and information sharing among various industry participants;
   - showcase Canadian ITS achievements and activities within the international community;
   - represent Canadian industry/interests in international activities such as standards development;
   - support the coordination of international conferences, workshops, etc.

Other Public Sector

1. **Provide the opportunity to showcase Canadian ITS capabilities including display components.** The role of other levels of government and transit authorities would include establishment of a demonstration project scope, site and capital and operations funding. Other public sector agencies should accommodate the demonstration of advanced ITS display applications within their capital programs. Specific measures should include:

   - identification of roadway and transit system display requirements and review of the international market

with respect to products available and other agency experiences;

- scope the operational testing of prototype variable message signs or transit display systems;
- provide funding for operational tests;
- increase exposure to operational tests through objective evaluation, publications, conferences, etc.

2. **Provide incentives for increased research and development.** Specific measures to be considered include the provision of monetary incentives, access to Canadian research, and/or legislative mandates.

Industry Participants

1. **Pursue the development of media wall systems for application within ITS and other related applications.** The development of configurable hardware/software solutions for LED, LCD and LCD projection can be applied for ITS applications as well as other control room applications, casinos, advertising, etc. This presents opportunities for transportability of technologies to or from related industries, and provides the opportunity to offset development costs.

2. **Develop industry alliances to foster the productization, marketing, manufacturing, and support of ITS display products for the international market.** Existing VMS manufacturers should seek to establish a presence in the European and Asia-Pacific market through:

   - partnering with local sign fabricators;
   - combined marketing efforts with large high technology firms seeking to expand market share in these regions;
   - participation in international trade missions.

   Access to the on-board display system market could be achieved through the establishment of ties to the auto parts industries (e.g. Magna).

Research Organizations

1. **Foster the development of enabling technologies for ITS applications, and other related applications.** Specific technologies include LED displays, LCD, and voice recognition/synthesis.

2. **Strengthen links to industry in order to focus research on market needs and market products resulting from successful R&D programs.** Experience with other ITS solutions developed in academia, (such as Autoscope video vehicle detection originating from U of Minnesota) suggest that representation from the ITS industry is necessary to lend direction to research, and provide channels for productization, and international marketing, distribution and support.

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APPENDIX A

SURVEY QUESTIONNAIRES

ATTACHMENT A
ITS TECHNOLOGY SURVEY
ROADSIDE DISPLAY TECHNOLOGIES

1. What are your company's primary products and/or services?

2. In addition to displays, what other ITS products does your company produce?

3. Is/Was your company involved in the production/development of displays for other applications?

4. What specific strengths does your company bring to the Intelligent Transportation Systems market?

ROADWAY DISPLAYS

1. How long has your company been involved in producing displays?

2. List technology(ies) your organization is involved or is considering venturing into:

   -- LED
   -- Fibre optic
   -- Hybrid
   -- LCD
   -- Mechanical - rotating drum
   -- Other

3. Please specify the following performance specifications:

   -- viewing angle
   -- emitter luminance (in candela/m^2)
   -- contrast ratio

4. What type of controller is used?

5. What are the communication standards, protocols and interfaces utilized? Comment on compatibility of your product with existing standard interfaces/equipment.

6. Are your displays used in applications other than ITS?

7. What are the adverse operational considerations and how have you resolved them (i.e. heating/cooling, etc)?

8. What are the maintenance requirements?

9. What new types of displays/improvements of existing are currently under development?

DISTRIBUTION AND OPERATIONS

1. What are the typical display prices and how do they compare with competing/alternative technologies? What is your product target price?

2. Please indicate installed base of your equipment (ITS and non-ITS) and quantity deployed.

3. What market share does your product occupy and in what countries it is being (will be) sold?

4. How do you envisage your products changing over the next five years? What market penetration do you anticipate for your products over the next two years, five years, and ten years?

5. Have any specific barriers been encountered by your organization in selling your products on ITS markets (domestic or international)?

6. What are the primary domestic and international standards, regulations and laws which govern the production and marketing of your products or services?

ATTACHMENT B
ITS TECHNOLOGY SURVEY
CONTROL CENTRE DISPLAY TECHNOLOGIES

1. What are your company's primary products and/or services?

2. In addition to displays, what other ITS products does your company produce?

3. Is/Was your company involved in the production/development of displays for other applications?

4. What specific strengths does your company bring to the Intelligent Transportation Systems market?

CONTROL CENTRE DISPLAYS

1. How long has your company been involved in producing control centre displays?

2. List technology(ies) your organization is involved or is considering venturing into:

   -- Large Screen Projection Units:

      -- Front Projection CRT-based
      -- Rear Projection CRT-based
      -- Liquid Light Valve
      -- LCD Light Valve
      -- Projection Cube

   -- Video Monitors

   -- High Resolution Graphics Monitors

   -- Other

3. What are their main features/specifications?

4. What are the communication standards, protocols and interfaces utilized? Comment on the compatibility of your product with existing standard interfaces/equipment.

5. What routine maintenance is required?

6. What types of displays are currently under development?

DISTRIBUTION AND OPERATIONS

1. What are your display product prices and how do they compare with competing/alternative technologies? What is your product target price?

2. Please indicate installed base of your equipment (for ITS and non-ITS applications).

3. What market share does your product occupy and in what countries it is being (will be) sold?

4. How do you envisage your products changing over the next five years? What market penetration do you anticipate for your products over the next two years, five years, and ten years?

5. Have any specific barriers been encountered by your organization in selling your products on ITS markets (domestic or international)?

6. What are the primary domestic and international standards, regulations and laws which govern the production and marketing of your products or services?

ATTACHMENT C
ITS TECHNOLOGY SURVEY
IN-VEHICLE DISPLAY TECHNOLOGIES

1. What are your company's primary products and/or services?

2. In addition to displays, what other ITS products does your company produce?

3. Is/Was your company involved in the production/development of displays for other applications?

4. What specific strengths does your company bring to the Intelligent Transportation Systems market?

IN-VEHICLE DISPLAYS

1. How long has your company been involved in producing in-vehicle displays?

2. List technology(ies) your organization is involved or is considering venturing into:

   -- LCD
   -- CRT
   -- LED
   -- Head-up displays
   -- Synthesized Voice

3. How are the displays mounted in the vehicle?

4. What are their main features/specifications?

5. What are the communication standards, protocols and interfaces utilized? Comment on compatibility of your product with existing standard interfaces/equipment.

6. What information do they provide to the driver?

7. What type of processing device is used, if any? Are your displays configurable to support evolving ITS applications?

8. What routine maintenance is required?

9. What types of displays are currently under development?

DISTRIBUTION AND OPERATIONS

1. Are any of your displays offered as options in commercially available vehicles?

2. What is the cost compared to competing/alternative technologies? What is your product target price?

3. Please indicate the installed base of your equipment (for ITS and non-ITS applications).

4. What market share does your product occupy and in what countries it is being (will be) sold?

5. How do you envisage your products changing over the next five years? What market penetration do you anticipate for your products over the next two years, five years, and ten years?

6. Have any specific barriers been encountered by your organization in selling your products on ITS markets (domestic or international)?

7. What are the primary domestic and international standards, regulations and laws which govern the production and marketing of your products or services?

LISTING OF FIRMS CONTACTED

Advanced Display Systems
Amerigon
CAE
Computing Devices
Delco
Electrohome
Electrosonic
Federal Highway Administration
Ideal Visuel
Interalia
Japanese Traffic Management Association
Litton
Mando
Ministry of Transportation Ontario
Mobitec
M3i
New Jersey Transit
Sony
Toshiba
University of California PATH

APPENDIX B

INDUSTRY CONTACTS

B1 Canada
B2 U.S.
B3 EU
B4 Asia-Pacific

B1 Industry Contacts - Canada

COMPUTING DEVICES

ADDRESS: Ottawa, Ontario
K1G 3M9

CONTACT: Mr. Dave Scott, President
Tel: (613) 596-7000
Fax: (613) 596-7775

KEYWORDS: Video Display Systems, High Resolution Graphics Monitors.

HISTORY: Established in 1948.

ITS CAPABILITY: Manufacturer of vehicle electronics, display systems and communications systems for military applications. Display technologies include high resolution graphics monitors, graphics engines and generators. Technologies under development include flat panel LCD and EL displays. Not active is ITS market.

ITS PERSONNEL: No data

GROSS SALES: No data

PLANT SIZE: No data

EQUIPMENT: No data

ITS EXPERIENCE: No data

B1 Industry Contacts - Canada

Other Contacts (Ref. The International ITS Index, 1996)

LASM Technologies
(Division of Signalization LASM, Inc.)
7400 rue Vérité
Ville St-Laurent, Quebec H4S 1C5

Tel: (514) 333-8030/800-413-8030
(USA)/800-361-9909 (Canada)
Fax: (514) 333-0186

Summum Signs Inc.
2180, rue de Rouen
Montréal, Québec H2K 1L4

Tel: (514) 528-4900
Fax: (514) 528-4999

Teleride Sage Limited
156 Front Street West, 5th Floor
Toronto, Ontario M5J 2L6

Tel: (416) 596-1940
Fax: (416) 595-5653

Sirius Solutions Limited
One Research Drive, Suite 215
Dartmouth, Nova Scotia B2Y 4M9

Tel: (902) 456-2328
Fax: (902) 464-0931
E-Mail: sirius@sirius.ns.ca

Telecite, Inc.
Suite 400
Place du Canada
1010 de la Gauchetiére Street West
Montréal, Québec H3B 2N2

Tel: (514) 875-2483
Fax: (514) 875-6849

B1 Industry Contacts - Canada

INFOCITÉ GROUP INC.

ADDRESS:	2579 Chomedey Boulevard Laval, Quebec H7T 2R2
CONTACT:	Daniel Chevalier, President Tel: (514) 978-1230 Fax: (514) 978-8811
KEYWORDS:	LED Displays, VMS, Lane Use Signals, Variable Speed Limit Signs
HISTORY:	No data
ITS CAPABILITY:	Outdoor LED Displays
ITS PERSONNEL:	No data
GROSS SALES:	No data
PLANT SIZE:	No data
EQUIPMENT:	No data
ITS EXPERIENCE:	Boston Central Artery/Tunnel, Milwaukee FTMS, Montreal ATMS, MTA Bridges & Tunnels, New York, Port Authority of New York and New Jersey.

B1 Industry Contacts - Canada

INTERALIA INC.

ADDRESS: 4110-79 Street N.W.
Calgary, Alberta
T3B 5C2

CONTACT: Mr. Bob Cormac, V.P. Operations
Tel: (403) 288-2076
Fax: (403) 288-5935

KEYWORDS: Digitized Vice, Transit Information Systems

HISTORY: Established in 1975. A Canadian company with branches in the U.S. and United Kingdom

ITS CAPABILITY: Interalia is a designer and manufacturer of digital voice announcement systems for transit operations

ITS PERSONNEL: No data

GROSS SALES: No data

PLANT SIZE:: No data

EQUIPMENT: No data

ITS EXPERIENCE: Installed on-board train announcement systems in Vancouver, B.C.; Detroit, Michigan and Stenstead, U.K.

B1 Industry Contacts - Canada

LEDSTAR, INC.

ADDRESS:	315 Flint Road Downsview, Ontario M3J 2J2
CONTACT:	Mr. Vince McEwan Tel: (416) 663-8500 Fax: (416) 663-8552
KEYWORDS:	LED VMS
HISTORY:	No data
ITS CAPABILITY:	LED VMS
ITS PERSONNEL:	No data
GROSS SALES:	No data
PLANT SIZE:	No data
EQUIPMENT:	No data
ITS EXPERIENCE:	COMPASS, Toronto, Arizona DOT, Virginia DOT

B1 Industry Contacts - Canada

LITTON SYSTEMS

ADDRESS: 25 City View Drive
Etobicoke, Ontario
M9W 5A7

CONTACT: Mr. Tom McGuigan, Litton Systems
Tel: 249-1231 ext. 2430
Fax: 246-2955

KEYWORDS: Flat Panel Displays, LED Displays, LCD Displays, Navigation Systems.

HISTORY: Established in 1961. Litton Systems is a major operating division of Litton Industries.

ITS CAPABILITY: Litton Systems manufactures large panel displays and in-vehicle displays for military applications. Not active in ITS.

ITS PERSONNEL: No data

GROSS SALES: No data

PLANT SIZE: No data

EQUIPMENT: No data

ITS EXPERIENCE: No data

B1 Industry Contacts - Canada

MARK IV INDUSTRIES

ADDRESS: 6020 Ambler Drive
Mississauga, Ontario
L4W 2P1

CONTACT: Mr. Kelly Gravelle, VP
Tel: (905) 624-3025
Fax: (905) 624-4572

KEYWORDS: Fibre Optic VMS, LED VMS, electra-magnetic VMS

HISTORY: No data

ITS CAPABILITY: VMS, vehicle roadside communications, transit passenger information systems.

ITS PERSONNEL: No data

GROSS SALES: No data

PLANT SIZE: No data

EQUIPMENT: No data

ITS EXPERIENCE: Long Island INFORM, Ministry of Transportation Ontario, IAG E-Z Pass, HELP.

B1 Industry Contacts - Canada

ELECTROHOME LIMITED

ADDRESS: 809 Wellington Street North
Kitchener, Ontario
N2G 4J6

CONTACT: Mr. G. Remers, Director of Marketing
Tel: 519-744-7111
Fax: 519-749-3136

KEYWORDS: LCD Projectors, CRT Projectors, Rear Screen Projectors, 3 Lens Projectors, High Resolution Graphics Monitors.

HISTORY: A Canadian, public company founded in 1907.

ITS CAPABILITY: Electrohome Projection Systems and Display Systems divisions manufacture high resolution video/data/graphics projection systems and monitors for traffic control centre applications.

ITS PERSONNEL: No data

GROSS SALES: 130 MILLION U.S.

PLANT SIZE: 400,000 sq. ft.

EQUIPMENT: No data

ITS EXPERIENCE: No data

B1 Industry Contacts - Canada

M3I SYSTEMS INC.

ADDRESS: 1111 St-Charles West
Suite 135, East Tower
Longueuil, Quebec
J4K 5G4

CONTACT: Mr. Richard Gobeil, Project Manager
Tel: (514) 928-4600
Fax: (514) 442-5076

KEYWORDS: Large Screen LCD Projectors, Mosaic Displays, High Resolution Graphics Monitors.

HISTORY: Canadian manufacturing company.

ITS CAPABILITY: M3i manufacturers display systems for traffic control centre applications.

ITS PERSONNEL: No data

GROSS SALES: No data

PLANT SIZE: No data

EQUIPMENT: No data

ITS EXPERIENCE: M3i supplied large panel mosaic display for Traffic Control Centre in Tokyo.

B1 Industry Contacts - Canada

TELE-SPOT SYSTEMS

ADDRESS: 13 Holland Drive, Unit 7
Bolton, Ontario
L7E 5S6

CONTACT: Mr. Daryl Schneider
Tel: (905) 857-5544
Fax: (905) 857-5577

KEYWORDS: Fibre Optic VMS, LED VMS, Electramagnetic VMS

HISTORY: Founded 1970.

ITS CAPABILITY: VMS

ITS PERSONNEL: No data

GROSS SALES: No data

PLANT SIZE: No data

EQUIPMENT: No data

ITS EXPERIENCE: Long Island INFORM, Ministry of Transportation Ontario, BC Ministry of Transportation and Highways, Lincoln & Holland Tunnels, New York, Dan Ryan Expressway, Illinois, Ft. McHenry Tunnel, Maryland.

B2 Industry Contacts - U.S.

AMERICAN VIDEO COMMUNICATIONS

ADDRESS: 10650 Humbolt Street
Los Alamitos, California 90720

CONTACT: Mr. John Higgins, Account Manager, Trooper Division
Tel: 310-493-3771/800-443-7802
Fax: 310-598-5380

KEYWORDS: Rear Screen Projection

HISTORY: No data

ITS CAPABILITY: No data

ITS PERSONNEL: No data

GROSS SALES: No data

PLANT SIZE: No data

EQUIPMENT: No data

ITS EXPERIENCE: No data

B2 Industry Contacts - U.S.

AMERIGON INC.

ADDRESS: 404 East Huntington Drive
Monrovia, California 91016-3600

CONTACT: Mr. Zaya S. Younan, V.P. Sales and Marketing
Tel: (818) 932-1200 (Z.Y.'s# 818-932-1277)
Fax: (818) 932-1220

KEYWORDS: Voice Interactive Systems, Side Vision Sensors, Collision Warning Systems

HISTORY:

ITS CAPABILITY: Amerigon develops advanced automotive technologies - electronics and ITS. The company is transferring defense and aerospace technology to automotive applications

ITS PERSONNEL: Engineers - 42

GROSS SALES: No data

PLANT SIZE: No data

EQUIPMENT: No data

ITS EXPERIENCE: Amerigon Inc. has developed AudiNav, an interactive voice navigation system for in-vehicle applications.

B2 Industry Contacts - U.S.

ELECTROSONIC SYSTEMS INC.

ADDRESS: 10320 Bren Road East
Minneapolis, Minnesota 55343

CONTACT: Mr. Karl Johnson
Tel: 612-938-7508
Fax: 612-938-9311

KEYWORDS: Large screen projection systems, video walls, high resolution graphic monitors.

HISTORY: No data

ITS CAPABILITY: Manufacturer of high resolution graphics/video/data displays. Electrosonic specializes in integrating multiple computer and video sources onto a high resolution graphics displays.

ITS PERSONNEL: No data

GROSS SALES: No data

PLANT SIZE: No data

EQUIPMENT: No data

ITS EXPERIENCE: Electrosonic supplied video solutions for Texas Department of Transportation

B2 Industry Contacts - U.S.

Other Contacts (Ref. The International ITS Index, 1996)

AGS Group/Amsign Corporation
749 New Ludlow Road
P.O. Box 817
South Hadley, Massachusetts 01075

Tel: (413) 535-2100/800-VMS-SIGN
Fax: (413) 535-1105

American Signal Company
3649 Clearview Parkway
Atlanta, Georgia 30340

Tel: (404) 458-7278
Fax: (404) 458-1613

Clever Devices Ltd.
133 Glenwood Landing
Glenwood Landing, New York 11547

Tel: (516) 674-8000
Fax: (516) 674-8067

Digital Recorders, Inc.
P.O. Box 14068
Research Triangle Park, North Carolina
27709-4068

Tel: (919) 361-2155
Fax: (919) 361-2947

Echelon Industries, Inc.
556 N. Diamond Bar Blvd., Suite 202
Diamond Bar, California 91765

Tel: (909) 861-3881
Fax: (909) 861-8251

Glenayre Digital Systems, Inc.
4201 Congress Street, Suite 455
Charlotte, North Carolina 28209

Tel: (704) 553-0038
Fax: (704) 553-0524

American Electronic Sign
Spokane Industrial Park, Building #10
3808 North Sullivan Road
Spokane, Washington 99216-1670

Tel: (509) 928-2296/800-727-9111
Fax: (509) 928-2968

C.J. Hood Co.
76 Progress Drive
Stamford, Connecticut 06902

Tel: (203) 348-8688
Fax: (203) 316-5155

Daktronics
P.O. Box 5128
331 32nd Ave.
Brookings, South Dakota 57006

Tel: (605) 697-4302/800-843-5843
Fax: (605) 697-4700

E-Systems, a Raytheon Company
P.O. Box 660248
Dallas, Texas 75266

Tel: (214) 661-1000
Fax: (214) 661-8508

Fiberoptic Display Systems, Inc.
90 Douglas Pike
Smithfield, Rhode Island 02917

Tel: (401) 232-3370
Fax: (401) 232-7130

I.D. Systems, Inc.
325 Broadway, Suite 504
New York, New York 10007

Tel: (212) 267-5444
Fax: (212) 962-7300

B2 Industry Contacts - U.S.

ADVANCED DISPLAY SYSTEMS INC.

ADDRESS: 1399 Executive Drive West, Suite 1
Richardson, Texas 75089

CONTACT: Mr. Joseph Zhou
Tel: 214-644-7796
Fax: 214-644-7967

KEYWORDS: Variable Message Signs LCD Displays, In-vehicle Displays.

HISTORY: Privately owned U.S. firm.

ITS CAPABILITY: Advanced Display Systems Inc. is a manufacturing company developing LCD displays for roadway and in-vehicle applications. The technology, still under development, employs backlighting to increase luminosity.

ITS PERSONNEL: No data

GROSS SALES: No data

PLANT SIZE: No data

EQUIPMENT: No data

ITS EXPERIENCE: No data

B2 Industry Contacts - U.S.

International Business Machines Corporation (IBM)
Old Orchard Road
Armonk, New York 10504

Lake Technology Products, Inc.
28248 County Road 561
P.O. Box 267
Tavares, Florida 32778

Tel: (904) 742-1777/800-771-1799
Fax: (904) 742-8444

Multisystems, Inc.
10 Fawcett Street
Cambridge, Massachusetts 02138-1110

Tel: (617) 864-5810
Fax: (617) 864-3521

Skyline Products, Inc.
2903 Delta Drive
Colorado Springs, Colorado 80910

Tel: (719) 392-9046/800-759-9046
Fax: (719) 392-3839

Interplex Solar, Inc.
1003 West Thomas Street
Arlington Heights, Illinois 60004

Tel&Fax: (708) 392-1976

McCain Traffic Supply, Inc.
2575 Pioneer Avenue
Vista, California 92083

Tel: (619) 727-8100
Fax: (619) 727-8184

Orbital Sciences Corporation
(previously Fairchild Space and Defense Corporation)
20301 Century Boulevard, MS B-14
Germantown, Maryland 20874

Tel: (301) 428-6023
Fax: (301) 428-6466

Vultron, Inc.
2600 Bond Street
Rochester Hills, Michigan 48309

Tel: (810) 853-2200
Fax: (810) 853-7571

B3 Industry Contacts - EU

IDEAL VISUEL INTERNATIONAL

ADDRESS: ZAT du Perray
4 rue R. Le Ricollais
Nantes, France 44300

CONTACT: Christian Mellet, Expert for Northern Europe
Tel: (33)40 93 90 40
Fax: (33)40 52 26 64

KEYWORDS: Large Screen Display Systems, LED, LCD, Video Walls, Road Traffic Displays, VMS.

HISTORY: Ideal Visuel International has been manufacturing displays since 1988.

ITS CAPABILITY: Ideal Visuel International is a designer and manufacturer of a wide range of display systems including LCD, three gun projectors, video walls, and LED flat panel displays. The company also manufacturers VMS, outdoor video and graphic colour displays and multiline panels for toll systems.

ITS PERSONNEL: No data

GROSS SALES: No data

PLANT SIZE: No data

EQUIPMENT: No data

ITS EXPERIENCE: ITS applications include the main control room for Barcelona, Spain, Department of Transportation and City of Lyon Traffic Control Room and Police Command Centre. Ideal Visuel supplied the world's largest LED display panel (24 m x 3 m) for the English Tunnel's main control room at Folkestone, U.K.

B3 Industry Contacts - EU

Other Contacts (Ref. The International ITS Index, 1996)

Altaroute
6 The Beeches Industrial Estate
Yate
Bristol
UK-BS17 5QX
United Kingdom

Tel: 44-1454-311475
Fax: 44-1454-273065

ComFuture Europe
Klaterbos 36
Hoofddorp
NL-2134 JE
The Netherlands

Tel: 31-2-50-32-20-39
Fax: 31-2-50-32-53-41

EDS CVI
Electronic Data Services
Centrum Voor Informatieverwerking
Croeselaan 22
Utrecht
NL-3521 CB
The Netherlands

Mailing Address:
Postbox 2233
NL-3500 GE
The Netherlands

Tel: 31-30-924211
Fax: 31-30-924651

Ferrograph
4 Jesmond Road
Newcastle-upon-Tyne
UK-NE2 4PWQ
United Kingdom

Tel: 44-191-281-9222
Fax: 44-191-281-9027

ComFuture
3 Tuval Street
Ramat Gan
52522
Israel

Tel: 972-3-7510940
Fax: 972-3-7522935

Dambach
Electrical Engineering Division
Adolf-Dambach-straße
Postfach 1240
Gaggenau
D-7560
Germany

Tel: 49-7225-64-01
Fax: 49-7225-64-300

EEV
106 Waterhouse Lane
Chelmsford
Essex
U.K.-CM1 2QU
United Kingdom

Tel: 44-1245-493-493
Fax: 44-1245-492-492

Forest City
Park Road
Timperley
Altringham
Cheshire
UK-WA14 5QX
United Kingdom
Tel: 44-161-969-0441
Fax: 44-161-905-1408

B3 Industry Contacts - EU

GTMH
72 rue Gabriel Péri
Montrouge
F-92120
France

Mailing Address:
P.O. Box 370
Montrouge Cedex
F-92-541
France

Tel: 33-1-46-56-42-00
Fax: 33-1-46-56-42-01

Hewlett-Packard GmbH
Herrenbergerstrasse 124
Böblingen
D-71034
Germany

Tel: 49-7031-14-2196
Fax: 49-7031-14-2216

Lacroix Technologie
Zl 1 avenue 11 rue
Carros
F-06516
France

Tel: 33-92-08-43-00
Fax: 33-92-08-43-19

Prisma
Västergatan 4
Malmö
S-211 21
Sweden

Tel: 46-40-757-90
Fax: 46-40-757-98

Häni-Prolectron AG
Industriestrasse
Bronschofen
CH-9552
Switzerland

Tel: 41-73-203-111
Fax: 41-73-225-402

Kolmikanta
Mittatie 17
Vantaa
FIN-01260
Finland

Tel: 358-0875-1599
Fax: 358-0875-1547

Microtima Traffic Informatics
Ouseburn Mews
3-7 Stepney Bank
Newcastle upon Type
UK-NE1 2PW
United Kingdom

Tel: 44-191-230-4411
Fax: 44-191-230-4422

Rainford Group
Mill Lane
Rainford
St Helens
Merseyside
UK-WA11 8LS
United Kingdom

Tel: 44-1744-884721
Fax: 44-1744-882022

B3 Industry Contacts - EU

R-R Industrial Controls
Kingsway
Team Valley
Gateshead
Tyne and Wear
UK-NE11 0QJ
United Kingdom

Tel: 44-191-4870811
Fax: 44-191-4820006

Securité et Signalisation
35 A
39 avenue du Danemark
BP 0267
Tours Cedex
F-37002
France

Tel: 33-47-62-66-26
Fax: 33-47-54-28-97

Signature Industries
Tom Cribb Road
Thamesmead
London
UK-SE28 0BH
United Kingdom

Tel: 44-181-316-4477
Fax: 44-181-854-5149

Solari di Udine SpA
Via Gino Pieri 29
Udine
I-33100
Italy

Tel: 39-432-497205
Fax: 39-432-480160

Sabik
Pellinki
FIN-070370
Finland

Tel: 358-15-540-719/358-15-540-809
Fax: 358-15-540-810

Siemens Traffic Controls
Sopers Lane
Poole
Dorset
UK-BH17 7ER
United Kingdom

Tel: 44-1202-782-000
Fax: 44-1202-782-435

Signaux Girod
Société Française de Signalisation
BP 4
Bellefontaine
Morez Cedex
F-39401
France

Tel: 33-84-34-61-00
Fax: 33-84-34-61-10

Techspan
Church Lane
Chalfont St. Peter
Buckinghamshire
UK-SL9 9RF
United Kingdom

Tel: 44-1753-889911
Fax: 44-1753-887496

B3 Industry Contacts - EU

Verenigd Streekvervoer Nederland
Groep - VSN
Graadt van Roggenweg 300
Utrecht
NL-3511 AH
The Netherlands

Mailing Address:
Postbus 19222
Utrecht
NL-3501 DE
The Netherlands

Tel: 31-30-97-18-00
Fax: 31-30-93-82-45

Zelisko
Steinfeldergasse 12
Mödling
A-2340
Austria

Tel: 43-22-36-406
Fax: 43-2236-406-299

MANDO MACHINERY CORPORATION

ADDRESS: P.O. Box 2
Duk-So
Kyung Ki-Do
South Korea

CONTACT: Mr. Hee Su Jin, Chief Engineer
Tel: 82-346-68-6211 ext. 6300
Fax: 82-346-68-3288

KEYWORDS: In-Vehicle Navigation, Collision Warning System, Head-Up Displays, LCD, Synthesized Voice.

HISTORY: Mando Machinery has been developing in-vehicle navigation technology since 1990. The company was founded in 1962 and manufactures automobile components.

ITS CAPABILITY: Mando machinery produces in-vehicle navigation systems and collision warning systems.

ITS PERSONNEL: 31 total

GROSS SALES: No data

PLANT SIZE: No data

EQUIPMENT: No data

ITS EXPERIENCE: No data

B4 Industry Contacts - Asia Pacific

SONY ELECTRONICS INC.

ADDRESS: 1 Sony Drive
Park Ridge, New Jersey 07866-8003

CONTACT: Mr. Doug Wilsterman, V.P. Mobile Electronics Division

Tel: 1-201-930-6994
Fax: 1-201-930-1000

KEYWORDS: LCD Projectors, CRT Projectors, Rear Screen Projection Systems, High Resolution Graphics Monitors, In-Vehicle Navigation Systems, In-Vehicle LCD Displays.

HISTORY: Sony is a large electronics company based in Japan with factories in the U.S. and East Asia.

ITS CAPABILITY: Sony designs and manufactures in-vehicle navigation and display systems, large screen display systems and high resolution graphics monitors.

ITS PERSONNEL: No data

GROSS SALES: No data

PLANT SIZE: No data

EQUIPMENT: No data

ITS EXPERIENCE: No data

B4 Industry Contacts - Asia Pacific

TOSHIBA AMERICA CONSUMER PRODUCTS

ADDRESS: 82 Totowa Road
Wayne, New Jersey 07470

CONTACT: Mr. Douglas Turner, Director of Marketing
Tel: 1-201-682-8000
Fax: 1-201-682-0672

KEYWORDS: Colour LCD displays, In-Vehicle Displays, In-Vehicle Navigation Systems.

HISTORY: Toshiba America Consumer Products is a division of Toshiba America Inc.

ITS CAPABILITY: Toshiba is developing colour LCD display panels for in-vehicle navigation systems. The product is planned for release in 1996.

ITS PERSONNEL: No data

GROSS SALES: No data

PLANT SIZE: No data

EQUIPMENT: No data

ITS EXPERIENCE: No data

B4 Industry Contacts - Asia Pacific

Other Contacts (Ref. The International ITS Index, 1996)

Fujitsu Ten
1-2-28 Gosho-dori
Hyogo-ku
Kobe 652
Japan

Tel: 81-78-671-5081
Fax: 81-78-671-7160

Kyosan Electric
Traffic Control Department
2-10-5 Kamisueyosi
Turumi-ku
Yokohama
Japan

Tel: 81-45-575-8860
Fax: 81-45-575-1844

Sumitomo Electric Industries
Systems and Electronics Group
3-12 Moto-akasaka 1-chome
Minato-ku
Tokyo 107
Japan

Tel: 81-3-3423-5634
Fax: 81-3-3423-5680