GREATER PORTLAND INTELLIGENT TRANSPORTATION SYSTEMS (ITS) EARLY DEPLOYMENT PLAN

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GREATER PORTLAND
INTELLIGENT TRANSPORTATION SYSTEMS (ITS)
EARLY DEPLOYMENT PLAN

Prepared By:

Portland Council Governments

Prepared For:

Greater Portland Council of Governments

Intelligent Transportation Systems Early Deployment Plan Advisory Committee

March,

Greater Portland Intelligent Transportation Systems Early Deployment Plan Advisory Committee

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1. INTRODUCTION

The Greater Portland Intelligent Transportation Systems Early Deployment Plan is a strategic vision of how "smart" technology can be applied to help improve mobility in Maine's largest metropolitan area. The Early Deployment Plan was produced by staff from the Greater Portland Council of Governments working in close collaboration with a group of stakeholders constituted as the Plan Advisory Committee. Funding was provided through a grant from the Federal Highway Administration, with matching funds from Greater Portland Council of Governments member communities.

Intelligent transportation systems (ITS) are developing as the creative convergence of advances in communications and electronics. ITS technologies are being deployed to disseminate traveler information, improve traffic flow, optimize transit system performance, and in a myriad of other transportation applications. The promise of lTS is to improve the operations of transport facilities and services while also making both more user-friendly. A national effort has been taking place - given great impetus with creation of Intelligent Vehicle Highway Systems Act included in the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991 - to bring this promise to life.

1.1 Purpose

"To move ITS from research, prototyping, and pilot projects into routine usage, decision makers at the corporate, state, regional, and local levels need reliable information about the contribution that ITS products can make toward meeting the demandfor safe and efficient movement of people and goods."[1]

Although Maine is primarily a rural state, millions of visitors and seasonal residents arrive each year. To a large extent, Greater Portland - as the state's transportation hub as well as commercial and cultural center - is Maine's gateway. From cruise ship passengers who Iand in Portland for only a few hours, to weekend shoppers at the Old Port and Freeport, to summer-long residents, visitors to the region all need accurate and user-friendly travel information. Intelligent Transportation Systems (ITS) can provide this information to people through the Internet, at "smart kiosk" terminals, and by the in-vehicle navigation systems being deployed now in several areas around the country.

Greater Portland, like most parts of the country, has limited resources for transportation investments. ITS technology can make more efficient use of existing road and transit capacity used by year-round residents and visitors alike. Better coordination of traffic signals and more flexible signal timing plans, as well as - for the Maine Turnpike - electronic toll payment can expedite automobile and truck travel. lTS technology can also improve transit operating efficiency through automated vehicle location, "smart card" electronic fare payment, and computer-assisted trip planning and dispatching.

The purpose of the Early Deployment Plan is to inform decision-makers about the strategic contribution that ITS can make to the region's mobility needs. The strategic vision and recommended investment program set forth in this document are intended to be guides to action by those who make or support key transport investments in the region: the Maine Department of Transportation (MDOT) and Maine Turnpike Authority (MTA), the Portland Area Comprehensive Transportation Committee (PACTS), area public transit boards, Portland area cities and towns, and the corporate community. Although the vision and

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1 Intelligent Transportation Infrastructure Benefits: Expected and Experienced, USDOT, January 1996, p. iv.

recommended investment program contained in the Early Deployment Plan may take many years to realize - and will no doubt need alteration over time to reflect new realities and opportunities - the strategic direction set forth should be a valuable guide toward effective use of "smart" technology.

1.2 Process

Development of the Greater Portland Intelligent Transportation Systems Early Deployment Plan has been overseen by an Advisory Committee that met ten times between January 8, 1997 and January 14. 1998. During this series of meetings, the Advisory Committee received briefings on ITS applications, benefits and costs, a framework for ITS evaluation and priority-setting, and a draft report of findings and recommendations. In addition, staff prepared two supplemental reports: Briefing Paper #1 Advanced Traveler Information Systems and Briefing Paper #2 Advanced Public Transit Systems3 for Advisory Committee review. [Parts of an intended Briefing-r #3: Advanced Traffic Management Systems' have been incorporated into the Early Deployment Plan. This third Briefing: Paper is alsobeing issued as a separate document.]

The Advisory Committee and staff approached Early Deployment Plan development as strategic. rather than project-level planning within a regional framework. While certain ITS technologies, such as automated vehicle location for Portland area transit providers, are described and prioritized as part of a recommended regional investment program, the Early Deployment Plan does not set forth in detail how such a technology should be deployed. That tactical-level task will need to be undertaken by the implementing agency, in this case one or more Greater Portland public transit operators, before such a project is actually implemented. The Greater Portland ITS Early Deployment Plan development process consisted of several elements, as follows:

- ***Assemble Stakeholder Committee***

The Greater Portland Intelligent Transportation Early Deployment Plan Advisory Committee, chaired by Portland Transportation and Waterfront Facilities Director Thomas Valleau served this function. A full listing of Advisory Committee members is contained on the Early Deployment Plan inside cover.

- ***Develop EDP Goals, Assess ITS Market Packages, Raise Awareness***

The Advisory Committee adopted the following set of ITS Early Deployment Plan Goals to guide the planning process:

- ***More Accessible and Complete Travel Information***
- ***More Efficient, -Cost-effective Transportation System***
- ***Safer Travel***
- ***Cleaner Air***

2 Greater Portland Council of Governments, July 1997.
3 Greater Portland Council of Governments, September 1997.
4 Greater Portland Council of Governments, February 1998.

- ***More Energy-efficiency***

- ***Economic Development***

- ***Improved Interagency Coordination/Cooperation***

.A long list of "Market Packages". or clusters of related ITS applications, identified by the USDOT was reviewed for applicability in the Portland region. Advisory Committee staff combined related Market Packages into larger bundles and presented and described a "short list" of large Market Packages for Committee consideration. [As an example, the six public transit Market Packages were grouped together as one Advance Public Transit Systems package. The Advisory Committee determined that three large "families" of ITS applications had most applicability to Greater Portland: Advanced Traveler Information, Advanced Public Transit Systems. and Advanced Traffic Management. Staff then prepared and delivered Committee briefings on each of these three clusters of applications.

In addition. a variety of ITS awareness-building activities - including organization of the first Maine ITS Symposium and Vendor Exhibition - were undertaken by the Advisory Committee and staff in order to become better informed about ITS capabilities, A list of awareness-raising activities follows:

* Participation by the principal Advisory Committee staff member in an October 30, 1996 ***Early Deployment Planning Seminar*** conducted by the Federal Highway Administration in Washington, D.C. for Early Deployment Plan grant award recipients.

* Participation by two Committee members and a member of the Committee staff in the February 24-25. 1997 ***Atlanta ITS Executive Scan Tour and Workshop*** given by the U.S. Department of Transportation. A summary report of what was learned on the Tour and Workshop was prepared and delivered to the Advisory Committee.

* Sponsorship of the first ***Maine ITS Symposium and Vendor Exhibition,*** held at the University of Southern Maine on March 28, 1997 Many Advisory Committee members and staff attended this event.

* Conduct by Council of Governments staff. under Advisory Committee auspices, of an ***ITS Users' Focus Group*** in conjunction with the Maine ITS Symposium and Vendor Exhibition. Focus group participants toured ITS vendor exhibits and then participated in a structured discussion of what they learned. A report of focus group findings was presented to the Advisory Committee.

* A presentation at the June 18, 1997 Advisory Committee meeting by an executive with ***SmartRoute Systems*** on use of ITS in Boston and other metropolitan areas to disseminate traveler information. Information packets on SmartRoute were also made available at subsequent Advisory Committee meetings for those members who were unable to attend the June 18" presenthion.

5 ITS Strategic Assessments, Federal Highway Administration and Federal Transit Administration, October 26. 1996. pp. Al-A39.

* Sponsorship of ***a Federal Highway Administration ITS Awareness Seminar,*** held at the Council of Government offices on June 35, 1997. Many Advisory Committee members and staff attended this event. Federal Highway Administration ITS publications brought to this event were also made available at subsequent Advisory Committee meetings for those members who were unable to attend the Awareness Seminar.

* Participation bv many Advisory Committee members and staff in an August 20, 1997 ***Maine Turnpike Transpass and Changeable Message Sign Deployment Site Tour*** sponsored by both the Maine Turnpike Authority and HNTB consulting engineers for the Turnpike.

* Participation of two Advisory Committee members in the August, 1997 ***Rural Advanced Technology and Transportation Systems International Conference*** in Bozeman, Montana.

* Participation as a scholarship recipient by the principal Advisory Committee staff member in the November 9-14, 1997 ***Intelligent Transportation Systems Southwest U.S. Study Tour*** sponsored by the Institute of Transportation Engineers.

- ***Develop Evaluation Framework***

Advisory Committee staff presented and Advisory Committee adopted a simple evaluation framework for comparative assessment of the contribution of single ITS applications or sets of interrelated applications defined as a "project". This framework, which is described in more detail within Section 5.3.2 of this document, relates probable contribution of a given ITS proposal (application or "project") to regional ITS Goals adopted by the Advisory Committee.

- ***Define Regional ITS "Projects"***

Committee staff prepared a program of hypothetical ITS "projects" (also described as "scenarios" to better differentiate them from individual ITS applications) for Advisory Committee review. The Advisory Committee subsequently revised the staff proposals to create the program of ITS projects described in Section 5.4.

- ***Evaluate Regional ITS "Projects" or "Scenarios"***

After revisions to initial draft program by the Advisory Committee, staff rated each "project", as well as each constituent application within it, using the adopted evaluation framework. The Advisory Committee in turn reviewed the results of staff evaluation and then adopted a regional program of ITS projects in priority order.

- ***Issue Draft and Final Report of Findings and Recommendations***

Staff prepared and presented to the Advisory Committee a draft of this document. After Advisory Committee review, a final report of findings and recommendations in the form of the Greater Portland Intelligent Transportation Systems Early Deployment Plan will be issued.

1.3 Contents

The remainder of the Early Deployment Plan consists of Chapters 2 through 6 as follows: Chapter 2 **- Executive Summary;** Chapter 3 **- What is ITS?;** Chapter 4 - **ITS Costs and Benefits;** Chapter 5 **- Recommended Directions for the Greater Portland Region;** Chapter 6 **- Paths Not Chosen for the Greater Portland Region.** Each contains sections that treat important topics within the chapter heading.

Chapter 3 comprises summaries of the three broad Market Packages that hold the most promise for application to Greater Portland. These are Advanced Traveler Information Systems (ATIS), Advanced Public Transit Systems (APTS), and Advanced Traffic Management Systems (ATMS). Chapter 4 describes what is known about the benefits and costs of seven major types of ITS applications. Chapter 5 includes a description of regional ITS functional requirements and system architecture. institutional issues, and funding opportunities; a recommended program of ITS projects for the Portland region. in priority order with suggested phasing; a presentation of a regional ITS evaluation framework or model and results of its application to proposed Greater Portland lTS projects; recommendations for outreach and education: and regional lTS program of projects implementation steps. Chapter 6 discusses various types of ITS applications not considered or recommended in the Early Deployment Plan and why.

II. EXECUTIVE SUMMARY

Introduction -

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Greater Portland, like most parts of the country, has limited resources for transportation investments. ITS technology can make more efficient use of existing road and transit capacity used by year-round residents and visitors alike. Better coordination of traffic signals and more flexible signal timing plans, as well as - for the Maine Turnpike - electronic toll payment canexpedite automobile and truck travel. ITS technology can also improve transit operating efficiency through automated vehicle location, "smart card" electronic fare payment, and computer-assisted trip planning and dispatching.

The purpose of the Early Deployment Plan is to inform decision-makers about the strategic contribution that ITS can make to the region's mobility needs. The strategic vision and recommended investment program set forth in this document are intended to be guides to action by those who make or support key transport investments in the region: the Maine Department of Transportation (MDOT) and Maine Turnpike Authority (MTA), the Portland Area Comprehensive Transportation Committee (PACTS), area public transit boards, Portland area cities and towns, and the corporate community. Although the vision and recommended investment program contained in the Early Deployment Plan may take many years to realize - and will no doubt need alteration over time to reflect new realities and opportunities - the strategic direction set forth should be a valuable guide toward effective use of "smart" technology.

Intelligent Transportation Systems Applications

The United States Department of Transportation has defined Intelligent Transportation Systems (ITS) in the following way: "The application of sensor, computer, electronics, and communications technologies and management strategies in an integrated manner.. . to increase the safety and efficiency of the surface transportation systems." [1] While ITS deployments from computerized traffic signal systems to automated transit location systems predate the passage of the Intermodal Surface Transportation Efficiency Act (ISTEA) in 199 1, ISTEA established a national commitment to what was then termed Intelligent Vehicle and Highway Systems (IVHS). The name change to ITS signified the recognition that public transit and traveler information systems were key parts of a comprehensive approach to applying advances in electronics and communications as tools for improving the nation's mobility of goods and people.

The USDOT defines fifty-three ITS "market packages" and thirty more broadly defined ITS "user services" (see Appendix A for complete lists). The DOT market packages are group into larger sets of related ITS applications, as follows: Traffic Management, Public Transportation, Traveler Information, Advanced Vehicle Safety, Commercial Vehicle Operations, Emergency Management, and Planning.' Greater Portland ITS Early Deployment Plan Advisory Committee and staff have used three of these broad groupings as a basis for plan development:

* *Advanced Traffic Management Systems*
* *Advanced Public Transit Systems*
* *Advanced Traveler Information Systems*

- **Traveler Information (ATIS)**

"While teaching people to use ATIS is a considerable challenge in behavior modification, the research is clear that the use *of ATIS, increasing over time, is a powerful tool for changing the route, time or mode of drivers' travels "2.*

Traveler information systems are a key component of ITS strategic planning. The purpose of ATIS deployment is to provide the traveling public with the right information at the right time to help make better, or at least more informed, choices. ATIS offer such supportive information to the traveler in four phases:

1. *Planning of the Trip (Pre-Trip Information)*
2. *Making of the Trip (En-Route Information)*
3. *Connections/ Transfer Points (Intermediate Information)*
4. *Point of Destination {Final Information)*

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1 Deploying Integrated Intelligent Transportation Systems: Participant's Guide, United States Department of Transportation 1997, p. 6.
2 William Toomey, VP of SmartRoute Systems, from ITS America News, May 1997, p.8.

ATIS disseminates information through a wide array of electronic, navigational and telecommunication technologies, which may be classified into one or several of these key categories:

- *Radio*
- *Television, Text-TV and Cable-TV*
- *Electronic Bulletin Boards*
- *Changeable Message Signs/ Variable Message Signs*
- *Pagers/ Cellular phones/ Telephones*
- *The Internet*
- *Interactive Cable Television*
- *Information Kiosks/ Smart Kiosks*
- *In-vehicle Devices*

- **Advanced Public Transit Systems (APTS)**

"APTS technologies can revitalize transit by directly improving service, increasing transit efficiency and reducing operation cost as well as by producing direct benefits for travelers such as reduced travel times, increased safety and security, and reduced stress in dealing with transit unreliability.3

The development and deplovment of ITS technologies, including specific APTS technologies, have seen an almost exponential growth. As society continues to shape itself into an information village, this trend will continue. It is important, however, to retain a strategic approach to ITS investments in response to opportunities in the "electronic village". This strategic approach is based on the mission of mass transit, emphasizes linkages between ITS technologies, and looks ahead toward expanding ITS applications as needs, resources, and technical feasibility permit.

The benefits of deploying ITS technologies in transit, traveler information, or traffic management individually - rather than linked together - are often limited. APTS technologies can only realize their full potential in concert with the electronics and communications systems that also manage traffic and guide travelers to their destinations.

Traveler information systems in public transit environments, as with any information system, are typically judged on three essential criteria: quality of presentation, accuracy of information presented, and the degree of relevance of the information. Two categories of traveler information systems in transit are typically identified - pre-trip and en-route/ in-terminal information systems. These systems comprise a wide variety of services based on either static (historical) or dynamic (real-time) input, or a combination of both, such as:

* *Arrival and departure times/schedules*
* *Transit vehicle location (AVL) display and estimated time of arrival (ETA) .*
* *Best route selection, travel time, fare, comfort, etc.*

3 Journal of Public Transportation, Vol. 1, No. 1, Fall 1996, p. 42.

* *Connection points*
* *Trip chaining*
* *Multimodal itinerary optimization*
* *Rideshare opportunities*
* *Terminal, terminal surrounding area, destination and trip information*
* *Advance ticketing and reservations*

Several features of modem buses makes them "smarter", including:

* *Automatic Passenger Counting (APC)*
* *Automatic Vehicle Identification Systems (AVI)*
* *Automatic Vehicle Monitoring Systems (AVM)*
* *Global Positioning Systems (GPS)*
* *Roadside to Vehicle Communication (RVC)*

The key technologies for the different "keep track systems" are ***Automatic Vehicle Location*** (AVL), ***Global Positioning Systems*** (GPS), along with ***Geographic Information Systems*** (GIS) technologies. These systems report the transit vehicle's location on a transit route system link along with other relevant information depending on which systems are integrated with AVL/GPS systems. Such information typically includes the bus' occupancy rate and its mechanical status.

Relating AVL data to a GIS map and relational database allows visual tracking of bus fleet movements, as well as comparison of real-time to scheduled headways. This information is useful for both management of bus fleet operations and - when disseminated to the traveler via the Internet, smart kiosks or through other means - as traveler information.

Automated dispatching and ***computer-aided dispatching*** (CAD) systems have great potential to increase transit service efficiency and convenience. In demand-response transit applications of the type common in human service transport, these systems can shorten the gap between a request for service and provision of service. In fixed-route applications common in urban areas, these systems can speed deployment of additional buses or trains to meet excess demand, as well as assist drivers in maintaining headways (time spacing between vehicles). In case of mechanical difficulties in either demand-response or fixed-route settings, automated dispatching and CAD can also expedite deployment of replacement vehicles and repair crews.

Automated dispatching and CAD systems require either a beacon network (radiofrequency-based) or GPS-based AVL for vehicle location, map bases (typically CD-ROM) to display location of transit vehicles - in paratransit applications potentially passenger locations as well- and communication links.

Some systems have communication links established to pre-trip information systems (such as a Web site on the Internet) or in transit./ in-terminal information systems (such as Electronic Bulletin Boards (EBB), or both, providing the traveler with information in real-time. As these systems get even "smarter" and more integrated travelers will be able to get "best route" information, such as trip chaining, according to the criteria selected by the user. These criteria might include trip itinerary (desired service times and destinations), parking requirements, walking distance, waiting times, facilities, etc.

As these systems adapt to two-way communication standards that allow the traveler to interface with the system, passengers themselves will be able to make seat and ticket reservations and transit systems will move toward dynamic scheduling.

Automatic passenger counting, or "keep track" systems, are useful for monitoring demand or vehicle occupancy in real-time, as well as by stop, route, and system. Applications of these data range from dispatch of additional transit vehicles to meet excess demand to transit route and system planning. Passenger counting systems can be based on either a pressure-sensitive mat tread upon by boarding/alighting passengers or infrared beams through which passengers pass upon boarding or alighting.

All systems use random access memory (RAM) to store data collected. Most existing passenger counting systems exchange information between the dispatch center and selected bus stops, where communication links are established, but new technologies allow for information independent of the location of a bus on a route. This new technology allows data transfer or exchange in real time, thus reducing any delay in dispatch response to excess demand on a transit vehicle. Automated passenger counting is especially useful for transit analysis and planning purposes since the database contains information on not only the total number of passengers, but also the actual number of passengers on a bus at any given time or point of its route, and the number of passengers boarding and alighting at each bus stop.

Smart Cards are becoming increasingly popular in Europe, Asia, as well as North America. The areas for usage are widespread and include smart parking, electronic toll collection, fleet management, traveler information, and other ITS applications. Current trends reveal a Smart Card revolution that will go beyond the ITS arena.

The Smart Card is an advanced version of a standard memory-chip card. In a standard memory-chip card system, the data processing hardware and software read the information from the card, perform calculations, and write new data back to the card (i.e. a Read-Write transaction). An example of a typical standard memory card is the pre-paid phone cards. They are very inexpensive to manufacture and are, as a result, often disposed of when they are used up. A Smart Card contains *a* microchip instead of a memory-chip, i.e. it contains not only data storage capabilities but also processing capabilities. Hence a Smart Card system allows for the card to carry out all transactions. Scrambling and unscrambling makes the card secure enough for its intended usage. Smart Cards are more expensive to manufacture than magnetic and optical cards. They are, however, considered to be more cost-efficient due to much lower operating costs. For example, the cards can be re-loaded, have very low failure rates (due to the lack of moving parts) and can handle multiple function usage.

Advanced Traffic Management Systems (ATMS)

Advanced Traffic Management Systems (ATMS) maximize the benefits to the motorist and other road users by improving overall roadway safety, reducing travel delay, and minimizing costs. ATMS can be subdivided into several functional categories, some which may have substantial overlap with and connection to lTS applications presented earlier under ATIS and APTS.

The key to a successful ATMS deployment is in providing for dynamic real-time management. The following functional requirements are therefore essential:

- *To monitor and direct the flows of traffic*
- *To operate and supervise elements of the transporration network of critical importance*
- *To manage incidents*
- *To support and coordinate all activities relating to the transportation network*
- *To provide information to transportation network users*

Most ITS applications can be located in one or more of the following areas:

- *Traffic Control*
- *Incident Management*
- *Emergency Management*
- *Emissions Testing and Mitigation*

Many ITS applications are dependent on the elements that comprise *traffic control* functions. In brief, traffic control is about managing the movement of traffic on streets and highways. Traffic flow is improved through a variety of rules and strategies, some that are fully automated and pre-programmed and others that require human interface. The key to ITS success on any surface street or freeway system is to collect the right data from the right places and analyze that information in an integrated manner. Consequently, these systems often require not only substantial equipment in the field, such as sensors, counters and cameras, but cooperation between the operators of the transportation infrastructure and services provided in the transportation system. When fully functional across all sub-systems of the transportation system, ITS applications within this functional category will not only improve traffic flow but also ensure prioritization of certain types of traffic such as public transit and emergency vehicles.

The essential first step-to generate capabilities for traffic control is to deploy enough surveillance equipment to monitor traffic conditions at key locations of the transportation system, such as on- and off- ramps, bridges, intersections and access roads to major activity centers. Surveillance equipment range from loop detectors and video cameras for point surveillance to aerial surveillance for wide-area surveillance. A series of point surveillance locations create an overall understanding of the status the transportation system.

Today, many automated traffic control systems exist at critical locations. However, they often operate as individual systems not integrated with other elements the transportation system. Such systems are often found at intersections of the surface street system or on certain stretches of access roads connecting to the freeway network. With emerging information technologies such as data and voice communications. along with the new opportunities for human interface in automated and cyclical programs of such subsystems, real-time adaptive and integrated approaches are emerging. The key is a processing center, often referred to as the Traffic Management Center (TMC) or Traffic Operations Center (TOC) where all the data from the diverse surveillance sources in the transportation system are analyzed and fused. These data are augmented with other sources of information such as roadwork reports, weather reports, incident reports, and historical data to better achieve efficient traffic control strategies. The output from the control strategy models or decisions is disseminated to street traffic signals. street and freeway Changeable Message Signs (CMS) and Lane Closure Signs (LCS), and freeway ramp meters.

ITS applicationsfor *Incident management* are intended to assist public as well as private organizations to better identify incidents in the transportation system and to implement successful response plans in a coordinated matter among the responsible entities. Incidents such as accidents, road construction, maintenance, cultural and sport events all affect the flow of traffic. ITS applications can assist in almost any incident scenario, but incidents that can be scheduled, such as construction and special events, are often resolved using conventional transportation management tools such as road closures and fixed-sign re-routing of traffic. Incident Management is therefore often thought of as a real-time application that can be used to deal with accidents only. In any event, incidents, whether scheduled or random, need to be detected in order to create an efficient response plan. Hence, advanced surveillance and monitoring capabilities are needed in the transportation systems infrastructure. The key is to generate an incident report based on noticeable changes in system performance, or through interaction from individuals using the transportation system via cellular or fixed telephone 911 services. Progress in the areas of communication technology will allow law enforcement agencies and “roving” patrols to send real-time audio and video to control mechanisms to facilitate the detection of incidents and support “big-picture” understanding in generating efficient response plans. In fully developed Incident Management system responses, organizations and incident status will be tracked, coordinated and achieved. The vision is to create more automation without sacrificing the role of human interface in local and regional TOCs and TMCs.

Great technical advancements have occurred in the permanent applications of ITS equipment, hardware and software. Most efforts have to date been on hard-wired permanent elements but rapid improvements of especially wireless communication technologies are bringing life to new and interesting mini-applications for traffic management. These include such technologies as machine-vision, as well as advances in radar, videocameras, and modular changeable/variable message signs. When integrated, these technologies are forming a comprehensive, real-time traffic management tool. Promising examples of these protable traffic management system tools have been tested in both urban and rural construction zones with very positive results.

Incident management is most often disaggregated into five non-distinct functional areas - detection and verification, motorist information, response. site management, and clearance. Incident management, which started in response to large urban area issues such as traffic congestion (note that efforts to improve the management of incidents have been taking place for nearly three decades in Chicago, Illinois) is now producing benefits in smaller municipalities and their respective rural areas. Benefits from a more managed response include improved safety for both motorists and responders, improved agency efficiency,

Recommended Program of Greater Portland ITS Projects

The Greater Portland ITS Early Deployment Plan Advisory Committee carefully evaluated a list of potential intelligent transportation system "projects" (clusters of linked applications). Projects and related applications were prioritized based on their likely respective contributions to regional goals adopted by the Advisory Committee. The result of Committee deliberations is a Recommended Program of Greater Portland ITS Projects. The Program of Projects consists of three broad ITS projects, each consisting of a varying number of more specific ITS applications. Each project and each of the favored applications within projects was ranked by the Advisory Committee in priority order. Applications that the Committee deemed desirable, but not of high priority, were placed in the Recommended Program without a priority ranking. The Advisory Committee assigned all applications a deployment phasing time period: before the year 2003, between the year 2003 and the year 2008, and - for unranked applications - "before 2008 if feasible". Associated with each application of the Program of Projects is one or more suggested implementing entities.

The Recommended Program does not include cost estimates, which are more properly made by implementing agencies once specific deployments are given project scopes. Future cost estimation is problematic in electronics, given trends in the computer and communications markets toward ever-higher capability at lower and lower cost. Additionally, ITS project unit costs - like those for conventional transportation projects - vary greatly with quantities purchased and optional feature or enhancements desired. Chapter 4 of this document, however, includes representative costs for various ITS applications.

- **First Priority: Automated Public Transit Systems**

The Advisory Committee recommends that various public transit applications be given the highest priority for ITS *deployment in the Portland* region. The Advisory Committee strongly felt that the following significant benefits were obtainable through intelligent transportation systems investments in the Greater Portland transit operations:

- *increased operational efficiency*
- *Better customer service*
- *Reduced costs*
- *Improved integration of disparate transit operations*
- *Increased transit system patronage*

Further, the Committee believed that transit operators in the region were keenly interested in deployment of a number of key ITS applications, including automated vehicle location systems, automated dispatching, and electronic fare payment. In the view of the Advisory Committee, this strong operator interest made more likely in transit than elsewhere in the transportation system the implementation of ITS projects and realization of their benefits.

The highest priority for deployment of ITS public transit applications before the year 2003 was given to automated vehicle location systems for Greater Portland transit fleets, “smart cards” for electronic fare payment, and development of a network of electronic passenger information kiosks linked to the world wide web.

RECOMMENDED GREATER PORTLAND ITS PROGRAM OF PROJECTS			
First Priority: PUBLIC TRANSIT PROJECT			
ITS COMPONENTS	**COMPONENT RANKING**	**DEPLOYMENT BEGINS BY**	**DEPLOYED BY**
Automated Vehicle Location/Global Positioning Systems/Computer-Aided Dispatch	*1*	*before 2003*	*METRO, RTP, South Portland Bus Service*
Smart Cards	*2*	*before 2003*	*CBITD, METRO, RTP, South Portland Bus Service*
Smart Kiosk/World-Wide Web	*3*	*before 2003*	*CBITD, METRO, RTP, South Portland Bus Service*
Electronic Bulletin Boards/Text TV	*4*	*between 2003 and 2008*	*CBITD, METRO, Vermont Transit, Concord Trailways, AMTRAK*
OTHER APPLICATIONS:			
On-board Annunciators	*Unranked*	*before 2008 if feasible*	*METRO, South Portland Bus Service*
Passenger Counters	*Unranked*	*before 2008 if feasible*	*METRO, South Portland Bus Service*
Passenger Security Systems	*Unranked*	*before 2008 if feasible*	*METRO, South Portland Bus Service*
Transit Systems Management Center	*Unranked*	*before 2008 if feasible*	*METRO, RTP*
Traffic Signal Pre-emption	*Unranked*	*before 2008 if feasible*	*Portland, South Portland, Westbrook*

Table 2.1: First Priority Project - Public Transit

- **2 Second Priority: Automated Traveler Information Systems**

The Advisory Committee's second highest project priority is electronic traveler information, with an emphasis on variable message signs (conventionally classified as traffic management tool), highway advisory radio, and an expanded menu of electronic travel information kiosk choices. The Committee recommends that a significant start in deploying these applications be made before the year 2003.

In the view of the Advisory Committee, provision of accurate and timely traveler information is essential both for the Portland region's role as a gateway to Maine and for better-informed daily travel by residents and commuters. Economic benefits flowing from improvements in pre-trip andenroute traveler information include travel time savings for residents and increased visitations to - and consequent spending within - the region by tourists.

Second Priority: TRAVELER INFORMATION PROJECT			
ITS Components	**Component Ranking**	**Deployment Begins By**	**Deployed By**
PRIORITY APPLICATIONS -			
Changeable/Variable Message Signs, Highway	*1*	*before 2003*	*Maine DOT, Maine Turnpike Authority, Portland, South Portland*
Highway Advisory Radio	*2*	*between 2003 and 2008*	*Maine DOT, Maine Turnpike Authority, Portland, South Portland*
Smart Kiosks/World-Wide Web	*3*	*before 2003*	*Maine DOT, Maine Turnpike Authority, Portland, South Portland Westbrook, Maine Mail, University of Southern Maine*
OTHER APPLICATIONS-			
Highway Advisory Radio Parking	*Unranked*	*before 2008 if feasible*	*Portland*
Highway Advisory Radio, Weather	*Unranked*	*before 2008 if feasible*	*Maine DOT, Maine Turnpike Authority, Portland, South Portland*
Changeable/Variable Message Signs, Parking	*Unranked*	*before 2008 if feasible*	*Portland*

Table 2.2: Second Priority Project - Traveler Information

- **Third Priority: Automated Traffic Management Systems**

The Advisory Committee recommends that two linked traffic management applications be given an overall third project priority: traffic signal pre-emption for emergency vehicles and perhaps also for transit vehicles and comprehensive traffic signal automation as well as signal coordination along corridors and between municipalities. In the Committee's view, implementation of these two measures will reduce emergency response times and improve traffic flow on the region's roadways.

Second Priority: TRAVELER INFORMATION PROJECT			
ITS Components	**Component Ranking**	**Deployment Begins By**	**Deployed By**
PRIORITY APPLICATIONS -			
Traffic Signal Pre-emption	*1*	*before 2003*	*Maine DOT, Portland, South Portland, Westbrook, Scarborough*
Traffic Signal Automation & Coordination	*2*	*before 2003*	*Maine DOT, Portland, South Portland, Westbrook, Scarborough*
OTHER APPLICATIONS-			
-Trans. Mgt. Center(s)	*unranked*	*before 2008 if feasible*	*MDOT, PACTS*

Table 2.3: Third Priority Project - Traffic Management

What Next?

The <u>Greater Portland Intelligent Transportation Systems Early Deployment Plan</u> documents ITS capabilities and contains a recommended Program of Greater Portland ITS Projects. Advancing ITS deployment in the region, however, requires both raising awareness of ITS on the part of decision-makers and the traveling public as well as actual implementation of ITS projects. The Advisory Committee recommends the following "next steps" for advancement of intelligent transportation systems in the region.

3 Outreach and Education

Recommended "next steps" in outreach and education initiatives are as follows:

Activity:
Distribute the Greater Portland ITS Early Deployment Plan and recommended Program of Greater Portland ITS Projects to the Maine DOT, Federal Highway Administration, Federal Transit Administration, Maine Turnpike Authority, PACTS, Portland area municipal managers, and Portland area transit managers

Purpose:
To inform decision-makers about ITS capabilities and recommended deployment program.

Initiators:
Greater Portland Council of Governments staff

Completed by:
March. 1998

Activity:
That Maine DOT Form a Maine Chapter of ITS America

Purpose:
To provide professional and technical support and coordination to ITS project planners

Initiators:
Maine Department of Transportation, Maine Turnpike Authority, Portland Area Comprehensive Transportation Committee, Greater Portland Council of Governments

Completed by:
July. 1998

Activity:
Convene an annual meeting of Greater Portland ITS Stakeholders, formed with the ITS EDP Advisory Committee at its cure

Purpose:
To review progress in ITS implementation and recommend revisions to the recommended Program of Greater Portland ITS Projects

Initiators:
PACTS and Greater Portland Council of Governments

Completed by:
Annually, beginning in September 1998

Activity:
Further integrate education about intelligent transportation systems into the ongoing educational enrichment efforts in the region

Purpose:
Educate youth on advances in electronics and communications technology in transportation and careers available in these emerging fields

Initiators:
Greater Portland Council of Governments and Portland area teachers

Completed by:
Ongoing, beginning in March, 1998

. Implementation

Recommended "next steps" in implementation are as follows:

Activity:
Ptepute detailed project scopes for initiatives recommended and ranked for implementation :before 2003" in the Progtam of Greater Portland ITS Projects

Purpose:
Initiation of ITS project-level planning

Initiators:
Implementing agencies such as municipalities, the Maine DOT, Maine Turnpike Authority, other State agencies, and transit operators.

Completed by:
December 1998

Activity:
Prepare grant applications, capital improvement program requests, and other funding requests or partnerships to support initiatives recommended and ranked for implementation "before 2003" in the Program of Greater Portland ITS Projects.

Purpose:
Initiation of ITS project-level planning

Initiators:
Implementing agencies such as municipalities, the Maine DOT, Maine Turnpike Authority, and transit operators.

Completed by:
December 1998

- **Recommended Next Steps**

A unifying framework that enables ITS infrastructure components to share information and function as an intermodal transportation system needs to be established. Stakeholders in the area still need to build consensus regarding:

- *Current information sharing needs and future opportunities*
- *Data descriptions, processing specifications, and process flows*
- *Subsystem definitions, functionality, and standard interface needs*
- *Telecommunications options for subsystem inter-connections*
- *Potential institutional roles, responsibilities and relationships*

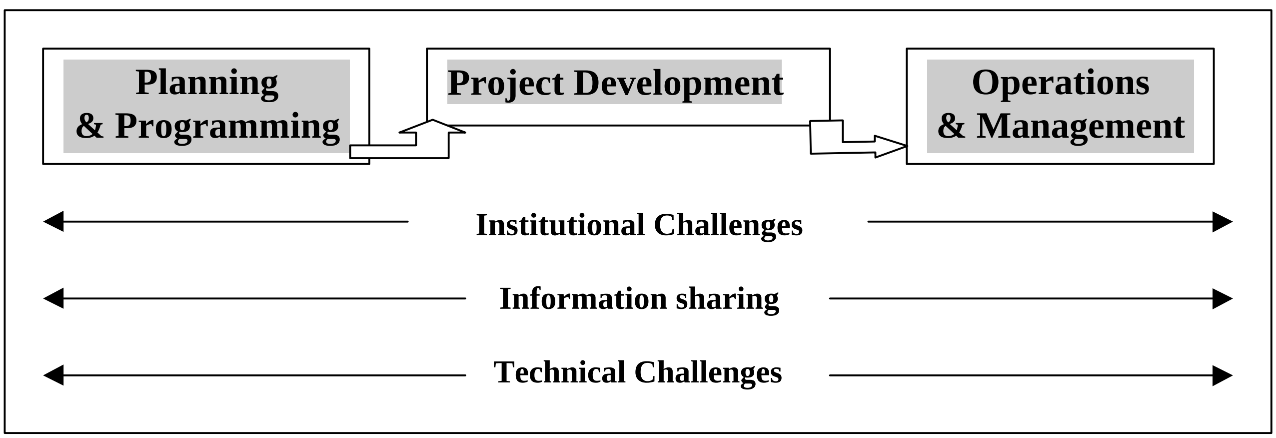

Figure 2.1: Challenges of planning, deploying, and operating ITS within the transportation system

A major key to success will be to implement a productive dialogue between those who recognize, understand, and "own" transportation problems, and those who implement and invent technological solutions. Thus, a regional Technical Coordinating Committee should be formed to advance development of an intelligent transportation systems infrastructure in the region.

3. WHAT IS ITS?

3.1 Background Overview and Typology

The United States Department of Transportation has defined Intelligent Transportation Systems (ITS) in the following way: "The application of sensor, computer. electronics, and communications technologies and management strategies in an integrated manner.. . to increase the safety and efficiency of the surface transportation systems."[1] While ITS deployments from computerized traffic signal systems to automated transit location systems predate the passage of the Inter-modal Surface Transportation Efficiency Act (ISTEA) in 199 1, ISTEA estabhshed a national commitment to what was then termed Intelligent Vehicle and Highway Systems (IVHS). The name change to ITS signified the recognition that public transit and traveler information systems were key parts of a comprehensive approach to applying advances in electronics and communications as tools for improving the nation's mobility of goods and people.

"While ITS technologies alone cannot solve our transportation problems, they can enable us to rethink our approach to solutions, and make current activities more efficient and cost-effective".

The USDOT defines fifty-three Market Packages and thirty more broadly defined "ITS User Services" (see Appendix A for complete lists). The Market Packages are grouped into larger sets of related ITS applications, as follows: Traffic Management Systems, Advanced Public Transportation Systems, Traveler Information Systems, Advanced Vehicle Safety, Commercial Vehicle Operations, Emergency Management, and ITS Planning.[3]

Advisory Committee and Staff focused on three of these broad groupings as a basis for Plan development, namely:

* ***Advanced Traffic Management Systems***
* ***Advanced Public Transit Systems***
* ***Advanced Traveler Information Systems***

Advanced "bundles" or "families" of lTS applications appeared to the Advisory Committee and Staff to both have the most relevance to the Greater Portland region (see Section 5.1 for a discussion of regional transportation issues and problems) and to be within the policy and funding reach of a regional transportation plan. For purposes of Early Deployment Plan development, Emergency Management was subsumed under a Traffic Management Advanced Vehicle Safety and Commercial Vehicle Operations both thought by the Advisory Committee and Staff to be largely in the province of the private

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1 Deploying Integrated Intelligent Transportation Systems: Participant's Guide, United States Department of Transportation 1997, p. 6.
2 Intellignet Transportation Systems (ITS) Projects, U.S. Department of Transportation, January 1996, p. I.
3 ITS Strategic Assessments, Federal Highway Administration and Federal Transit Administration, October 1996.

sector and both state and federal governments rather than subject to effective local or regional control. ITS Planning, the seventh group. will as the name implies be an ongoing effort that needs special attention for ITS purposes of deployment, integration and operation.

3.2 ITS – The Concept

ITS technologies include a myriad of products and services that can affect almost all individuals of our society (see Figure 3.1).

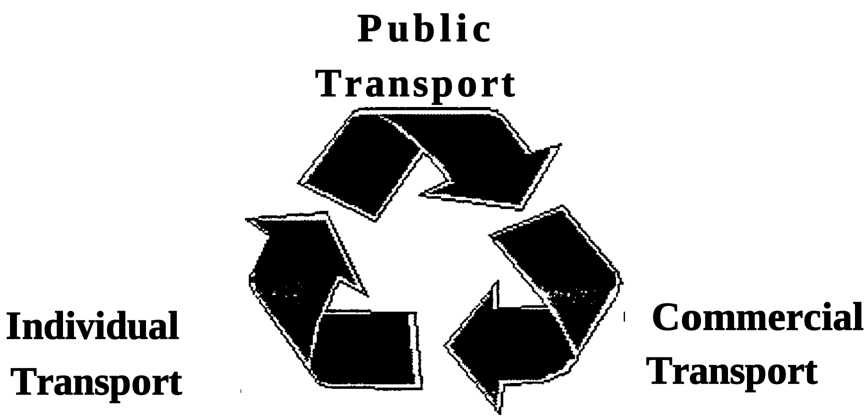

Figure 3.1: Conceptual View of Study Region Transportation System

One of many fundamentals behind ITS as a concept is that it aims at creating an intermodal transportation system, which will make life easier for travelers switching from one mode to another. Another fundamental is that it attempts to deal with current limitations of the technology of our transportation system by providing intelligence. Intelligence is in most cases based on information n how it is collected, shared, processed and disseminated to/ from/ by/ all users of the transportation system. ITS is fundamentally different from traditional measures of developing and maintaining a transportation system. ITS provides an alternative to "more of the same" and "band-aid" measures by creating information infrastructures to support existing and planned infrastructure.

3.3 ITI - the Intelligent Transportation Infrastructure

ITS is typically discussed based on the involved II'S Infrastructure Components – often referred to as the Intelligent Transportation Infrastructure (ITI). The ITI is traditionally classified into nine elements, namely:

- **Traveler Information Systems (TIS)**
- **Freeway Management Systems (FM)**
- **Traffic Signal Control Systems (TSC)**
- **Transit Management Systems (TMS)**

- **Electronic Toll Collection Systems (ETC)**
- **Electronic Fare Payment Systems (EP)**
- **Incident Management Systems (IM)**
- **Emergency Management Services (EM)**
- **Highway-Rail Intersections Systems (HRI)**

The framework allows discussion of what the components are and how they function together. The element that facilitates the integration of these components into a system is communication technologies, especially the telecommunications technologies. Integration of all the nine components is a desired result, and communications certainly provides the "glue" in doing so since there needs to be an "informational backbone" in the infrastructure which can transmit control and surveillance data voice messages and video images.

3.4 ITS Components and Sub-systems

A generalized model – or ITS System Architecture – shows the basic communication needs between the different ITS components an ITS sub-system. As Figure 3.2 depicts, ITS components and ITS sub-systems can be classified into four categories. These categories, which really present "spatial placeholders", are:

1. **Centers Component** for sub-systems which deal with the planning, control and administration of the transportation system;
2. **Roadside Component** housing all the sub-systems which deal with the surveillance and operations of the transportation systems, such as the street and roadway, fee collection, parking management, etc.;
3. **Vehicles Component** with sub-systems to be developed in private, transit, commercial, or emergency vehicles; and
4. **Remote Access Component** mainly remote traveler support and personal information access sub-systems.

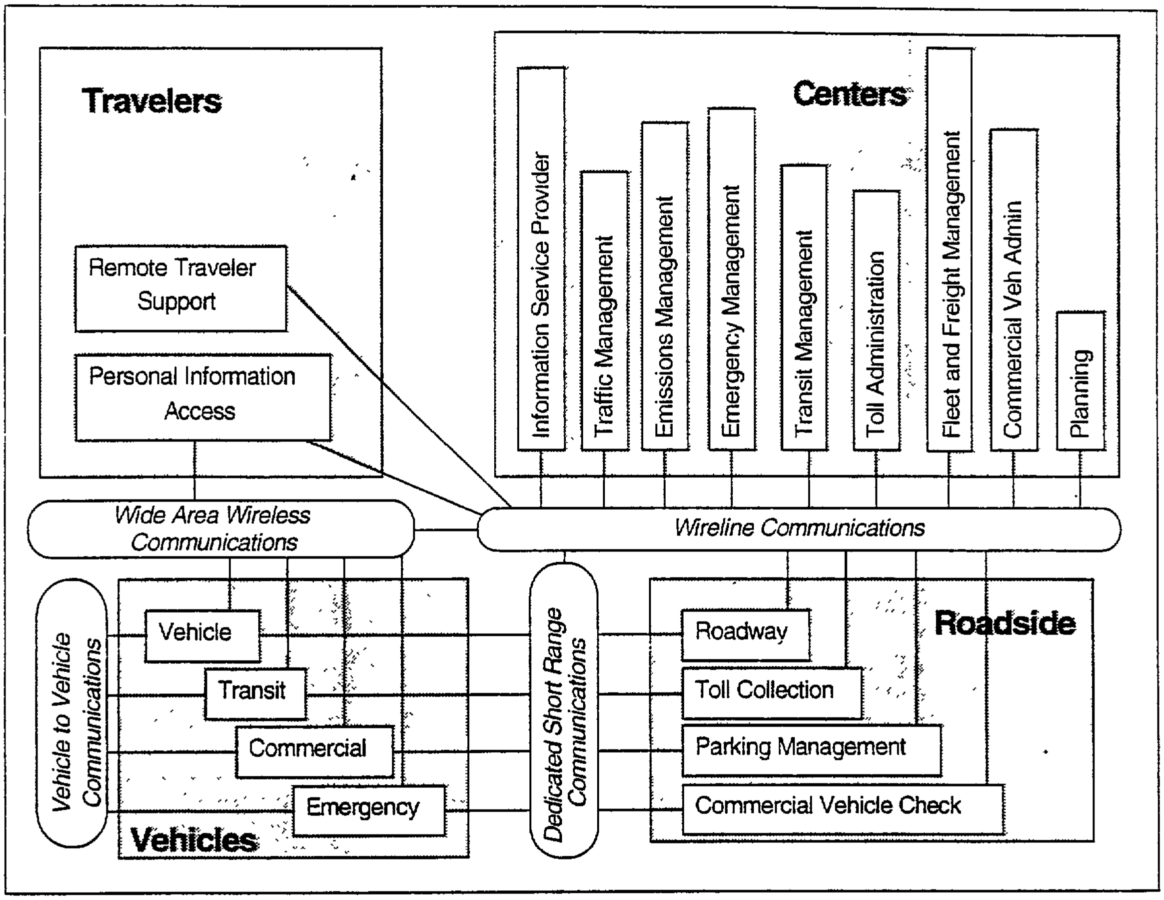

Figure 3.2: Typical Components and Sub-systems of ITS

The basic infrastructure needs for creating this "informational backbone" are further implied by the different telecommunication set-ups and technologies therein; wireless Wide Area Network (WAN) communications, Dedicated Short-Range Communications (DSRC), and vehicle-to-vehicle communications.

The ever increasing availability of communications, together with fast, inexpensive, and miniaturized computing technology, have created the technological momentum that launched the ITS development we see today, and will experience tomorrow.

3.5 Traveler Information Systems (ATIS)

"While teaching people to use ATIS is a considerable challenge in behavior modification, the research is clear that the use of ATIS, increasing over time, is a powerful tool for changing the route, time or mode of drivers' travels".[4]

Traveler information systems are a key component of ITS strategic planning. The purpose of ATIS deployment is to provide the traveling public with the right information at the right time

[4] William Toomey, VP of SmartRoute Systems, from ITS America News, May 1997, p.8.

to help make better, or at least more informed. choices. ATIS offer such supportive information to the traveler in four phases:

1. *Planning of the Trip (Pre-Trip Information)*
2. *Making of the Trip (En-Route information)*
3. *Connections/ Transfer Points (Intermediate Information)*
4. *Point of Destination (Final Information)*

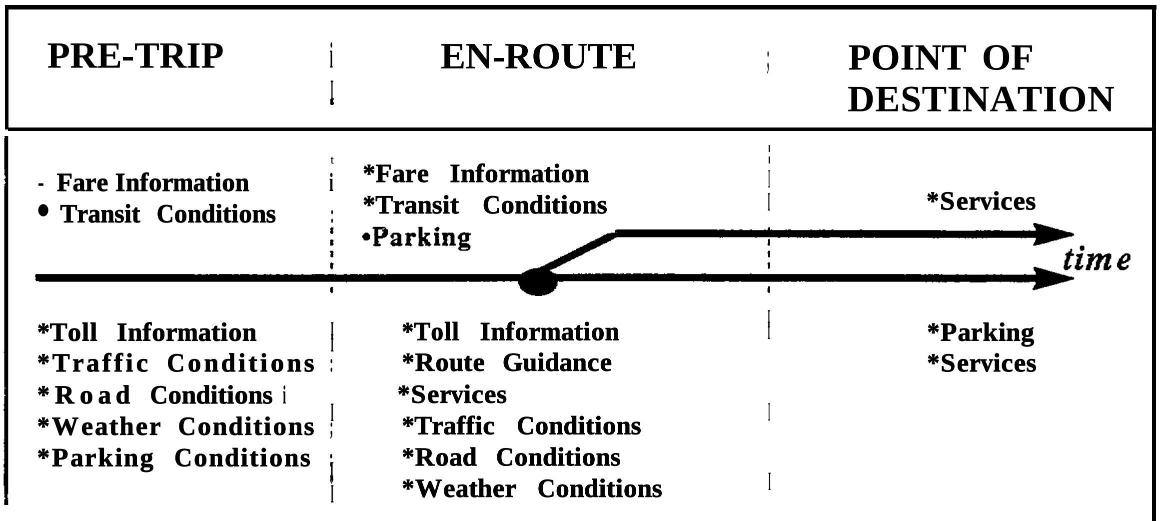

Figure 3.3: The Traveling Public's Perspective on Traveler Information in Terms of ITS User Services.

Although motorist user services are quite different from transit-oriented user services, they do, however, have several common denominators in terms of attributes and functionality. Fixed information for both is based on static database data, while variable information is based on data collected in the transportation system itself. Sources of real-time data include loops embedded in the pavement; roadside sensors; closed circuit cameras; motorists, transit, and commercial operators through cellular/ mobile telephones; motorist call-boxes; technologies allowing for vehicles to probe in the transportation system; and police and other emergency agency reports.

The value of this information, as it is being disseminated to the traveler, is dependent on three criteria:

* ***Accuracy***
* ***Reliability***
* ***Timeliness***

If these criteria for valuable information are satisfied, the transportation user can make better Pre-Trip and En-Route decisions regarding one or more of the following travel/ trip variables:

* ***Modes/Modal Choice***
* ***Routes/ Path of Travel***
* ***Point in Time for Travel***

An identification of the features of traveler information applications is required in order to evaluate ATIS. Some features of these applications may already generate benefits today, while others may not. However, the features that currently do not add value, or enough value, to the end-users of the system (the traveling public) may require some level of adjustment over time, as with any type of groundbreaking product in the marketplace. As a result, it is sometimes risky to neglect any potential applications of ATIS in terms of long-term deployment.

The degree of early deployment and integration of these new but existing technologies will most certainly affect the outlook on future use of ATIS. With private industry opening new windows of opportunity and governmental/ public organizations encouraging development of new products and services, many may in time become accepted in the marketplace as “necessities” rather than “niceties”. The role of private industry opening some of these new markets, as well as the role of governmental/ public organizations coordinating these efforts, cannot be underestimated in the development and evolution of ATIS.

ATIS disseminates information through a wide array of electronic, navigational and telecommunication technologies, which may be classified into one or several of these key categories:

- *Radio*
- *Television, Text-TV and Cable-TV*
- *Electronic Bulletin Boards*
- *Changeable Message Signs/ Variable Message Signs*
- *Pagers/ Cellular phones/ Telephones*
- *The Internet*
- *Interactive Cable Television*
- *Information Kiosks/ Smart Kiosks*
- *In-vehicle Devices*

Table 3.1 presents a selection of attractive uses of ATIS today.

User Service	Commuter	Frequent Traveler	Occasional Traveler	Temporary Traveler
Travel time selection [Pre-trip]	•	•	•	•
Mode selection [Pre-trip]	•	•	•	•
Route selection [Pre-trip and En-Route]	•	•	•	•
Static Route Guidance [En-route]			•	•
Dynamic Real-Time Route Guidance [En-route]	•	•	•	•
Weather Information [Pre-route]	•	•	•	•
Emergency Warnings [En-route]	•	•	•	•

Table 3.1: User Categories and Their Usage of ITS User Services (• = high usage level/ likely to be used)

Pre-Trip (planning) systems as well as En-Route (assisting/ modifying) systems are built up around both static and dynamic/ real-time information. The static information consists mostly of information on the unchanging transportation infrastructure and planned information such as scheduled road construction or timetables for any transit mode. The dynamic/ real-time information enhances this static information by updating or modifying it to reflect the current situation. such as traffic and road conditions, as well as more dynamic transit schedules.

Effective systems must be focused on the task of helping the traveler mocify his or her behavior in order to avoid problematic locations when such occur. Such systems help reduce travel times and alleviate frustration and stress for the traveler, as well as help solve overall traffic and transit management problems. Effective systems should also allow for some level of integration of both motorist information and transit information. Such systems not only promote intermodal usage among commuters and other frequent travelers, but also assist the occasional/temporary traveler as well.

The differences between Pre-Trip and En-Route systems appear along a range of attributes. These attributes are the following: type, either "push" (information disseminated out to traveler with little or no prompting) or "pull" (information disseminated out to traveler with moderate or considerable prompting); time of *usage: major user group: user cost; user engagement* in terms of inconvenience and/or demand on him/her in terms of physical and psychological distraction; *equipment required by the user; andcommercial potential* as a value-adder to providers.

Radio and Television

Type:	"Push Type"/ One-way communication
Time of Usage:	Pre-Trip and En-Route
Major User Group(s):	Any Traveler
Cost for User:	Zero
Engagement for User:	Low
Equipment/Services Required for User:	Radio/Car Stereo and/or Television set
Commercial Value:	**Yes**
Other:	Concerns with information being sensational and sketchy rather than customized and in-depth.

Along with regular weather reports, radio and TV stations in major metropolitan areas now consider traffic bulletins an essential element of morning and afternoon broadcasting. The first traffic reports appeared on the radio in the late 1970s.[5] In the recent past this information has not only been given increased and more frequent chunks of air time, but often also instant on-demand chunks of air time as the conditions of the transportation network change. In summary, broadcast networks have been and remain the most commonly used media in providing information to the traveler.

5 Kenneth Orski, "Broadcasting vs. Narrowcasting of Traveler Information," ~~ITS On-line.~~

Radio and TV broadcasting allow for both pre-route and en-route traveler information to be disseminated. Broadcast networks can be set up in three major ways: commercial, public-private and public. The commercial broadcasting model is in general limited to very brief traffic bulletins and does not cost the radio or TV station any money since they are typically underwritten by commercial sponsors. The information is usually independent, even though information sharing is becoming more common, and collected via ground and aerial surveillance and probe vehicles. As the market becomes more competitive, due to increased listener demand. many radio and TV stations are now subscribing to some type of professional reporting service. The public-private partnership model is often based on a private Traffic Information Center (TIC). where the data collected from the transportation network is synthesized and interpreted. This information is then sold to the commercial radio or TV station. Benefits of this model are based not only on the vast resources that are contained in the TIC, but on the good macro understanding of the transportation network that is contained therein. The private TIC and other private traffic reporting services have been funded in part by public sector, but are expected to become self-supportive through the growing markets for enhanced information. State Departments of Transportation have been a major actor in the field of collecting data and synthesizing and interpreting traffic information. This is done through a Traffic Operations Center (TOC) - which would constitute the third major way in which broadcasting can be done, assuming the broadcasting was done over a public radio or TV channel.

The audience for these broadcasting models is almost unlimited since radios or television sets are nearly universally available at home, in vehicles and in the workplace. The listening audience is typically high since the traffic reports are often bundled with a program such as a newscast. Even though the commercial broadcasting is likely to remain economically viable through continuous improvements, such as more frequent and longer chunks of air time (quantity aspects) and more in-depth or understandable information (quality aspects), it will remain a wide area information mechanism with sketchy information compared to other ATIS dissemination technologies.

Radio

Radio broadcasting is a medium which is typically limited in scope and focused on major events such as information on:

- *Traffic accidents*
- *Traffic jams*
- *Weather warnings*
- *Road construction sites*

The typical user of the type of information broadcast on a'variety of radio channels is the general traveler, i.e., the commuter. Only a few radio channels, typically in major cities, have been able to provide valuable information for the visiting tourist with respect to traveling information.

The information is not only lacking a visual dimension (graphical interface), but is very limited as traffic reports are seldom longer than 15 seconds during off-peak hours and 30 seconds during peak hours. The fact that the information is often not location-specific for the traveler may not cause major changes in travel behavior. In such cases, the information is merely a "check-point" in the planning or realization of a trip. Even as a "check-point" the information could been seen as irrelevant because of a lack of timeliness. In trying to increase the completeness of traffic coverage, traffic bulletins and traffic reports also face the daunting problem of information overload of their listeners, who are also bombarded with audio messages on products, services, news, weather, sports, and entertainment.

A major benefit of radio broadcasting as a channel of disseminating traveler information is that its "push" character imposes the information on the traveler. However, as discussed above, traffic bulletins and reports are often bundled with plenty of commercials, which may divert some of the listeners away from some of the better traveler information channels. This problem is partially overcome by the entry of a new generation of car stereos with EON and TIM standards (see Figure 3.4). EON stands for enhanced other networks, a feature which simply tunes the radio into a traffic message on one of the approved traffic information stations. This is done independently of whatever the station the traveler was listening to, as well as in the case when the traveler was listening to a CD or a cassette tape. This new generation of car stereos is available in areas with Radio Data System - Traffic Message Channel (RDS-TMC), which allows for yet other interesting features, such as Radio Text (RT) and Turn On Message (TOM). RT basically allows for traffic messages to be paged on the LCD screen while TOM serves as a memory base of current traffic messages.

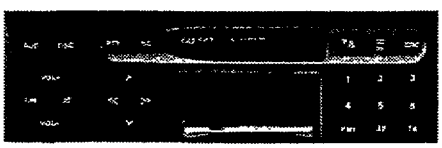

Figure 3.4: Modern Car-stereo with RDS-TMC Features by Blaupunkt (model Arizona RCM 127).[6]

Television

Local television stations can also be a good source of traffic information. As is the case of radio, television is ubiquitous in the United States. No segment of the society is truly lacking access to broadcast television and most segments of society have access to either cable-TV or satellite-TV in their dwellings. Like radio stations, TV stations provide regular updates during peak hours of travel, especially during the morning when major metropolitan TV channels seldom report on the traffic less than every 15 minutes. Usually these bulletins are limited in scope and focused on major events such as information on:

* *Traffic accidents*
* *Traffic jams*
* *Traffic flows and speeds*

* *Traffic conditions (in general) at major thoroughfares such as bridges and tunnels*
* *Weather warnings*
* *Road construction sites and alternative routes*

In some locations throughout the country flow and speed maps are now available. Many stations incorporate the flow and speed maps with live traffic video over major points of travel and/or points where problems are occurring. This has been done through similar set-ups and partnerships as in the field of radio broadcasting, where information is either subscribed to or supplied by public agencies. A major concern for the smaller traffic reporting stations has been the high cost of graphical interfaces and other ways of presenting the information. New software, however, is making such a process less of a resource concern and public agencies are often providing not only funding but professional staff. As broadcast channels and cable channels become more involved with traveler information, they will continue to develop new means to disseminate the information. Most channels today make extensive use of:

* *Maps with icons showing accident and incidents sites on the road or transit system*
* *Maps which are color-coded to indicate current and expected delays, levels of service, flows and speeds*
* *Static images/p ho tos*
* *Live surveillance video feeds from fixed and moving cameras*
* *Scrolling advisory boards for traffic and transit information*

Television broadcasting has indeed been established as an effective delivery mechanism, but it remains a traffic information medium which only offers information in the pre-trip phase. Advanced television projects are being conducted and "pull" systems may soon become more the norm than experimental. While technological advances continue to reduce the cost of transmission, there are several administrative and institutional obstacles that must be overcome before interactive services will be launched.

Highway Advisory Radio

Type:	**"Push Type"/One-way communication**
Time of Usage:	**En-Route only**
Major User Group(s):	**Any Traveler**
Cost for User:	**Zero**
Engagement for User:	**Low**
Equipment/Services Required for User:	Car Stereo with AM-receiver
Commercial Value:	n/a
Other:	Interference problems

Highway Advisory Radio (HAR), or **Travelers Information System (TIS),** or **Emergency Warning Systems** as it is sometimes alsb referred, presents no state of the art technologies. In the 1970's, national parks and airports introduced the concept of HAR by broadcasting pre-recorded visitor and parking information. The information was often outdated and the listenership was. as a result, low. An HAR system is basically a low-powered AM radio station broadcasting messages to motorists through standard car radios. Messages are in general broadcast from pre-recorded audio sources that cycle. Messages are more easily changed with the entry of cellular telecommunication technologies and messages could also be broadcast live when needed.

The traveler information disseminated often alerts motorists of severe traffic conditions or a major disruption such as a lane closure. When used, the motorist's attention is typically caught by a few flashing lights on top of a board which asks the motorist to tune in to a specified frequency (see Figure 3.5). HAR broadcasts DTMF tones to activate flashing lights on the signs. These signs are usually located at the outer edges of the reception area for purely static information just before the area in which the traveler should start listening. These tones can be recorded in advance into messages or generated through live broadcast features. One could classify the system as "on-demand", since the driver is only tuning into the HAR messages when alerted. HAR is potentially very useful in giving both real-time and location-specific information. Nevertheless, current HAR systems often have low rates of data and poor signal quality. New digital technologies could solve such problems, but the capital investment is relatively high and new features of regular radio broadcasting may replace the functions of an HAR system.

This type of broadcasting does, however, make it easier to be more "local" than regular traffic reports over the FM-radio (and other wide-area broadcast mechanisms). Running a "loop" or a "looped message" makes the information accessible instantly to the traveler, which shouId be considered to be an advantage of the system. However, such loops must be updated to be accurate, reliable, and timely to perform successfully. HAR offers an excellent complement to other ATIS applications, especially Changeable Message Signs and Variable Message Signs (which are discussed below). A major problem with HAR, however, is that, unlike frequency modulation (FM-radio), amplitude modulation (AM-radio) follows the curvature of the earth. As a result, the deployment site needs to be a clear open area.

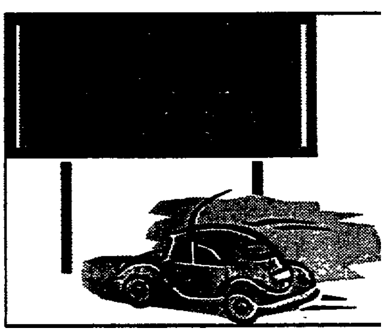

Figure 3.5: Roadside Signs Reminding Motorists to Turn into HAR while en-route.

Traffic Advisory Telephone System

Type:	"Pull Type"/Two-way communication
Time of Usage:	Pre-Trip and En-Route
Major User Group(s):	Commuters and Frequent Travelers
Cost for User:	**Low**
Engagement for User:	Moderate
Equipment/Services Required for User:	Phone and Phone Service Provider
Commercial Value:	**Yes**
Other:	Safety issues have been addressed

Traffic Advisory Telephone Systems (TATS), often called audiotext systems, are information systems based on telecommunication technology. A general purpose audiotext system requires a touch-tone telephone and an interactive computer system. The traveler requests information by calling up the information line which is connected to a computer system database. Typically the traveler is presented with a menu of alternatives from which he/she can choose. The information is stored as "text strings" in the data base and is presented by an automated voice reading to the traveler upon request. By touch-toning (key stroking), or in some cases by voice activating (speaking), the traveler locates the desired information and "pulls" it out from the computer system database.

As other sources of pre-route traveler information continue to increase, especially traveler information sites on the Internet, one might assume that a substitution effect would decrease the usage of these services. However, a continued expansion of the cellular phone market creates opportunities for an increase in the low-cost complementary services to new sources of travel information, especially during the users' actual travel. Audiotext providers are likely to help fill such a window of opportunity for en-route services because of their services' commercial value to cellular phone service providers. Not only is **TATS** becoming readily accessible and being consulted for traffic information, but it remains the "closest to time of travel" information source. The general convergence of telecommunications and computers continues to bring new products and services to the market (some which are described in the discussion further on in this section on personal communication devices).

The Case of SmarTraveler in Boston, Massachusetts

SmarTraveler is the flagship service of a firm called SmartRoute Systems. The firm is considered "cutting-edge" in the design, development and deployment **of ATIS.** Its focus has been on traveler information data collection, fusion, and dissemination.

The traveler information is synthesized from multiple inputs including pd/dot scanners, two-way radios, phones and video/surveillance cameras for output through audiotext phone system services.

The information is provided to the end-user by he/she calling:

* *(617) 374-1234 from home or office pre-trip*
* *“1 or similar combinations,from car/cellular phone while en-route (see Figure 3.6)*

The information provided includes traffic and road conditions, current (expected) travel times, transit options, alternate routes and construction sites.

The SmarTraveler system delivers “free” of charge up-to-the-minute, on-demand, location-specific traffic and transit information to anybody in eastern Massachusetts with a touch-tone telephone. The cost for dialing SmarTraveler has been a local call from areas with area codes 508 and 617, i.e. from calls made in metropolitan Boston. Car-phone/Cellular phone users are often offered the service free of air time and long distance charges as a value-added feature by their phone companies (while in the local area).

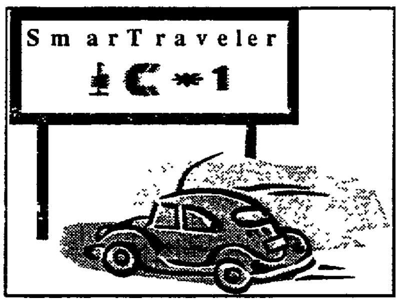

Figure 3.6: Roadside Signs Remind Motorists about SmarTraveler Services while en-route

Currently, SmarTraveler covers the Central Artery, Storrow Drive, Memorial Drive, Logan Airport, the Mass Pike (I-90), and routes 1,2,3,9,24,93,95, 128 (I-95) and I-495. It also incorporates information on the MBTA commuter rail, bus and subway systems. Overall, the system seems to be very successful, i.e. roadways are less congested, air quality benefits are being realized, and commuters save time traveling.

With its success in Boston and Cincinnati as an advanced T&provider, SmartRoute System has been selected to provide similar services in Pennsylvania, Washington DC and New York City’ by respective DOTS.

Electronic Displays

Type:	**“Push Type’/One-way** communication
Time of Usage:	Intermediate and En-Route
Major User Group(s):	Anybody
Cost for User:	Zero
Engagement for User:	Low
Equipment/Services Required for User:	n/a
Commercial Value:	**Some,** especially on Electronic Bulletin Boards
Other:	**Difficult** to decide the best location of sign Message protocol **not** clear enough

7 SmartRoute Systems Update, Winter 1997, Vol. 3,’ No 1, page 1.

Electronic displays is a general term for popular ITS applications. The group of electronic displays consists of both portable and fixed signs or boards. namely:
* *Electronic Bulletin Boards*
* *Changeable Message Signs*
* *Variable Message Signs*

The volume of information provided through dynamic message signs ranges from the brevity of a speed advisory on a CMS or a detour advisory on a VMS. to a scrolling sequence of transit arrival and departure data on EBBs.

Electronic Bulletin Boards are usually geared more toward transit information than are the other dynamic message signs. Located at various activity centers such as passenger terminals, shopping centers, and highway travel plazas, EBBs provide text messages via both Liquid Crystal Display (LCD) and Light-Emitting Diode (LED). Another frequent usage area of EBB technologies are parking management and other "queue based" systems. Examples of EBBs at activity centers include transit arrival or departure times displayed at the entrance to Vancouver's SeaBus Terminal, on several Metropolitan Atlanta Regional Transit Association (MARTA) bus shelters in Atlanta, and at the STCUM bus terminal adjacent to the Montreal Gare Centrale rail transit hub. EBBs are, as stipulated above, often deployed in the transit system. Users of transit systems are not only being informed on the status of the system, which may or may not modify their travel decisions, but also realize other benefits, such as time to seek better environments for waiting in order to avoid harsh weather and/or to reduce the exposure to potential criminal elements.

Changeable Message Signs (CMS) and **Variable Message Signs** (VMS) are frequently deployed in freeway/ highway environments (see Figure 3.7). Statistics show that they represent the most effective way to reach the traveling public. In general they are geared toward traffic management rather than pure traffic information dissemination. Three key categories of CMSNMS traveler information messages are the following:
* *Early warning messages*
* *Advisory messages*
* *Diversion messages*

These applications are basic, yet known to be successful in terms of getting the message across. Two factors are key to CMS/VMS success: it is important to both identify the ideal location of the CMSNMS before deployment and to adhere to an efficient protocol for the messages on the signs. Early warning messages provide "upstream" information on important delay and/or safety conditions to expect "downstream", such as traffic disruptions, weather or queuing. This type of information is primarily designed to reduce the number of secondary accidents. Advisory messages inform not only about traffic problems, but also about special events. In addition, they often encourage motorists to tune into HAR or other alternative sources of information. The intention is to encourage the motorist to seek alternative routes or otherwise modify intended trips. Diversion messages are intended to inform the motorists about "downstream" traffic problems such as closed roadways and reduced roadway capacities, while at the same time provide detour directions. Depending on the severity of these traffic problems, motorists will either be advised or forced to seek alternative routes.

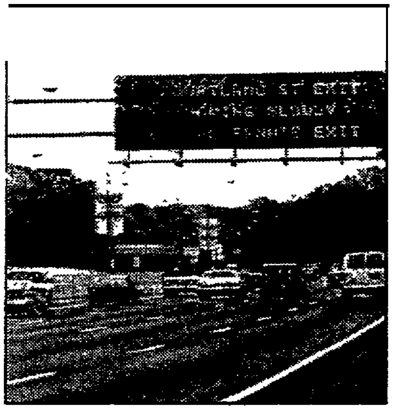

Figure 3.7: A VMS spanning all lanes of a freeway.

Elements of a CMS/VMS are:

* *Problem statement (e.g. accident, roadwork)*
* *Effect Statement (e.g. delay, heavy traffic)*
* *Attention Statement (i.e. to whom; commuter, tourist)*
* *Action Statement (i.e. "what to do")*

Adjustments in the motorist behavior relate to route choice, speed, trip timing and travel path. The major use of CMS/VMS technology today is probably the usage of Portable Variable Message Signs (PVMS). PVMS are typically used at construction sites and during special events in an area.

Kiosks

Type:	Extreme "Pull Type"/Two-way communication
Time of Usage:	Intermediate and En-Route
Major User Group(s):	Any Traveler. especially Tourists/ Visitors
Cost for User:	**Zero**
Engagement for User:	Low-Moderate
Equipment/Services Required for User:	None
Commercial Value:	Yes: Advertisement (Yellow Pages) as well as Value-Adding at the Stationary Location
Other:	Public Access is limited to Activity Centers ADA accessibility Vandalism

Computerized Information Kiosks, or "Smart Kiosks" as they are often called, are computer systems generally located in a high-traffic area such as airports, bus and transit service terminals. company cafeterias and restaurants, hotel lobbies, travel plazas, intermodal transfer points, parking garages, government offices and other activity centers (see Figure 3.8). Kiosks are used as point-of-information systems to deliver or gather information to and/or from a user in the fastest, most efficient, and easiest manner possible.

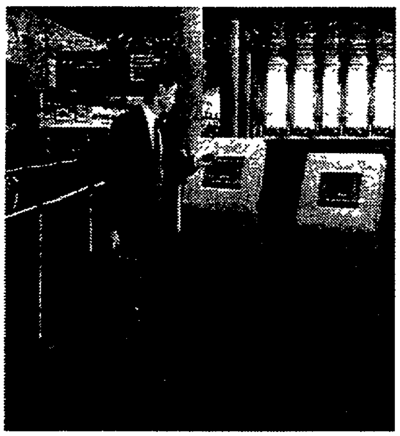

Figure 3.8: Man-Machine Interaction at an Airport Terminal Equipped with Kiosk Stations'

Most kiosk systems operate under a standard Microsoft Windows environment or equivalent. The computers are usually "high memory" and "high speed processing" in order to accommodate attractive audiovisual interfaces and fast response times for the delivery of information. Kiosk systems may be connected to network communications through devices such as a modems or network interface cards to access information from databases on servers and web sites on the Internet.

8 http://www.montegonet.corn/airportict.html ,

Kiosks are menu-driven devices accessed by users through touching desired menu choices on a multimedia screen interface. A key feature of a kiosk is that a user may walk up to the system and immediately begin interacting with the application. A request is usually expedited within a few seconds and the delivered information can include not only text and graphics, but sounds and full motion videos. Early kiosk systems were mostly used for guiding, instructing or educating people. Other uses related to ordering of products or services as well as interactive customer surveys. These fundamental building blocks remain important in terms of serving the traveling public with travel and transit information.

A typical kiosk contains a computer running a multimedia application, audio speakers, and a touch-screen monitor. Transportation information disseminated through a sequence of menus can include both static and real-time traffic conditions, transit routes and schedules, and auto or transit trip planning information for specific destinations. Travel-related information may also be displayed, including special events, yellow pages for ordering such services as taxis or even hotel/ motel rooms. Much of this information relates to tourist attractions, as tourists and temporary visitors have been primary user groups. Kiosk deployments often include a printer as an output device for hard copy of information displayed on screen. The potential for computerized kiosks has been described as "limited only by the intention of their developers and the number and diversity of resources they can bring to the project."[9]

One key factor in a successful man-machine relation, including the use of kiosks, relates to the kiosk's degree of user-friendliness and actual usefulness. This has been acknowledged by the vendors in the field, so that most kiosks now let the traveling public interact in a variety of ways by using one or more of the following:

* *Alphabetical entries*
* *Alphabetical listing entries*
* *Map-driven entries*
* *Landmark-driven entries*
* *Graphical Logo entries*

The Case of TraveLink Advanced Traveler Information Kiosks and GeorgiaNet in Atlanta, Georgia

The most extensive deployment of Smart Kiosks in the United States to date took place in the Atlanta region and in several other locations in Georgia as part of preparation for the 1996 Summer Olympic Games. A total of 130 TraveLink advanced traveler information kiosks were installed in freestanding structures, each equipped with a touch screen interface and a printer (see Figure 3.9).

9 SchroederJ L . and Green, Jeff, The Emergence of Smart Traveler Kiosks and the User Interface Requirements for their Successful Deployment,

Figure 3.9: Freestanding Kiosk S true ture at a Visitor Center[10]

The information for the kiosks, which were placed at transit stations, hotels, visitor centers, hospitals, airports, office buildings, rest areas and shopping centers, was provided by Georgia DOT Advanced Transportation Management System. MARTA (the mass transit system in Atlanta), the Weather Channel, airline companies, and the Georgia Department of Industry, Trade and Tourism." A number of other Smart Kiosk deployments have been undertaken in the United States, including those for the Los Angeles Smart Traveler project, the Seattle Smart Traveler project, TravLink in Minneapolis, and the Yosemite Area Traveler Information System (YATI). Design issues to be solved in any deployment include monitoring of hardware and software failures, handicap accessibility, getting the attention of potential users, and ease of use12

Internet and Interactive Cable-TV

Type:	"Pull Type"/Two-way communication
Time of Usage:	Pre-Trip
Major User Group(s):	Any Traveler
Cost for User:	Moderate -High initial investment Low subscription cost to Internet provider
Engagement for User:	Low-Moderate
Equipment/Services Required for User:	Personal Computer
Commercial Value:	Yes: Advertisement (Yellow Pages) Value-Adding and/ or Goodwill of sponsors
Other:	Public Access is limited to users of the Internet Processing time (download time) as well as Procedure time ("surfing the Net for the right information")

10 http:www.georgia-traveler.com/Showcase/kiosks.htm
11 Atlanta Traveler Information Showcase 1996 (information sheet).
12 Schroeder, J.L. and Green, Jeff, The Emergence of Smart Traveler Kiosks and the User Interface Reauirements for Successful Deolovment.

The Internet/World Wide Web

In the last few years, usage of the Internet has skyrocketed and the exponential growth is still in full progress. both in terms of homes and offices gaining access to the Internet and in terms of the number of new Web sites that are being developed. This growth does not exclude traveler and multi-modal trasnportation sites. Such sites on the World Wide Web (WWW) are often sponsored by a wide range of public sector agencies and organizations, even though private for-profit traveler information sites exist. Typical sponsors are academic institutions, chambers of commerce, tourist bureaus, state and local governments, and non-profit organizations. The private for-profit sites continue to increase in number, not only as the Internet boom continues, but as the public starts to realize the benefits and potential services of traveler information.

Figure 3.10: Pre-Trip Planning on the Internet via Modem at Home Making Use of a Site On the World Wide Web by Using a Personal Computer.

Most transportation-related WWW sites appear to be in their development phase. This seems to be especially true for traveler information sites. Nevertheless, the markets for these types of services define the framework in which ATIS applications can develop. As with radio and television, the WWW offers the site providers great potential for advertisement and sponsorship on their sites. Vice versa, other w w w sites have simply realized the value-added of bundling their regular services with traveler information. The way the WWW is structured with hypertext links, the traveler can often find related information on other WWW sites.

There are several convenient features of modem WWW sites. A common set-up **or** design of a WWW page involves so called “thumbnails”, which enable the user to get an overview of the WWW site’ s contents. These thumbnails not only let the user preview information such as images (and in some cases video), but also to cut down on potential time wasted through lengthy downloads or time spent looking for the right information (“surfing”). Bookmarking is another useful feature that is found on most browsers (such as Internet ExpIorer and Netscape Navigator). Some browsers also provide for memory in terms of user profiles which makes the surfing process more efficient and less tedious.

The usage of the Internet, as a source for traffic and transit information, may be limited to the morning commute for many commuters since many offices still do not provide Internet access or monitor the Internet usage in a way that it becomes an infeasible source of traveler information. This problem may be overcome by new types of electronic mail such as "flash mail" (by which the computer user is notified of electronic mail delivery and its degree of urgency) and new and developing types of "subscription mail" services (in which the user subscribes to an electronic bulletin/report which is delivered via electronic mail at specified times of the day), as well as through the deployment of bulletin board systems and intranet systems.

Internet/WWW can provide a mixture of static, dynamic and real-time information and services concerning:

- *Trip Guidance*
- *Route Guidance*
- *Regulations and Tolls*
- *Road Conditions*
- *Parking Conditions*
- *Ride Matching*
- *Park and Ride Facilities*
- *Transit Schedules, both inter- and intra-city*
- *Transfers and Fares*
- *Road Construction and Maintenance*
- *Weather Conditions*
- *Attractions and Special Events*

By locating some database/web servers, where the information is contained within TICs, TMCs, TOCs or other data-collecting and fusing agencies, the disseminated information "on-line" becomes more relevant, i.e. the traveler information is real-time. WWW sites with automatic refreshing capabilities make traffic and transit information instant.

The Case of AOL's City-Boston and Microsoft's Sidewalk

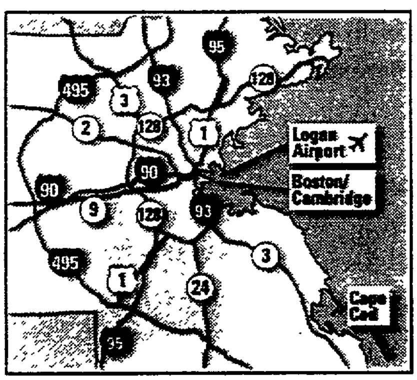

Figure 3.11: The Internet Provides Increasing Access to Location Specific Real-time Traveler Information for the Boston Area

Two major players, one in ATIS and one in computing in general, recently moved "on-line". They are SmartRoute Systems in partnership with America Online ("Digital City - Boston) and Microsoft ("Sidewalk"). Members of "Digital City - Boston" access information based on a "point -and-click" concept to read current traffic conditions for the route they choose, and may even see camera images of major congestion points throughout the Greater Boston area (see Figure 3.11).

The all new “Sidewalk” w w w sites highlight activities, news and recreational happenings along with traveler information. The traveler information is contained in-house through a hyperlink to what Microsoft calls "Trafficview". The information can be previewed based on a “drag-and-point” concept to access in detail, or at enlarged levels through zooming features, by regular “point -and-click” user maneuvers. The main infrastructure is built around the following components:

* *Color-coded dynamic real-time map with additional text information (e.g. 55 mph and steady)*
* *Customizable map features (e.g. show only HOV-lane data, graphics and images)*
* *Trip calculators using real-time data as input*
* *Traffic information by electronic mail subscription*

Interactive Television

One of the latest developments in the field of ATIS is an application which has been coined an “Interactive TV”. This new application is a showcase of what new ATIS application may develop as the convergence of computing and telecommunications continues. A large field operational test of this new application took place during the Atlanta Olympics in Georgia, where about 300 hotel rooms got access.” Each hotel room was equipped with a regular television set, a customized/ special remote control, a “top box”, and a dedicated telephone line (see Figure 3.12). In such a system the viewer interacts with the TV by selecting information from various menus and graphical interfaces on the TV-display through the customized/specialized remote control which communicates with the “top box”. The top box is linked through the room’s telephone line to a head-end computer, which in turn is linked to a data server in a TIC, TOC or TMC. As the inquiry is processed, a multi-media response **is** sent back to the television set over the cable TV distribution system. The system does not require any special “navigation” knowledge since it is completely menu-driven and the requested information is displayed via maps, slides and voice. A special feature of the interactive TV project, as with Smart Kiosks, was the possibility of getting print-outs of the information (available at the front desk in the hotel lobby). The interactive TV showcase in Atlanta offered the following interactive services:

* ***Traffic Incidents and Highway Speed3***
* ***Public Transportation***
* ***Area Attractions and Special Events***
* ***Restaurants***
* ***Hotel Services***
* ***Weather Conditions and Forecast***
* ***Electronic Yellow Pages***
* ***Tutorial of the Interactive TV system***

[13] The Traveler, Atlanta Traveler Information Showcase, Issue Number 4. May 1996.

Figure 3.12: Interactive TV Provides Travel Information to Viewers On Demand.[14]

Personal Communication Devices and In-Vehicle Devices

Type:	Mostly "Push Type"/One-way communication but also "Pull Type"/Two-way communication and some "hybrids"
Time of Usage:	Pre-Trip, Intermediate and En-Route
Major User Group(s):	Any Traveler
Cost for User:	Cost of Product plus potential service charges
Engagement for User:	Low-Moderate-High
Equipment/Services Required for User:	Personal/In-vehicle Device plus potential subscription services
Commercial Value:	Yes; Advertisement (Yellow Pages) as well as Value-Adding to product lines and other services
Other:	Access is limited to owner and/or subscriber Safety of using the devices while driving Theft of equipment

Personal Communication Devices (PCD)

Personal Communication Devices are emerging as fast as the communications industry is growing. These technologies are typically based on the development of one-way communication systems providing messaging and information services. This development, and the expansion of two-way communication systems, will probably continue to boom as the telecommunication and computing industries are converging. PCDs are almost synonymous with dynamic real-time information. As a result, the value and quality of the information will depend on the data fusion and distribution to these systems. While a classification of the PCDs is quite difficult to do since it is difficult to clearly identify a product with a certain bundle of features or functions, common PCDs are as follows:

- *Wristwatches*
- *Cellular Telephones*
- *Pagers*

14 FHWA and Georgia Department of Transportation

Wristwatches such as Seiko’s MessageWatch (see Figure 3.13) are currently penetrating the market of information technology products. The MessageWatch is one of the smallest communication devices now on the market . This portabiIity means that the bearer can stay in-touch and be informed at little or no inconvenience. Another benefit of wristwatch technologies such as Seiko’s Message Watch for information dissemination is that, unlike other wireless PCDs (such as the cellular telephones and palm-tops), they run on regular quartz batteries and require minimal maintenance: Beyond its traditional paging features, subscribers to the service package of this wristwatch have the option of staying up-to-the-minute with information that affects their days. An ever-growing selection of information services, which can be customized to fit the individual, can keep the owner up-to-date on not only the current traffic conditions, but weather. sports, etc. In order for this type of technology to be suitable for ATIS applications, the owner and subscriber has to supply information about his/ her usual routes as well as time of travel. This profile will alleviate the problem of limited message storing capacity in the wristwatch pager. Thus, only those traffic and transit problems that would result in substantial delays or related to warnings are sent.

Traveler information is disseminated every minute. The message format of the traffic information is encoded in accordance with standard protocol similar to the European Radio Broadcasting Data System (RBDS) called International Traveler Information Interchange Standard (ITIS).

Wristwatches

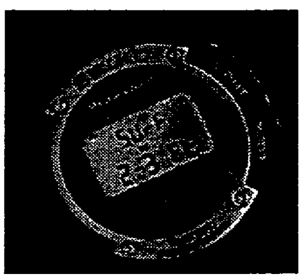

Figure 3.13: Seiko’ s MessageWatch - A Watch of its Time”

This product and service package represented a key activity in the development of High Speed Data System (HSDS) wireless communications technology as part of the Seattle Wide-area Information for Travelers (SWIFT) project and the Triology ITS program in Minnesota. Currently, Seikois wristwatches are available and usable in four areas of the U.S.: Southern California, Oregon, Washington and Las Vegas.‘” The wristwatches can only receive messages from FM stations equipped with HSDS. Any FM broadcast transmitter can be enabled to carry this HSDS subcarrier. Since this infrastructure already exists, the cost of delivering information to the customer is drastically reduced. HSDS takes advantage of the unutilized spectrum available in the non-audio region of commercial FM transmitters around the world.

15 http://www.messagewatch.comipricingpage.htmi.
16 http://www.messagewatch.com/img/toolbar.map.

Palmtops and Laptops

Palmtops, also known as pen-tops, are handheld computers equipped with wireless modems (see Figure 3.14). Laptops. now a staple of business travel. are larger dimension portable computers which can be similarly equipped. Access to these devices allows users to obtain a wide variety of travel information. During the Atlanta Traveler Information Showcase, palmtops were used for customized transit routing; airline, Amtrak, and Greyhound schedules; street-level maps and business listings; special events locations and times, and real-time traffic information via a wireless communications link. These devices can operate in a bulletin board system (BBS) environment in which text messages give real-time traffic and transit data. Bus locations can also be shown on a map display, updated about once a minute. In addition, static bus schedule and yellow page information is available from the hard disk. Some portable computers may also be outfitted with a GPS receiver.

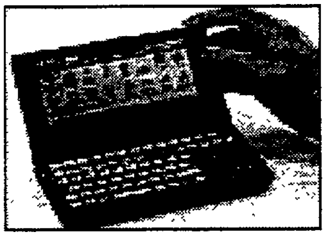

Figure 3.14: Hewlett-Packard's HP200LX - A Handheld Personal Communication Device for Two-way Paging"

The Atlanta Traveler Information Showcase made use of two different hand-held computers, each with a wireless communications link. The Motorola Envoy employed a touch-screen interface with a stylus or pen to access a map of Atlanta showing real-time traffic data, as well as electronic yellow pages and other services. In contrast, the Hewlett-Packard HP2OOLX employed a Windows-like interface and pull-down menus to access traveler information.

In general, the Atlanta Showcase proved the technical feasibility of these devices. Nevertheless, unit costs will need to fall before their deployment for routine access of a traveler information system is viable in the consumer market.

In-Vehicle Systems

A classification of in-vehicle systems is quite simple since all the products aim at presenting similar information in different ways. Two general system approaches exist for in-vehicle dissemination of information:

* *Car stereos (see discussion of this approach under the section on radio and television)*
* *In-car displays*

In-car displays, or in-vehicle systems as they are usually referred, are of three basic types:

* *Static Navigation Systems/Route Guidance Systems*
* *Dynamic Navigation Systems*
* *Autonomous Navigation Systems* .

17 **http://www.georgia-traveler.com/Showcase/PCD.htrn.**

A static navigation system has a monitor which is connected to a GPS (Global Positioning System) navigation system. The system uses the signals from the GPS satellite system, the speedometer and a gyro to calculate the precise position of the car on digitized map displays. The geographic data are stored on CD-ROM discs and read by a CD-ROM player. The maps. which are displayed on the monitor, cover the road system down to small town level and up to span whole continents when the user desires. The usefulness of such static navigation tools are ultimately dependent on the detail of the maps as well as the maps' reliability in terms of being up-to-date.

The basic concept behind a dynamic in-vehicle system is to better prepare drivers that are en-route by informing them of what lies ahead, both in terms of navigation and'real-time messages. These systems are still very new on the market, but car manufacturers who have invested in such projects are finally starting to offer them in their more luxurious models or as optional upgrades to their basic models. In general, these systems have been tried out in several field operational tests and the product is just starting to reach an early maturity level.

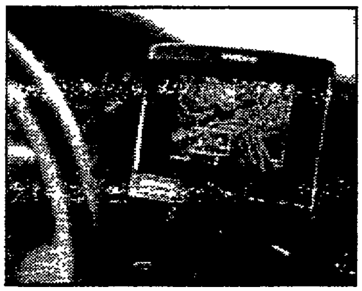

Figure 3.15: The High-resolutions LCD Display of Volvo's Dynaguide."

One of these systems is Dynaguide (see Figure 3.1.5), which uses the Radio Data System/Traffic Message Channel (RDS/TMC) to transmit the message to the driver. RDS/TMC is basically a traffic information network. RDS is the subcarrier for the disseminated information in which the message is encoded as a TMC. As with the newer HSDS technology, RDS technology need not be expensive in large scale deployments. The infrastructure exists and the data or information transmission occurs at sufficient rates.

The driver receives information on an in-car screen about the current traffic situation. With the aid of the satellite-based Global Positioning System (GPS), a system like Dynaguide can locate the position of the car on the map display. The system uses several logos similar to road signs on the display map. Scheduled road construction or closures are shown constantly and warnings are issued in good time. As a result the driver knows, for example, when the snowplows have not managed to get through or where it is slippery. Typical message icons represent severe and minor accidents, roadwork, bad weather, traffic jams and possible delay. The fact that the user may zoom in and out and select different filters for the information makes it an interesting milestone in the development of autonomous in-vehicle systems. Several standardized filters help the user use the optimal display in terms of level of zoom as well as selection of traffic messaging criteria.

20 http://www.volvo.se/technical/dynaguide.html ,

Autonomous Navigation Systems are quite similar to dynamic navigation systems and are still not fully developed. Volvo's RTI-system (see Figure 3.16) is, however, being launched in their new product line - a system which issues instructions over the stereo system's speakers instructing the driver about the easiest or fastest way of reaching his/her final destination. These instructions are repeated before the driver reaches critical points in his/her path such as intersections, and entrances/exits to/from freeways. The synthetic voice also tells the driver which lane he/she should be in, all in accordance with the lay-out of the traffic system.

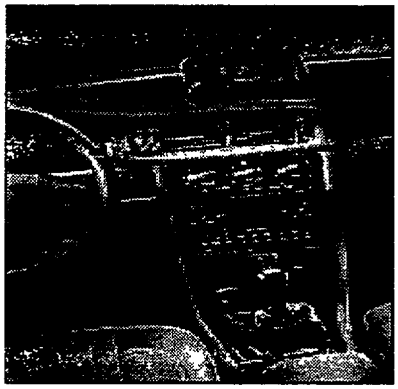

Figure 3.16: The High.-resolutions LCD Display of Vo1vo's RTI. 19

3.6 Advanced Public Transit Systems (APTS)

"APTS technologies can revitalize transit by directly improving service, increasing transit efficiency and reducing operation cost as well as by producing direct benefits for travelers such as reduced travel times, increased safety and security and reduced stress in dealing with transit unreliability."

The development and deployment of ITS technologies, including specific APTS technologies, have seen an almost exponential growth. As society continues to shape itself into an information village, this trend will continue. It is important, however, to retain a strategic approach to ITS investments in response to opportunities in the "electronic village". This strategic approach is based on the mission of mass transit, emphasizes linkages between ITS technologies, and looks ahead toward expanding ITS applications as needs, resources, and technical feasibility permit.

The benefits of deploying ITS technologies in transit, traveler information, or traffic management individually - rather than linked together - are often limited. APTS technologies can only realize their potential in concert with the electronics and communications systems that also manage traffic and guide travelers to their destinations.

19 http://www.volvo.se/technical/dynaguide.html.
20 Journal of Public Transportation, Vol. 1, No. 1, Fall 1996, p. 42.

Traveler Information Systems in Transit

Traveler information systems in public transit environments, as with any information system, are typically judged on three essential criteria: quality of presentation, accuracy of information presented, and the degree of relevance of the information. Two categories of traveler information systems in transit are typically identified - pre-trip and en-route/ in-terminal information systems. These systems comprise a wide variety of services based on either static (historical) or dynamic (real-time) input. or a combination of both. such as:

* *Arrival and departure times/schedules*
* *Transit vehicle location (AVL) display and estimated time of arrival (ETA)*
* *Best route selection, travel time, fare, comfort, etc.*
* *Connection points*
* *Trip chaining*
* *Multimodal itinerary optimization*
* *Rideshare opportunities*
* *Terminal, terminal surrounding area, destination and trip information*
* *Advance ticketing and reservations*

Figure 3.17: Smart Kiosk at Transfer Station

Pre-Trip Information Systems -

* **Automatic Dialphone Line** (typically a local phone number or toll free number with an automated "loop" message on an answering machine)
* **Audiotext Dialphone Line/TATS** (a menu-driven touchtone service; typically a local phone number or toll free number, but in some cases a pay service)
* **Telephone to Dispatch Center Line** (a service with some level of non-computerized or personal contact; typically a local phone number or toll free number, but in many cases a pay service; often provided by a TIC/TMC or agency with access to their information)
* **Radio**
* **Television/Cable TV**
* **Text-TV**
* **Interactive TV**
* **World Wide Web/ Internet**
* **E-mail/ Internet**
* **E-mail/ Intranet**

En-Route/ In-Terminal Information System -

* **Audio terminals**
* **Video terminals (keypad and/or touch-screen)**
* **TV-monitors**
* **Electronic Bulletin Boards (EBB)**
* **Synthesized voice message systems**

Figure 3.18: Text-TV/ TV-Monitor at a Bus Stop

Figure 3.19: Estimated Time of Arrival EBB at a Bus Stop

The Smart Bus

Several features of modem buses makes them "smarter", including:

* *Automatic Passenger Counting (APC)*
* *Automatic Vehicle Identification Systems (AVI)*
* *Automatic Vehicle Monitoring Systems (AVM)*
* Global *Positioning Systems (GPS)*
* *Roadside to Vehicle Communication (RVC)*

Figure 3.20: A MARTA "Smart" Bus in Atlanta, Georgia

Tracking Systems: Beacons

Tracking systems have played an important role in older dispatching systems and will continue to play an integral part until replaced with more modem and accurate systems. The fundamental concept of an old tracking system is that the fleet runs on a fixed-route where communication infrastructure has been put in place. As a result, these systems are often referred to as "pass by tracking systems" and can be classified as either:

* *Radio frequency beacon communications system*
* *Infrared optical beacon communications system*

Both systems are based on roadside beacons and in-bus receivers. The technology is simple and the system is set up by many independent sub-systems. As the buses pass by the roadside beacons information on the bus' current location is "picked up". This information can be used in several ways. Typically a signal is sent to the dispatching center to inform the dispatcher about the bus' performance in terms of keeping scheduled headways. The information can also be processed in the bus itself to help the bus driver better manage his/her driving. New traveler information services can benefit from this information too. Common uses are automated audio-text systems in the buses and estimated time of arrival systems at the bus stops or terminals. Modem systems have interpolation functions (based on odometer readings in the bus) built in to the system in order to facilitate more accurate and timely announcements. Even though the technology is believed to be scaleable to implement, other emergent systems are often considered more cost-effective, especially in terms of avoiding expensive maintenance costs. In many cases the technology also seems inflexible since bus routes may change while beacons are fixed and costly to move.

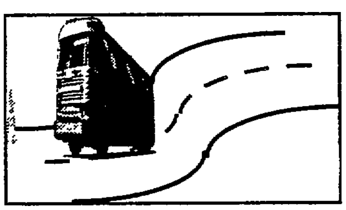

Figure 3.21: Smart-Bus with Roadside Beacon Communication Link

Tracking Systems: Differential Global Positioning Systems Technology (DGPS) -

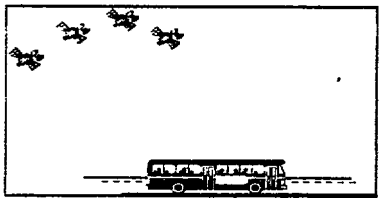

Figure 3.22: Smart-Bus with GPS Communication Link

Differential Global Positioning Systems Technology (DGPS) is based on signals from several satellites in a larger global system of satellites in orbit, along with receivers on bus roofs. The bus receives data on its location from satellite signals and then transmits the location to a dispatching center. Since satellite coverage includes all of North America, bus location information is not tied to a specific route as in the case of beacon technology. Nevertheless, DGPS signals can be interrupted by tall buildings ("urban canyons") or even foliage and cannot reach underground.[21] An array of U.S. transit systems, ranging in size from Napa, California to Denver, Colorado, have deployed automatic vehicle location through GPC technology.[22]

Automatic Vehicle Location, Global Positioning Systems and Geographical Information Systems -

The key technologies for the different "keep track systems" are Automatic Vehicle Location (AVL), Global Positioning Systems (GPS), along with Geographic Information Systems (GIS) technologies. These systems report the transit vehicle's location on a transit route system link along with other relevant information depending on which systems are integrated with AVL/GPS systems. Such information typically includes the bus' occupancy rate and its mechanical status.

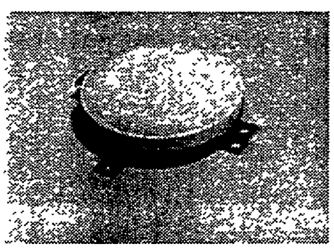

Figure 3.23: GPS Transponder, Bus Roof-mount Type

21 Advanced Public Trasnpostation Systems: The State of the Art. Update '96. U.S. Department of Transportation, 1996, pp. 10-13.
22 ibid, pp. 14-20.

Relating AVL data to a GIS map and relational database allows visual tracking of bus fleet movements, as well as comparison of real-time to scheduled headways. This information is useful for both management of bus fleet operations and - when disseminated to the traveler via the Internet. smart kiosks or through other means - as traveler infonnation.

Automatic Vehicle/Transit Stop Monitoring Systems -

Automatic Vehicle Monitoring Systems (AVM) consist of driver-activated "silent" alarms and in-bus microphones audible at central dispatch locations and Closed Circuit Television (CCTV). These systems increase driver and passenger security through transmission of information on incidents to dispatchers and public safety personnel. When linked to AVL technology, emergency response times are shortened due to availability of more precise information about vehicle location. CCTV deployment at transit stops, monitored by dispatch and/or public safety personnel also enhances passenger security.

Automated Dispatching and Computer Aided Dispatching Systems -

Automated dispatching and computer-aided dispatching (CAD) systems have great potential to increase transit service efficiency and convenience. In demand-response transit applications of the type common in human service transport, these systems can shorten the gap between a request for service and provision of service. In fixed-route applications common in urban areas, these systems can speed deployment of additional buses or trains to meet excess demand, as well as assist drivers in maintaining headways (time spacing between vehicles). In case of mechanical difficulties in either demand-response or fixed-route settings, automated dispatching and CAD can also expedite deployment of replacement vehicles and repair crews.

Automated dispatching and CAD systems require either a beacon network (radiofrequency-based) or GPS-based AVL for vehicle location, map bases (typically CD-ROM) to display location of transit vehicles - in paratransit applications potentially passenger locations as well- and communication links.

Figure 3.24: Dispatcher at the Transit Operations Control Center

Some systems have communication links established to pre-trip information systems (such as a Web site on the Internet) or in transit/ in-terminal information systems (such as Electronic Bulletin Boards (EBB), or both, providing the traveler with information in real-time. As these systems get even "smarter" and more integrated travelers will be able to get "best,route",information, such as trip chaining, according to the criteria selected by the user. These criteria might include trip itinerary (desired service times and destinations), parking requirements, walking distance, waiting times, facilities, etc.

As these systems adapt to two-way communication standards that allow the traveler to interface with the system, passengers themselves will be able to make seat and ticket reservations and transit systems will move toward dynamic scheduling.

Figure 3.25: In-bus Information (Electronic Bulletim Board)/
Automated In-bus Announcement (Audio-Text Information) Systems

Automatic Passenger Counting

Automatic passenger counting, or “keep track” systems, are useful for monitoring demand or vehicle occupancy in real-time, as well as by stop, route, and system. Applications of these data range from dispatch of additional transit vehicles to meet excess demand to transit route and system planning. Passenger counting systems can be based on either a pressure-sensitive mat tread upon by boarding/alighting passengers or infrared beams through which passengers pass upon boarding or alighting.

Figure 3.26: In-Bus Passenger Counter/Automatic In-bus Passenger Counting

All systems use random access memory (RAM) to store data collected. Most existing passenger counting systems exchange information between the dispatch center and selected bus stops, where communication links are established, but new technologies allow for information independent of the location of a bus on a route. This new technology allows data transfer or exchange in real time, thus reducing any delay in dispatch response to excess demand on a transit vehicle. Automated passenger counting is especially useful for transit analysis and planning purposes since the database contains information on not only the total number of passengers, but also the actual number of passengers on a bus at any given time or point of its route, and the number of passengers boarding and alighting at each bus stop.

Collision Systems -

Collision systems - or, more precisely, collision *prevention* systems - are an emerging APTS technology. In transit applications, such systems track the distance to the vehicle ahead, adapt transit vehicle speed to real-time traffic flow, and - for collision prevention - can activate both a warning to the driver and auxiliary brakes. Measuring the speed of the vehicle ahead can be done through radar, infrared laser, or sonar. Volvo’s Dynacruise system is an example of commercial application of this sophisticated version of cruise control.

Figure 3.27: Infra-red Dynacruise Unit[23]

On-Board Computers for Vehicle Diagnostics -

An increasing application of "smart" bus technology is in on-board computing for collecting data on oil levels, water levels, engine temperature. and other vehicle diagnostics. These data can be monitored by the driver, as well as transmitted to central dispatch, for remedial action. A vehicle diagnostics database provides a vehicle mechanical operating profile for use in maintenance and repair.

Smart Cards and Other Stored Value Cards

Smart cards are becoming increasingly popular in Europe, Asia, as well as North America. The areas for usage are widespread and include smart parking, electronic toll collection, fleet management, traveler information, and other ITS applications. Current trends reveal a Smart Card revolution that will go beyond the ITS arena.

The Smart Card is an advanced version of a standard memory-chip card. In a standard memory-chip card system, the data processing hardware and software read the information from the card, perform calculations, and write new data back to the card (i.e. a Read-Write transaction). An example of a typical standard memory card is the pre-paid phone cards. They are very inexpensive to manufacture and are, as a result, often disposed of when they are used up. A Smart Card contains a micro-chip instead of a memory-chip, i.e. it contains not only data storage capabilities but also processing capabilities. Hence a Smart Card system allows for the card to carry out all transactions. Scrambling and unscrambling makes the card secure enough for its intended usage. Smart Cards are more expensive to manufacture than magnetic and optical cards. They are, however, considered to be more cost-efficient due to much lower operating costs. For example, the cards can be re-ioaded, have very low failure rates (due to the lack of moving parts) and can handle multiple function usage.

There are three types of Smart Cards available:

- *Contact Card*
- *Contactless Card*
- *Contact-Contactless Combo Card* -

[23] http://www.volvo.net/technical/dynacruise_bus.html.

In contact chip cards. the embedded micro-chip connects to contacts on the surface of the* card see Figure 3.28)/ To be used. the card must be slid through a slotted Read.Write device that has a matching set of contacts. The transaction is very mechanical and since the Read-Write communication between the card and the device is only possible when the contacts touch the process, it is known for failures as dust and dirt often get into the devices.

The contactless chip cards do not have to be mechanically put into a slot to carry out an eIectronic transaction. They contain a micro-chip. a carrier, and an inductive antenna that allows the card to communicate with a card reader (see Figure 3.29). They can be presented any way up and any way around and need not touch the reader. As a result they are not only more dependable and reliabie but also easier and faster to use.

The combo card is simply a Smart Card which facilitates both types of transactions. As a result the card can be used in several environments which often makes it an even more viable alternative and solution to the society's needs. Table 3.2 summarizes the key differences between the two basic Smart Cards.

Contact Card	**Contactless Card**
Financial Industry Standard	Transportation System Standard (?)
Low Ccard cost ($0.60-$0.70)	Moderate Cost ($5-$7)
Disposable/Reloadable	Reloadable
Specific insertion requirements	Any orientation
Slow transaction speed (2-3 sec)	Fast transaction speed (<250 msec)

Table 3.2: A comparison of different Smart Card technologies[24]

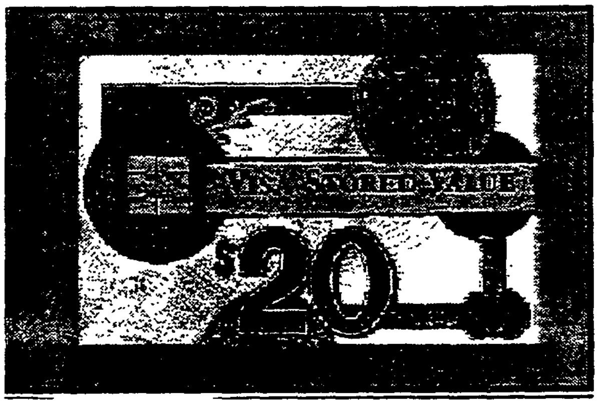

Figure 3.28: Contact SmartCard[25]

[24] ITS **World** Jan-Feb 1998 issue.
[25] Picture courtesy **of** IBI Group

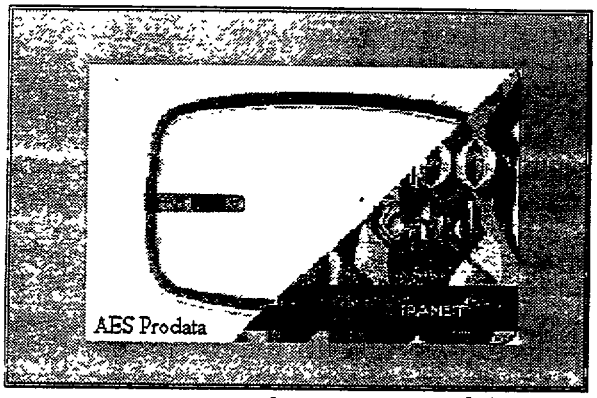

Figure 3.29: Contactless Smart Card (picture courtesy of IBI Group)

Smart Card for Private and Public Mass Transit


Figure 3.30: Transit passenger Conducting a Smart Card Transaction on a Bus

The transit operator benefits can be summarized by:

- *Reduced fare program cost*
- *Reduced equipment cost*
- *Faster boarding*
- *Improved ridership data*
- *Improved revenue data*
- *Increased possibilities for better fare policies and programs*

The transit passenger benefits can be summarized by:

- *No payment hassles; no need for exact change and less stress*
- *Can be tailored to the passenger needs and wants*
- *Easier inter-service transfers-*
- *Easier to conduct multimodal trips*
- *Convenient reload*
- *New discount and program possibilities.*

Smart Card for other uses

Besides ticketing and access to buses, ferries, taxis, trains and the street and highway system. Smart Cards can be used for other purposes as well. They can be used as debit/ credit cards and identity cards with multiple information stored in them. The ski industry uses Smart Card technology to control access to the lift system and to create a more seamless experience while taking advantage of the activities and facilities on the site. Tourism bureaus plan to make Smart Card technology an integral part of the stay in many continental metropolitan areas. The airline industry is considering Smart Card technology to create ticket-less traveling and to better keep track of frequent traveler points and other loyalty programs. In the long run, when integrated with emerging Internet technologies for e-trade, airline companies hope to eliminate travel agencies and minimize check-in procedures.

Smart Cards are transforming ticketing from intermodal purse cards to so-called ticketless travel. Benefits include more aspects than reliability, speed and reduced system cost. For example, new aspects of transport management that are gaining acceptance include:

- *Stored value tickets*
- *Travel card replacing travel agent, ticket and check-in*
- *Loyalty points*
- *Taxi/shuttle cards*
- *Smart identification*
- *Vehicle maintenance records*
- *Probe*
- *Smart vehicle road worthiness/tax/insurance cards/drivers license information*
- *Smart passports*

3.7 Advanced Traffic Management Systems (ATMS)

Overall Concept of ATMS -

ATMS maximizes the benefits to the motorist and other road users by improving overall roadway safety, reducing travel delay, and minimizing costs: ATMS can be subdivided into several functional categories, some which may have substantial overlap with and connection to ITS applications presented earlier under ATIS and APTS.

The key to a successful ATMS deployment is in providing for dynamic real-time management. The following functional requirements are therefore essential:

- *To monitor and direct the flows of traffic*
- *To operate and supervise elements of the transportation network of critical importance*
- *To manage incidents*
- *To support and coordinate all activities relating to the transportation network*
- *To provide information to transportation network users*

Most ITS applications can be located in one or more of the following areas:

- *Traffic Control*
- *Incident Management*
- *Emergency Management*
- *Emissions Testing and Mitigation*

Traffic Control -

Many ITS applications are dependent on the elements that comprise Traffic Control functions. In brief, Traffic Control is about managing the movement of traffic on streets and highways. Traffic flow is improved through a variety of rules and strategies, some that are fully automated and pre-programmed and others that require human interface. The key to ITS success on any surface street or freeway system is to collect the right data from the right places and analyze that information in an integrated manner. Consequently, these systems often require not only substantial equipment in the field, such as sensors, counters and cameras, but cooperation between the operators of the transportation infrastructure and services provided in the transportation system. When fully functional across all sub-systems of the transportation system, ITS applications within this functional category will not only improve traffic flow but also ensure prioritization of certain types of traffic such as public transit and emergency vehicles.

The essential first step to generate capabilities for traffic control is to deploy enough surveillance equipment to monitor traffic conditions at key locations of the transportation system, such as on- and off- ramps, bridges, intersections and access roads to major activity centers Surveillance epuipment range from loop detectors and video cameras for point Surveillance to aerial surveillance for wide-area Surveillance. A series of point Surveillance locations create an overall understanding of the status the transportation sy stem. In addition. the data collected at these locations may be used as input in potential strategy models to relive poorly performing points without generating negative impacts on the transportation system as a whole. The future for traffic control holds promise as vehicles become traffic probes in GPS and other navigation system technologies. thus allowing for cracking of traffic flow movements without infringing on the privacy of motorists.

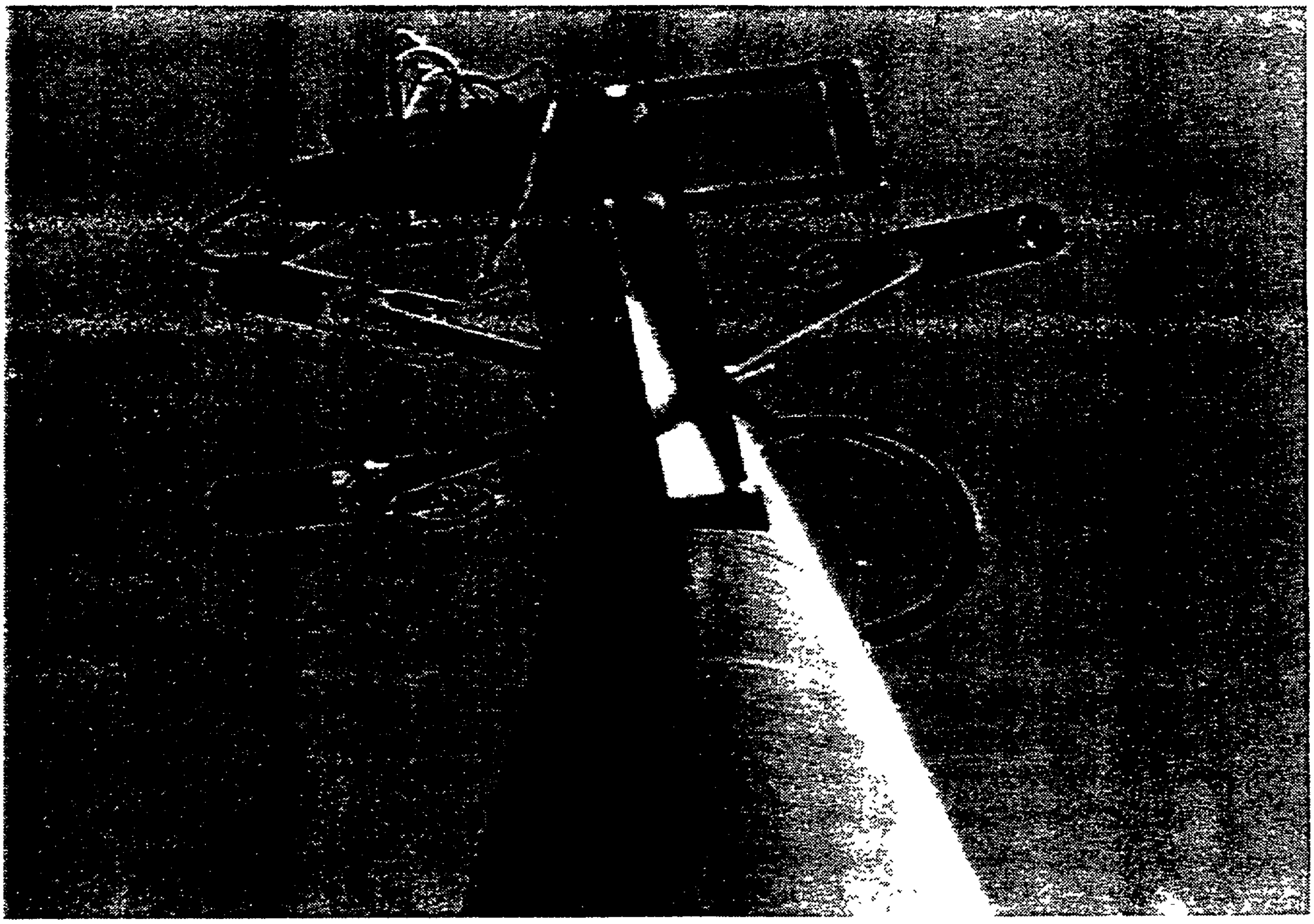

Figure 3.31: Freeway Video Surveillance Cameras on Pole

Today, many automated traffic control systems exist at critical locations. However, they often operate as individual systems not integrated with other elements the transportation system. Such systems are often found at intersections of the surface street system or on certain stretches of access roads connecting to the freeway network. With emerging information technologies such as data and voice communications, along with the new opportunities for human interface in automated and cyclical programs of such subsystems. real-time adaptive and integrated approaches are emerging. The key is a processing center. often referred to as the Traffic Management Center (TMC) or Traffic Operacions Center (TOC) where all the data from the diverse surveillance sources in the transportation system are analyzed and fused. These data are augmented with other sources of Information such as roadwork reports, weather reports, incident reports, and historical data to better achieve efficient traffic control strategies. The output from the control straegy models or decisions is disseminated to street traffic signals, street and freeway Changeable Message Signs (CMS) and Lane Closure Signs (LCS), and freeway ramp meters.

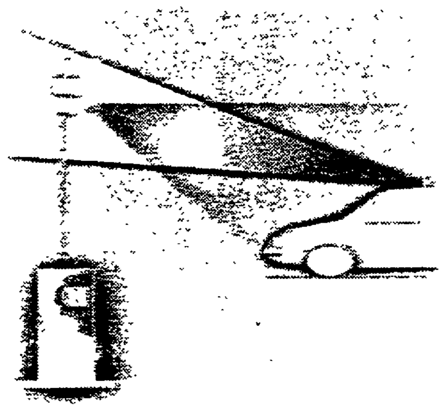

Figure 3.32: Traffic Signal Preemption

Figure 3.33: Video Camera Network in Seattle

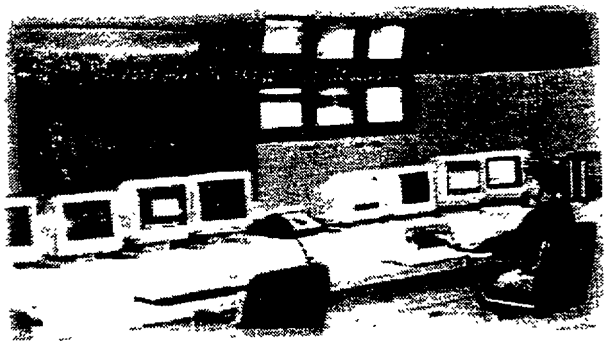

Figure 3.34: Traffic Management Center

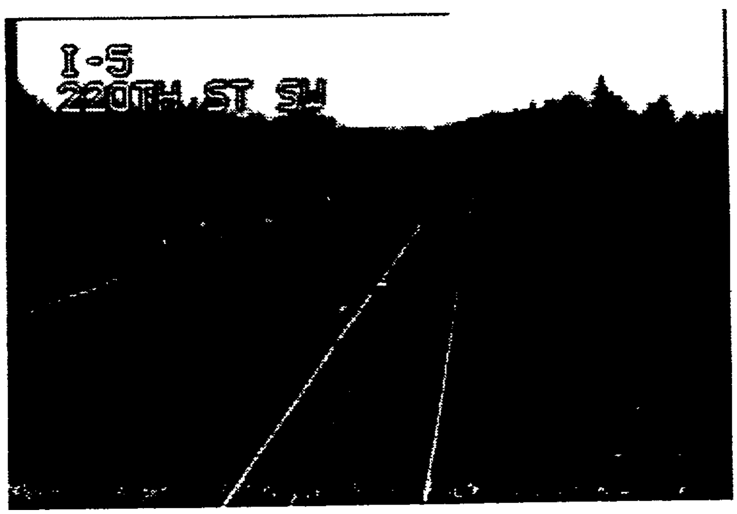

Figure 3.35: Video Image from Traffic Management Center

Incident Management

ITS applications under this functional category are intended to assist public as well as private organizations to better identify incidents in the transportation system and to impiement successful response plans in a coordinated matter among the responsible entities. Incidents. as a transportation term. refer to any event that creates a change of the expected performance of the transportation system when fully operational. Incidents such as accidents. road construction, maintenance. culturaI and sport events all affect the flow of traffic. ITS applications can assist in almost any incident scenario, but incidents that can be scheduled, such as construction and special events, are often resolved using conventional transportation management tools such as road closures and fixed-sign re-routing of traffic. Incident Managment is therefore often thought of as a real-time application that can be used to deal with accidents only. In any event, incidents, whether scheduled or random, need to be detected in order to create an efficient response plan. Hence, advanced surveillance and monitoring capabilities are needed in the transportation systems infrastructure. The key is to generate an incident report based on noticeable changes in system performance, or through interaction from individuals using the transportation system via cellular or fixed telephone 911 services. Progress in the areas of communication technology will allow law enforcement agencies and “roving” patrols to send real-time audio and video to control mechanisms to facilitate the detection of incidents and support “big-picture” understanding in generating efficient response plans. In fully developed Incident Management system responses, organizations and incident status will be tracked, coordinated and achieved. The vision is to create more automation without sacrificing the role of human interface in local and regional TOCs and TMCs.

Figure 3.36: Incident Response Unit

Great technical advancements have occurred in the permanent applications of ITS equipment, hardware and software. Most efforts have to date been on hard-wired permanent elements but rapid improvements of especially wireless communication technologies are bringing life to new and interesting mini-applications for traffic management. These include such technologies as machine-vision, as well as advances in radar, videocameras, and modular changeable/variable message signs. When integrated. these technologies are forming a comprehensive, real-time traffic management tool. Promising examples of these portable traffic management system tools have been tested in both urban and rural construction zones with very positive results.

Incident management is most often disaggregated into five non-distinct functional areas – detection and verification, motorist information, response, site management, and clearance. Incident management, which started in response to large urban area issues such as traffic congestion (note that efforts to improve the management of incidents have been taking place for nearly three decades in Chicago, Illinois) is now producing benefits in smaller municipalities and their respective rural areas. Benefits from a more managed response include improved safety for both motorists and responders, improved agency efficiency, improved public image, and reduced motorist delay.

As Intelligent Transportation Systems (ITS) continue to develop, the application of computer and communications technologies to improve incident management will become increasingly important. Existing technologies as well as emerging technologies show great promise for application in rural areas. Some, such as mayday systems, that combine automatic collision notification and vehicle location technologies, would almost uniquely benefit rural areas.

The successful transfer of incident management-related ITS concepts and technologies to smaller municipalities could be jeopardized if differences between urban and rural environments are not recognized early on. These differences arise not only in the motivation for improving incident management'but also in how incident management operations are performed and what resources are available. When "selling" options that improve incident management to rural travelers and stakeholders, it is important to understand the different motivations in urban and rural environments. Traffic congestion and consequent political pressures drive urban stakeholders. In smaller municipalities and rural areas, concerns over safety and limited resources prompt improvements (although, at times, congestion can be a motivator in rural areas). More specifically, rural responders are faced with resources that are stretched further and potentially limited expertise due to limited training opportunities. These issues respectively may lead to feelings of resentment toward urban area "deep pockets" and a limited understanding of the benefits of incident management. A clear understanding of the challenges faced by smaller municipalities and their respective ruraI areas will help to ensure a successful application of incident management-related ITS technologies and concepts for everyone's benefit.

Figure 3.37: Freeway Changeable Message Sign

4. ITS BENEFITS AND COSTS

To move ITS from research, protytyping, and pilot projects into routine usage, decision-makers . . . need reliable information about the contribution that ITS products can make *toward meeting the demand for safe and efficient movement of people and goods'*

The provision of early benefits has and remains central in ITS planning efforts both nationally and abroad. Therefore, benefits have been given much attention and consideration during the process of developing the ITS EDP for the Greater Portland region. Moreover, information on benefits is essential in deriving and forecasting benefits to cost ratios.

Studies done to date confirm that, suitably applied, ITS applications and technologies have great promise in improving travelers' comfort, mobility, and safety by generating more efficiency in the transportation system. Above all, most user groups – travelers, operators and planners – who have experience with these new products and services have found them easy to use and valuable. Ultimately this emerging and constantly evolving market supplies tools that are really invaluable to us in terms of revitalizing the transportation system since the Portland region must be able to transport people, goods and information as fast as, or faster, other regions in order to stay competitive.

Benefits received by all members of society are usually funded by taxes, whereas benefits to individual travelers and specialized road users are usually funded on a pay-per-use basis. ITS benefits are typically distributed among three major groups – individual travelers, society at large, and specialized users. These groups can be segmented further based on characteristics such as:

- ***Geography/Location (urban, suburban, or rural)***
- ***Level of usage (High/Low, Frequent/Infrequent)***
- ***Types of users (Regular/Special needs, Business/Non-business, LocaLNon-local)***

<u>Benefits</u>

National ITS Goals are:

- ***Decreased Travel Time***
- ***Increased Travel Speed***
- ***Increased Freeway Capacity***
- ***Decreased Accident Rate***
- ***Decreased Fuel Consumption***
- ***Decreased Emissions (CO, HC, NOx)***
- ***Increased Transit Service Reliability***
- ***Decreased Incident Response Time***
- ***Decreased Incident Clearance Time***
- ***Decreased Accident Fatalities***

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1 <u>Intelligent Transportation Infrastructure Benefits: Expected and Experienced</u>, United States Department of Transportation, January 1996, p. iii.

- *Increased Cost-Effectiveness of Transport Investments*
- *Decreased Operating Cost*
- *Increased Customer Satisfaction*

A matrix matching the Market Package with the national ITS goals is presented in Table 4.1.

The approach taken in order to assess ITS benefits – experienced and expected – was based on the Intelligent Transportation System Infrastructure. The ITI is basically the infrastructure portion of ITS and is the integrated set of the infrastructure components needed to get ITS deployed and implemented in its initial phases. The elements of the ITI are the systems any region will have to deploy first to achieve a fully developed ITS. Figure 4.1 depicts the relationship between the IT1 and the ITS System Architecture by implying that the IT1 is the core of the system on which the Market Packages could attach.

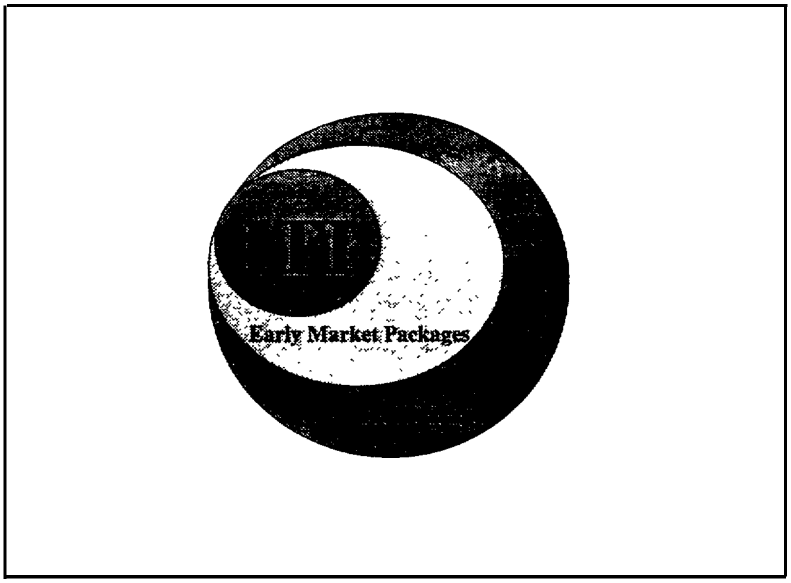

Figure 4.1: Relationship between the ITS Core Infrastructure and ITS User Services

The contact area around the "core" is less than in the periphery of the system, thus only a few ITS applications/technologies – Early Market Packages - can be beneficially applied/ deployed in the transportation system. As the applications and technologies grow in number it becomes easier and more cost efficient to deploy, implement and operate new ones from both the same and different "Market Package bundles". It is envisioned that the ITI deployment will be primarily accomplished by the public sector with the help or push from certain private sector players. It is important to keep in mind that ITI is a system, not just a series of elements, when assessing benefits since many benefits may only unfold as functions of a system or as systems themselves are integrated.

Table 4.1: Anticipated Market Package Benefits

	Market Packages	ITS System Goals: Increase Transportation System Efficiency	Improve Mobility	Reduce Fuel Consumption and Environmental Cost	Improve Safety	Increase Economic Productivity	Create an Environment for an ITS Market
APTS	Transit Vehicle Tracking	*	**	*		*	*
	Fixed-Route Operations	*	**	*		*	*
	Demand-Responsive Operations	*	**	*		*	*
	Passenger and Fare Management					**	*
	Transit Security				**		*
	Transit Maintenance					*	*
	Multi-modal Coordination	*	*			*	
ATIS	Broadcast Traveler Info	*	**	*			***
	Interactive Traveler Info	**	***	*			***
	Autonomous Route Guidance	**	***				***
	Dynamic Route Guidance	**	***	*	*		***
	ISP-Based Route Guidance	**	***	*	*		***
	Integrated Transp. Mgmt/Route Guidance	***	***	**	*		**
	Yellow Pages and Reservation		*				**
	Dynamic Ridesharing	**	*	*			*
	In Vehicle Signing		*		*		***
ATMS	Network Surveillance	*	*	*			*
	Probe Surveillance	*	*	*			**
	Surface Street Control	**	***	**	**		*
	Freeway Control	**	***	**	*		*
	Regional Traffic Control	***	***	***	**		*
	HOV and Reversible Lane Management	*	**	*			*
	Incident Management System	**	**	***	**		*
	Traffic Information Dissemination	**	*	*			*
	Traffic Network Performance Evaluation	**	**				*
	Dynamic Toll / Parking Fee Management					**	*
	Emissions and Environ. Hazards Sensing			***			**
	Virtual TMC and Smart Probe Data	*	*	*		*	*
	Standard Railroad Grade Crossing				***		*
	Advanced Railroad Grade Crossing				***		*
	Railroad Operations Coordination	*	*	*			*

Marker Packages		ITS System Goals					
		Increase Transportation system Efficiency	Improve Mobility	Reduce Fuel Consumption and Environmental Cost	Improve Safety	Increase Economic Productivity	Create an Environment for ITS Market
CVO	Fleet Administration		***			***	**
	Freight Administration		***			***	**
	Electronic Clearance	**	***			***	**
	CV Administrative Processes					**	*
	International Border Electronic Clearance	**	***			***	**
	Weight-In-Motion	**	***			***	**
	CVO Fleet Maintenance	*			**	**	*
	HAZMAT Management	*			**	**	*
	Roadside CVO Safety	*	**		**	**	**
	On-board CVO Safety				***	**	**
EM	Emergency Response	*		*	***	**	*
	Emergency Routing	*		*	***	**	*
	Mayday Support				***	*	**
	ITS Planning	**	**	**	**	**	***

Table 4.1: Anticipated Market Package Benefits

Based on the discussion above, it appears that it is beneficial to outline the benefits of ITS based on the ITI. Thus, the benefits are presented by the following ITI elements:

- **Traveler Information Systems (TIS)**
- **Freeway Management Systems (FM)**
- **Traffic Signal Control Systems (TSC)**
- **Transit Management Systems (TMS)**
- **Electronic Toll Collection Systems (ETC)**
- **Electronic Fare Payment Systems (EP)**
- **Incident Management Systems (IM)**
- **Emergency Management Services (EM)**

4.1 Overview and Typology

Experience with ITS deployment has provided guidance as to the benefits and costs of investment in these new technologies. Results of any ITS deployment depend on manyariables, including quality of project planning, functional scope of deployment, degree of integration with other applications, acceptance by the traveling public, readiness and capacity of operating agencies, transportation system characteristics of the area in which deployment takes place, and other factors. Thus experience in other areas should be referred to as a guide to action rather than a guarantee of result.

Costs

- *Capital investment*
- *Operational maintenance costs*

Cost data that follows is presented in summary form for groupings of related ITS applications. by cost range, for basic and more sophisticated deployment levels. Only capital costs are displayed due to the paucity of time series data on ITS operations costs. As a general rule of thumb, expected annual operations costs for many ITS applications are considered to be about 10% of the initial capital investment.

GREATER PORTLAND ITS PROJECT COST RANGE MATRIX

Traveler Information

ITS COMPONENTS	Estimated Cost Basic	Estimated Cost Enhanced
Radio, TV	<$100,000	<$100,000”
EBB/Text TV	<$100,000	$100,000-$500,000*
Smart Kiosk	<$100,000	$100,000-$500,000*
WWW/ Internet	<$100,000	$100,000-$500,000*
Toll-free/ Pay Number	<$100,000	$100,000-$500,000*
HAR	<$100,000	$100,000-$500,000*
CMS/ VMS highway	$500,000-$1,000,000	>$5,000,000*
CMS/ VMS parking	<$100,000	$100,000-$500,000*
TATS	<$100,000	$1,000,000-$5,000,000*
Weather/Wildlife Warning	<$100,000	$500,000-$1,000,000
Call Box/Mayday	<$100,000	$100,000-$500,000

Traffic Management

ITS COMPONENTS	Estimated Cost Basic	Estimated Cost Enhanced
Signal Automation/Coordination	$100,000-$500,000	$500,000-$1,000,000
Signal Pre-emption	$100,000-$500,000	$500,000-$1,000,000
Emergency Vehicle Guidance	<$100,000	$1,000,000-$5,000,000*
Parking Management	<$100,000	$500,000-$1,000,000
Incident/Emergency Management	$100,000-$500,000	$1,000,000-$5.000.000*
Lane/Speed Signs	$500,000-$1,000,000	$1,000,000-$5,000,000
Violation Deterrence/Enforcement	$100,000-$500,000	$1,000,000-$5,000,000
Smart Intersections	$100,000-$500,000	$1,000,000-$5,000,000
Transportation Management Center	$1,000,000-$5,000,000	>$5,000,000

Public Transit

ITS COMPONENTS	*Estimated cost Basic*	*Estimated Cost Enhanced*
Vehicle Guidance	<$100,000	$1,000,000-$5,000.000*
On-board Annunciator/EBB	<$100,000	$ 100,000-$500,000
AVL/GIS	$500,000-$ 1,000,000*	$1,000,000-$5,000,000
Passenger Counters	$ 100,000-$500,000	$500,000-$1,000,000*
Security Systems	$ 100,000-$500,000*	$500,000-$ 1,000,000*
Trip Itinerary Systems	<$100,000	$ 100,000-$500,000*
Computer-Aided Dispatch.	$100,000-$500,000	$500,000-$1,000,000*
Transit Management Center	$ 500,000 -$1,000,000	$1,000,000-$5,000,000

Electronic Payment		
ITS COMPONENTS	*Estimated Cost Basic*	*Eatimated Cost Enhanced*
Smart Cards	$100.000-$500.000	$ 1,000,000-$5,000,000

****requires Transportation or Transit Mgt. Center*

Sources: Intelligent Transportation Systems (ITS Projects: 1995 and 1996, U.S. Department of Transportation; Advanced Public Transportation Systems: State of the Art Update 1996, U.S. Department of Transportation; author's notes from the Institute of Transportation Engineers' Southwest Intelligent Transportation Systems 1997 Study Tour; IBI Group, Inc. - Boston; HNTB, Inc. - Portland, Maine; and presentation materials from David Hill, National Transit Institute, at the March 1997 Maine ITS Symposium.

A recent analysis of the aggregate national costs and benefits of implementing in the nation's 297 metropolitan areas the U.S. DOT's National Surface Transportation Goals and target for ITS ("To complete deployment of basic ITS services for consumers of passenger and freight transportation across the nation by 2005") was encouraging. Total net benefits were calculated at nearly $208 billion and a benefit/cost ratio of 5.7 was forecast.'

4.2 Traveler Information Systems/Multimodal Traveler Information Systems (TIS/MTIS) .

Traffic and traveler information are popular with consumers and systems that provide such information are producing data that anticipate system benefit when wider deployment occurs. Studies have calculated benefits and shown results in the following major Measures of Effectiveness (MOEs), including:

2Intellitent Transportation Systems National Investment and Market Analysis: Executive Summary Apogee Research, Inc., May 1997, p. 10.

- *Travel time;*
- *Travel delay;*
- *Fuel consumption and emissions.*

Travel time ,	Decrease 20% in incident conditions Decrease 8% - 20% for equipped vehicles
Travel delay	Decrease with up to 1900 vehicle-hours per incident
Fuel consum tion	Decrease 6% - 12%
Emissions	Decrease VOC 25% from affected vehicles
	Decrease HC emissions 33% from affected vehicles
	Decrease NOx emissions 1.5% from affected vehicles

Table 4.2: Summary of benefits from the TIS/ MTIS element

TIS/MTIS projects are growing both in number and size around the country. Some potential benefits have also been derived in laboratory environments as well as from surveys. It is important to note that the TIS/MTIS element is closely tied to the ATIS Market Package and the success of applications and technologies therein can often only be explicitly derived from user acceptance. For example, a Smart Kiosk is by no means imposing itself to the traveler like HAR, VMS and other dissemination technologies. Thus, its success as a tool to reduce the impact or solve the existing transportation probiem is solely dependent on the public's interaction with and perception of the tool and its different usage areas.

Demo-projects/Projects -

The Case of Los Angeles Smart Traveler project

The project included 78 information kiosks at various activity centers such as office lobbies and shopping plazas. The number of daily accesses ranged from 20 to 100 in a 20-hour day, with the lowest volume in offices and the greatest in busy pedestrian areas. The most frequent request was for a freeway map (83% of users), but many also requested bus and train information (50 % of users). In general the users were overwhelmingly positive in response to a survey relating to the project.

The Case of TATS and other Dial-Phone projects around the country

An automated transit information system implemented by the Rochester-Geneese Transit Agency resulted in an increase in calling volume of 80%. As calling volumes increase, a project such as the Rochester-Geneese project could experience down-turns or lose some of its potential. A similar system installed by New Jersey Transit confirms through a before-and-after study that this need not happen. The survey found a reduction of caller wait time from an average of 85 seconds to 27 seconds and a reduction of the caller hang-up rate from 10% to 3%. The Boston SmarTraveler, described in Chapter 3, experienced a 138% increase in usage from October 1994 to October 1995 to a total of 244,182 calls monthly, partly due to a partnership with a local cellular telephone service provider (making the service more available to the traveler).

3 http://www.its.dot.gov.docs

The Case of TravLink in Minneapolis

In brief. the Travlink test in the Minneapolis area distributed PC and videotext terminals to 3 15 users and made available transit route and schedule information, including schedule adherence information, as well as traffic incidents and construction information. While the access rate was not too impressive, the results show promise for APTS applications of the TIS/MTIS element. Approximately one-third of accesses to the system requested "static" bus schedules and another third examined information on bus schedule adherence (i.e. "dynamic" bus schedules). In addition. three downtown kiosks complemented these tools by offering similar information. Interesting to note is that the most frequently requested information was real-time data [4]

Surveys -

Surveys performed in Seattle and Boston found that 30% to 40% of travelers frequently adjust their travel patterns based on travel information. Of those that change travel patterns, about 45% change route of travel and another 45% change time of travel; an additional 5% - 10% change travel mode. A survey in Marin County, California, showed that if regular commuters had been presented with alternate routes including travel time estimates. 69% would have diverted. These results can be confirmed by actual demo-projects and deployments in Europe. A pilot project in the Netherlands found a 40% increase in route diversions based on traffic information by the 300 vehicles equipped with FM sideband data receivers (similar to the RDS-TMC radio unit presented in Chapter 3)[5]

4.3 Freeway Management Systems (FM)

Freeway management systems have demonstrated benefits over an extended period of time and in several measurable Measures of Effectiveness (MOEs), including:

- *Travel time;*
- *Travel speed;*
- *Freeway capacity;*
- *Collision experience:*
- *Fuel consumption and emissions.*

Travel time	Decrease 20% - 48%
Travel speed	Increase 16% - 62%
Freeway Capacity	Increase 17% - 25%
Accident rate	Decrease 15% - 50%
Fuel consumption	Decrease fuel used in congestion 4 1%
Emissions	Decrease HC emissions 1,400 tons annually (Detroit Study) Decrease CO emissions 122,000 tons annually (Detroit Study) Decrease NOx emissions 1,200 tons annually (Detroit Study)

Table 4.3: Summary of benefits from the FM element[6]

4 ibid see p. 3-7
5 ibid see p. 3-7
6 ibid, see p. 3-7

The Case of Seattle, Washington

"... freeway management system including ramp metering in the Seattle, Washington, area over a six-year period shows a growth in traffic of 10% to 100% along various segments of I-5 while speeds have remained steady or increased up to 48%, and accident rates have fallen consistentl to a current level of 62% compared to the base period. The improvements have occurred while average metering delays at each ramp have remained at or below three minutes."

The Case of St. PauI and other cities in Minnesota

"...DOT's Traffic Management Center, which operates freeways in the Minneapolis area, has produced the following experience: Capacity is 2,200 vplph compared with 1,800 prior to the use of the ramp meters. Average speeds have risen from 34 mph to 46 mph. Accident rates on I-35W before management were 421 per year and are now 308 per year. Annual accident experience on I-35W after management is 2.11 collisions/MVM compared to 3.40 before management was instituted. A survey of traffic management centers using ramp metering reported similar findings. In addition to speed increases of 16% to 62% and throughput increases of 17% to 25% that were frequently used to justify the installations in a benefit/cost sense, accidents in freeway systems under freeway management were reduced between 15% and 50%. While some other freeway improvements were implemented during the study periods, the combination of geometric, vehicle, and operational procedures showed significant reductions in accident rate."[8]

4.4 Traffic Signal Systems (TSC)

Ever since the first computerized systems came out in the 1960's, transportation authorities have progressively been installing more flexible traffic signals. Benefits have been reported in the following Measures of Effectiveness (MOEs):

- *Travel time*
- *Travel speed*
- *Travel delay*
- *Vehicle stops delay*
- *Fuel consumption and emissions.*

Back in 1966 a project in Wichita Falls, Texas, reported a 16% reduction in stops, a 3 1% reduction in vehicle delay, an 8.5% reduction in accidents, and an increase in speeds of over 50% This system was a so-called single-dial system They are now replaced with more advanced computerized systems.[9]

7 ibid see p.3-7
8 ibid see p.3-7
9 ibid see p.3-7

Travel time	Decrease 8% - 15%
Travel speed	Increase 14% - 22%
Ve hicle stops	Decrease 0% - 35%
Delay	Decrease 17% - 37%
Fuel consumption	Decrease 6% - 12%
Emissions	Decrease CO emissions 5% - 13% Decrease HC emissions 4% - 10%

Table 4.4: Summary of benefits from the TSC element"'

Traffic Signal Management Cases in California

The Fuel Efficient Traffic Signal Management (FETSIM) and Automated Traffic Surveillance and Control (ATSAC) programs in California showed benefit/cost ratios of 58: 1 and 9.8: 1 respectively. ATSAC, which includes computerized signal control. reported a 13% reduction in travel time, 35% reduction in vehicle stops, 14% increase in average speed, 20% decrease in intersection delay, 12.5% decrease in fuel consumption, 10% decrease in HC, and 10% decrease in CO."

The Case for SCATS from the FAST-TRAC program in the Detroit area

The program which was based on the SCATS adaptive signal control system, has seen the virtual elimination of certain types of accidents as a result, along with comparable benefits stated in Table 4-3. During the study period, the SCATS traffic management system (along with some geometrical changes in the roadway) intersections experienced the following changes:

- *Injury accidents decreased 6%*
- *Injuries decreased 27%*
- *Serious injuries decreased 100%*

Classifying all benefits by traffic movements and time-of-day in the studied intersections with SCATS technology generated the following data:

- *Left turn accidents decreased 89% while peak hour peak direction speeds increased 19%*
- *Intersection delay decreased by up to 30%*

The Case for SCOOT from the City of Toronto. Canada

The City of Toronto evaluated the SCOOT signal control system on two corridors and the central business district network, totaling 75 signals. The study evaluated SCOOT over a two-month period by comparing it to a "best effort" fixed timing plan. The results are encouraging and include the following indications:

- *Decreases in travel time of 8%*
- *Decreases in vehicle stops of 22%*
- *Decreases in vehicle delay of 17%*
- *Decreases in fuel consumption of 6% in CO-emission of 5%. and in HC-emissions of 4%*

10 ibid, see p. 3-7
11 ibid., see p. 3-7

4.5 Transit Management Systems (TMS)

A recent study found 24 U.S. transit systems operating more than 10,000 vehicles under AVL supervision and another 3 I transit systems in various stages of procurement. This transition to a better, more efficient and more manageable transit system has evolved for nearly a decade. Several AVL technologies have been used and evaluated as a result. AVL technologies include signpost, triangulation. LORAN, and GPS. Most new systems typically use a GPS-based location process.

When coupled with computer-aided dispatching systems, vehicle location technologies are producing benefits identified in the following Measures of Effectiveness (MOEs):

- *Security*
- *Travel time*
- *Service reliability*
- *Cost-effectiveness.*

These MOEs are outlined in Table 4.5. Several operators have reported incidents where AVL information assisted in resolving disputes with employees and patrons as well.

Travel time	Decrease 15% - 18%
Service reliability	Increase 12% - 23% in on-time performance
Security	Decrease incident response time to as little as one minute
Cost effectiveness	45% annual return on investment

Table 4.5: Summary of benefits from the TMS element 12

A Collection of Cases

AVL and dispatching systems have most directly improved schedule adherence. The Mass Transit Administration in Baltimore reported a 23% improvement in on-time performance by AVL-equipped buses. The Kansas City Area Transportation Authority improved on-time performance by 12% in the first year of operation using AVL, compared to a 7% improvement as the result of a coordinated effort between 1986 and 1989.”

Coordination between transit systems and traffic signal systems has also demonstrated operational benefits. Allowing buses to either extend green time or shorten red time by oniy a few seconds reduced bus travel time on a test route in Portland, Oregon by 5% to 8%.

An AVL system provides a rich source of data for analyzing bus operations. Examining AVL data collected in Kansas City led to‘ a schedule revision that reduced the 200-vehicle

12 ibid see p. 3-7
13 ibid see p. 3-7

fleet by seven buses while reducing scheduled travel times by up to 10%. Other transit systems have reported reductions in fleet size of 2% to 5% due to efficiencies of bus utilization. Alternatively, the efficiency gains could be used to increase frequency by the same amount. Using AVL data for analysis purposes also reduces the need for staff to perform schedule adherence and travel time surveys. Estimates of savings range from $40,000 per survey to $1.3 million annually.

4.6 Electronic Payment (EP) and Smart Cards/ Stored Value Cards

Several demonstration programs, field operational tests and pilot programs using newer electronic fare payment techniques are ongoing around the county. Experience from Europe, where Smart Card technology is much ahead of the advancements in North America, shows that Smart Cards are "better than cash" and that they are "easy to use". It is interesting to note that where Smart Cards were introduced several years ago, they do not only still show promise as commonplace payment for traveler and transit services, but also a "migration" to new areas creating new and very interesting multi-service cards.

The spectra has recently widened to incorporate Smart Card technology into toll and parking management systems. When institutional and political issues are completely resolved with respect to the potential for this new technology, new applications will tap into its potential. These include incorporation with social services, transit usage incentive programs and true traffic management applications (such as dynamic road-tolling systems).

Patron popularity	Up to 90% usage where available
Fare collection	Increase 3% - 30%
Data collection costs	Decreased $1.5 million - $5 million

Table 4.6: Summary of benefits from the EP element14

4.7 Electronic Toll Collection Systems (ETC)

The decision to deploy the ETC element in an ITS is usually based on reduction in operating cost to the toll authority, coupled with the benefits of emission reduction and capacity increases.

Operating expenses	Decrease up to 90%
Capacity	Increase 250%
Fuel consumption	Decrease 6% - 12%
Emissions	Decrease CO emissions 72%'per affected mile Decrease HC emissions 83% per affected mile Decrease NOx emissions 45% per affected mile

Table 4.7: Summary of benefits from the ETC element"

14 ibid see p. 3-7

Electronic toll collection can greatly improve throughput on a per-lane basis compared with manual lanes with attractive cost-benefit ratios. In general, even though many different configurations and technologies exist, the annual cost to operate an automated lane is $16.000. With conventional tollbooth operators, the cost of operation would be in the order of $ 170,000 per lane per year.

4.8 Incident Management and Emergency Management Systems (IM/ EM)

Incident management programs also follow an evolutionary route to full deployment. Frequently, incident management programs become part of the mission in expanding freeway management centers. Incorporating technology such as cellular call-in, loop detectors, video monitoring, and video detectors, this element is often referred to as the "eyes and ears" of motorists and other travelers. Incident management and emergency management programs show benefits with the following Measures of Effectiveness (MOEs):

- *Travel time*
- *Travel delay*
- *Fuel consumption and emissions*
- *Safety*

The Institute of Transportation Engineers (ITE) has estimated 10% to 42% decreases in travel time for incident management programs included in freeway management systems. In addition to delay reduction benefits, incident management programs are expected to benefit safety and emission reduction efforts. An analysis of the accident statistics on several California arterials and expressways shows that secondary accidents represent an increase in accident risks of over 600%, without controlling for climatic or other conditions. Reductions of incident notification times on urban freeways would result in a fatality reduction of 10% annually according to some estimators. These numbers are summarized in Table 4.8.

Incident clearance time	Decrease 8 minutes for stalls Decrease wrecker response time 5 - 7 minutes
Travel time	Decrease 10% - 42%
Fatalities	Decrease 10% in urban areas

Table 4.8: Summary of benefits from the IM and EM elements'16

15 ibid see p. 3-7
16 ibid see p. 3-7

5. RECOMMENDED DIRECTION FOR THE PORTLAND REGION

The Greater Portland Intelligent Transportation Systems Early Deployment Plan comprises a strategic ITS approach to regional transportation issues and needs. This approach includes the following elements:

* *assessing the region's transportation system*
* *establishing Early Deployment Plan goals by the Advisory Committee of stakeholders*
* *identification of functional requirements for ITS deployment*
* *consideration of institutional issues relating to ITS deployment*
* *review of funding opportunities*
* *definition of ITS system architecture*
* *consideration of potential regional ITS projects*
* *creation of a framework or model for evaluating ITS projects*
* *using this model to evaluate proposed ITS projects*
* *determining, in priority order and time-phased, a program of recommended ITS projects*

5.1 Overview of Transportation Issues and Problems

The Greater Portland region (see map attached) provides a multimodal mobility environment for 175,000 residents, 100,000 employees at work sites in the region, and hundreds of thousands of visitors who vacation or attend cultural or recreational events in the area. The Portland Peninsula (or urban core) contains the largest single concentration of employment in Maine. The "edge city" suburban environment around the Maine Mall and Maine Turnpike Exit 7 in South Portland and Scarborough and the Outer Congress Street corridor in Portland are among the most rapidly growing employment centers in the state. The urbanized area has two fixed-route local bus operators; a local ferry service; a paratransit provider; an international ferry (Portland to Nova Scotia); one of Maine's two principal air passenger terminals; a network of arterial roadways radiating out from the urban core; six interchanges on the Maine Turnpike (I-95&I-495) and eleven on I-295; two intercity bus carriers; several charter bus and limousine services; a vigorous regional carp001 and vanpool matching and promotion program; an emerging network of off-road and on-road bicycle ways; a variable number of annual cruise ship arrivals; two freight railroads; more than one hundred trucking firms; containerized sea to surface freight operations; seasonal rail passenger service to a ski resort in western Maine; and - by late 1998 - Amtrak passenger rail service to and from Boston. Portland has been historically and remains today the major transportation gateway to Maine.

Since the passage of the Intermodal Surface Transportation Efficiency Act (ISTEA), the Portland region has been engaged in some of the nation's most progressive multimodal transportation planning among the smaller metropolitan regions. The City of Portland Transportation Plan envisions a system of multimodal local and regional "transport centers" for intermodal exchange of passengers or freight.' Each passenger transport center is to be equipped with a "smart" traveler information kiosk. The first step in development of this system is being planned for the Forest Avenue Transit Corridor Improvement Project, a $1 million CMAQ initiative to double bus service and greatly improve passenger convenience along a major arterial into the Portland central business district. Five "smart" kiosks are planned as part of this project. A *major traveler information need and opportunity in the Portland region is expansion and integration of the passenger information kiosk network to include the regional airport, the two ferry terminals, the two intercity bus terminals, and the planned Amtrak station.*

The Portland Area Comprehensive Transportation Committee's Long-Range Transportation Plan also calls for a system of "smart" traveler information kiosks, as well as a highway strategy to "consider ITS solutions and ITS research in the PACTS area".' Regional traffic management concerns include improvement in traffic signal coordination and motorist traffic and weather information provision. Public transit concerns include potential for conversion to electronic fare payment with "smart" debit cards usable in all of the local transit services (and perhaps intercity services as well); automatic transit vehicle location systems (for paratransit. fixed-route bus transit, and ferry service applications); and "smart" kiosks (perhaps with Internet access for home and office computer users).

As the region's transportation policy document, the PACTS Lone-Range Transportation Plan stresses demand-side over supply-side solutions to traffic congestion, as well as more cost-effective management of such regional transportation assets as the roadway network and transit fleets. Traffic congestion along the arterials leading to the urban core requires better traffic signal coordination. Traffic congestion, road resurface and reconstruction, and Maine's often rigorous weather conditions require better driver information on road conditions. Funding shortfalls for public transportation and human service transport necessitate additional efficiencies in fleet management and more efficient fare collection in order to improve system productivity. The Portland area's geographic and economic function as a gateway to Maine makes provision of comprehensive and accessible traveler information on modal options, service characteristics, and fares especially important.

The Maine Turnpike Authority implemented electronic tolls in *1997. Integration of electronic toll-taking on the Turnpike with transit debit accounts (via "smart" cards) is an important ITS opportunity in Greater Portland.* Another opportunity is *integration of future electronic provision of driver information on traffic and weather conditions along the Turnpike with local and regional information about the off Turnpike road network.*

Overarching objectives of regional transportation planning for the Portland region have been to make the transportation system more *legible* to users (both motorists and transit passengers) and more *efficient* to operate-and maintain. *ITS applications have great*

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1 A Time of Change: Portland Transuortation Plan, July 1993.
2 Year 2015 PACTS Area Transportation Plan Update September 21, 1995.'

potential to accomplish both broad objectives within the Greater Portland environment. While Greater Portland has a complex and interesting transportation environment, the region has many fewer institutional barriers to implementation than those typically found. in a larger and more complex metropolitan transportation environment. *Greater Portland makes a good multimodal transportation "laboratory "for ITS solutions, where planning and demonstrating applications can be done in an effective and timely way.* Illustrative potential ITS applications in the region are as follows: include:

Traveler Information Systems -

* Provision of both static and real-time passenger travel information "Smart" kiosks at Portland area air, rail, bus, and ferry stations; Turnpike plazas within the region; the Forest Avenue Transit Improvement Corridor; other major activity centers in the region, including the Portland Public Library, the Maine Mall, and the mixed-use One City Center complex in downtown Portland; as well as home and office personal computers via the Internet. Transportation services and facilities information could include local bus and ferry operations; RideShare carpool and vanpool matching; the Maine Turnpike; intercity bus and rail; international ferry; air passenger; bicycle ways; and walking trails. Longer-term enhancements could include real-rime traffic conditions on the Turnpike, I-295, and principal arterial highways.

Traffic Management Systems -

* Coordinated, computerized traffic signal systems for all of the Portland urbanized area communities. Development of electronic changeable message signs on weather, road and bridge surface, and traffic congestion conditions for the City of Portland and other urbanized area communities. Integration of the City of Portland's computerized traffic signal system with the City's system of school zone flashing signals and a system of electronic message signs. Longer-term enhancements could include computerized, real-time traffic conditions information for on-board vehicle navigation.

Transit Fleet Management -

* Real-time electronic demand-response dispatching for paratransit services. Automatic vehicle or vessel location for fixed-route bus and ferry operators to provide traveler information and track fleet performance.

Electronic Fare Collection -

Deployment of "smart" debit cards usable on local bus and ferry services. Longer-term enhancements could include extension of convertible debit account use for intercity bus, rail, international ferry, and Maine Turnpike passage.

5.2 System Architecture

The Concept of an ITS System Architecture

The system architecture defines the functions (e.g. gather traffic information or request a route) that must be performed to implement a given user service, the physical entities or subsystems where these functions reside (e.g., the roadside or the vehicle), the interfaces/ information flows between the physical subsystems, and the communication requirements for the information flows (e.g., wireline or wireless). In addition. it identifies and specifies the requirements for the standards needed to support national, regional and local interoperability, as well as product standards needed to support economy of scale considerations in deployment. The system architecture for the Portland region can therefore be said to supply a framework for developing and implementing the applications and components of the ITS.

The Greater Portland ITS Early Deployment Plan focuses on the new ITS planning process. i.e. using the "Market Packages Approach" to the largest extent possible. These Market Packages may be bundled into the following categories:

- *Advanced Traveler Information Systems (ATIS)*
- *Advanced Public Transit Systems (APTS)*
- *Advanced Traffic Management Systems (ATMS)*
- *Commercial Vehicle Operations (CVO)*
- *Emergency Management (EM)*
- *ITS Planning*

Since the ITS EDP Plan only outlines the functional requirements for the region, no in-depth or in-detail system architecture will be presented in these pages. However, the Early Deployment Plan has acted as an efficient catalyst in building amongst stakeholders in the region. Future efforts and work are believed to greatly benefit from this solid foundation.

The envisioned ITS for the Portland region in the time frame of the ITS EDP is going to be centered on information. In order for the ITS to be information intense, the logical system architecture focuses on the traditional input-process-output model (IPO-model). Figure 5.1 depicts the generic information flows of the ITS. The input is based on the collection efforts in the transportation environment such as traffic flow data, road conditions, transit status data as well as weather reports. As illustrated in the figure, the collection of data requires implementation of new infrastructure in the transportation system, often referred to as the Intelligent Transportation Infrastructure (ITI). Typical elements of the ITI are sensors and automatic vehicle identification and location components. The data collected in the transportation environment will then be transferred over a communication link to data processors and/ or Traffic Information Centers (TIC), Traffic Operation Centers (TOC), Traffic Management Centers (TMC) for data processing. The purpose of the TICS, TOCs and TMCs is to add-value to the data -through analysis and synthesis - before the information is disseminated over a communication link to the end-users in the transportation system.

As the ITS becomes reality several fundamental changes are expected. New products and services will emerge as well as new institutional issues due to increased opportunities for private-public and private-private partnerships. The most fundamental change is however likely to be realized as a market for information is generated which will bring about so called Information Service Providers (ISP). Even though the potential for ISPs in the Portland region has not been estimated or evaluated in the Early Deployment Plan process, it is clear from experience in other larger metropolitan areas that they will play an integral role in building a Traveler Information System (TIS) as direct or indirect value-adders. As indicated in the figure building the TIS is a logical first step in the system architecture since it focuses or Pre-Trip and En-Route information of the primary users of the transportation system, whether they are motorists or passengers of private or public transit. As the TIS is realized efforts should focus on serving the secondary users of the ITS. namely the operators and planners of the transportation system. When completed, the ITS will generate new elements for control and management of the transportation system as a whole.

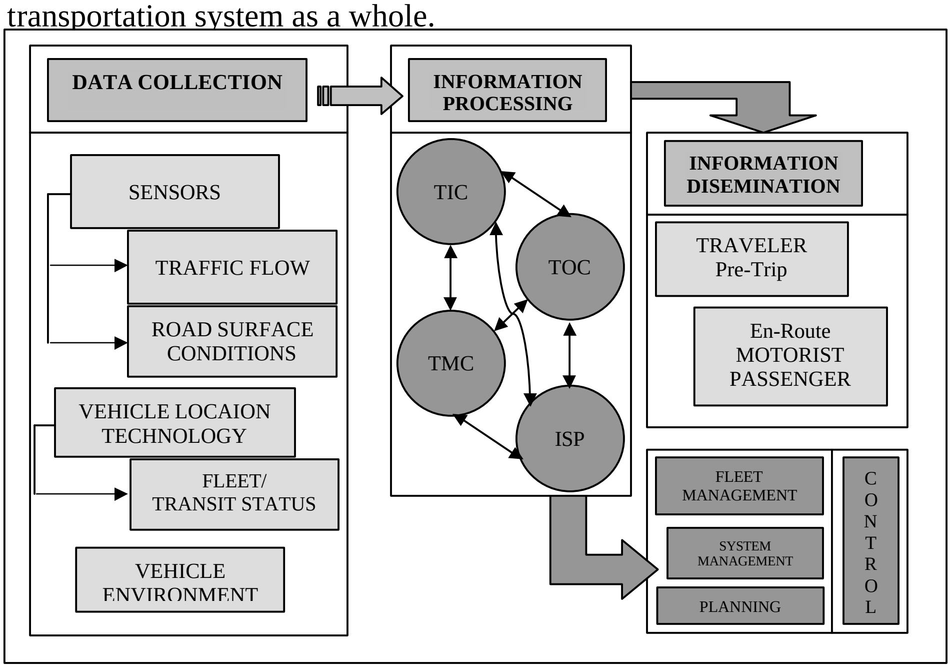


Figure 5.1: Conceptual System Architecture for the Region

A "short-list" of all the Market Packages is presented below for each Market Package Bundle. The full list of these Market Packages and the different Sub-systems introduced in earlier chapters can be found in Appendix A and Appendix C.

ATIS Market Packages -

Broadcast Traveler Information
Interactive Traveler Information
Autonomous Route Guidance
Dynamic Route Guidance
ISP Based Route Guidance
Integrated Transportation Management/ Route Guidance
Yellow Pages and Reservation
Dynamic Ridesharing
In-Vehicle Signing

APTS Market Packages -

Transit Vehicle Tracking
Transit Fixed-Route Operations
Demand Response Transit Operations
Transit Passenger and Fare Management
Transit Security
Transit Maintenance
Multi-modal Coordination

ATMS Market Packages -

Network Surveillance
Probe Surveillance
Surface Street Control
Freeway Control
HOV and Reversible Lane Management
Traffic Information Dissemination
Regional Traffic Control
Incident Management System
Traffic Network Performance Evaluation
Dynamic Toll/ Parking Fee Management
Emissions and Environmental Hazards Sensing
Virtual TMC and Smart Probe Data

CVO Market Packages
Fleet Administration
Freight Administration
Electronic Clearance
CV Administrative Process
International Boarder Electronic Clearance
Weigh in Motion
Roadside CVO Safety
CVO Fleet Maintenance
HAZMAT Maintenance

EM Market Packages -
Emergency Response
Emergency Routing
Mayday Support

ITS Planning -

ITS Planning is a stand alone Market Package which deals mostly with public transportation management and systems management functionalities in the transportation system.

Considerations and Insight in Developing a Regional ITS System Architecture

The breadth of ITS services covered by the Market Packages approach in the system architecture sometimes generates a "analysis paralysis" for the non-layman even when viewing the Market Packages as functionalities. Arriving at some understanding of these functionalities is essential in order to get a grasp of the best practice in creating a regional system architecture for the Greater Portland region and potential for synergies therein. Thus, the system architecture can be said to identify common features and shared functionality of the applications and technologies "hidden" in the more conceptual bundles presented in Chapter 3. The system architecture is therefore typically presented in several ways.

In general the system architecture identifies which subsystems and what equipment is needed to complete the representative ITS applications. In order to achieve such understanding the system architecture also needs to address the logical and physical elements associated with the involved sub-systems. The system architecture does not specify how the representative ITS applications are to be performed or implemented. That is a task that is defined by standards and protocols.

The **Logical Architecture** defines:

- *Architecture boundary*
- *Functions to be performed*
- *Relationships between functions*

The **Physical Architecture** describes:

- *Distribution of functionality between physical entities*
- *Interfaces between physical* entities
- *Boundaries between physical entities to ensure functionality and keep interfaces*

Market Package Relationships and Synergies in the ITS System Architecture

As stated above Market Packages that share common functionalities were bundled throughout the ITS EDP process. However some functionalities cross these boarders and creates interdependencies in any ITS system architecture. These interdependencies are important considerations when developing a system architecture since they at the same time constitute "a sweet spot" where incremental functions can be gained in the ITS at little additional cost (see Figure 5.2).

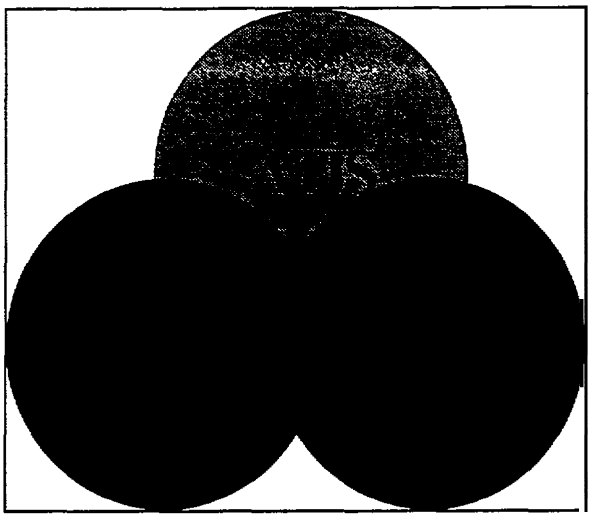


Figure 5.2: Conceptual illustration of the Double and Triple
Sweet spots for the Key Market Package Bundles in the Portland Region

The section below lists the individual Market Packages for each of the more conceptual Market Package Bundles. It also includes five diagrams which identify the potential and most significant synergies at the individual Market Package level. In each diagram, the connections represent the synergies between different Market Packages. Tracing the diagrams along the flows provides various efficient deployment sequences that leverage the incremental nature of each Market Package. The connections are coded to represent the types of synergies between Market Packages. The diagrams also outline the stakeholder area where the potential synergies could be realized. Often, these synergies will cross stakeholder boundaries (e.g., ATIS Market Packages are often reliant on information from the ATMS Market Packages). These synergies are documented by "off-page references" which indicate the stakeholder area in an oval along with the associated Market Package.

Advanced Traffic Management Systems (ATMS)

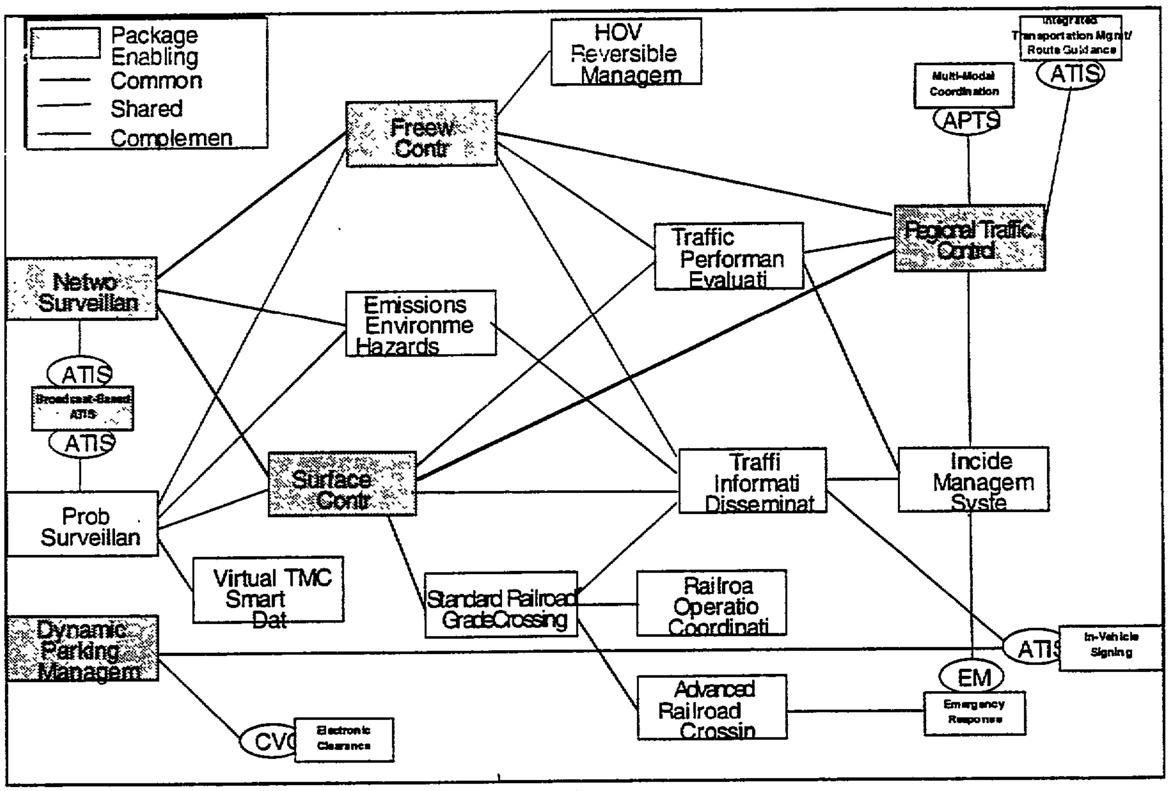


Figure 5.3: ATMS Market Package Synergies.

Advanced Traveler Information Systems (ATIS)

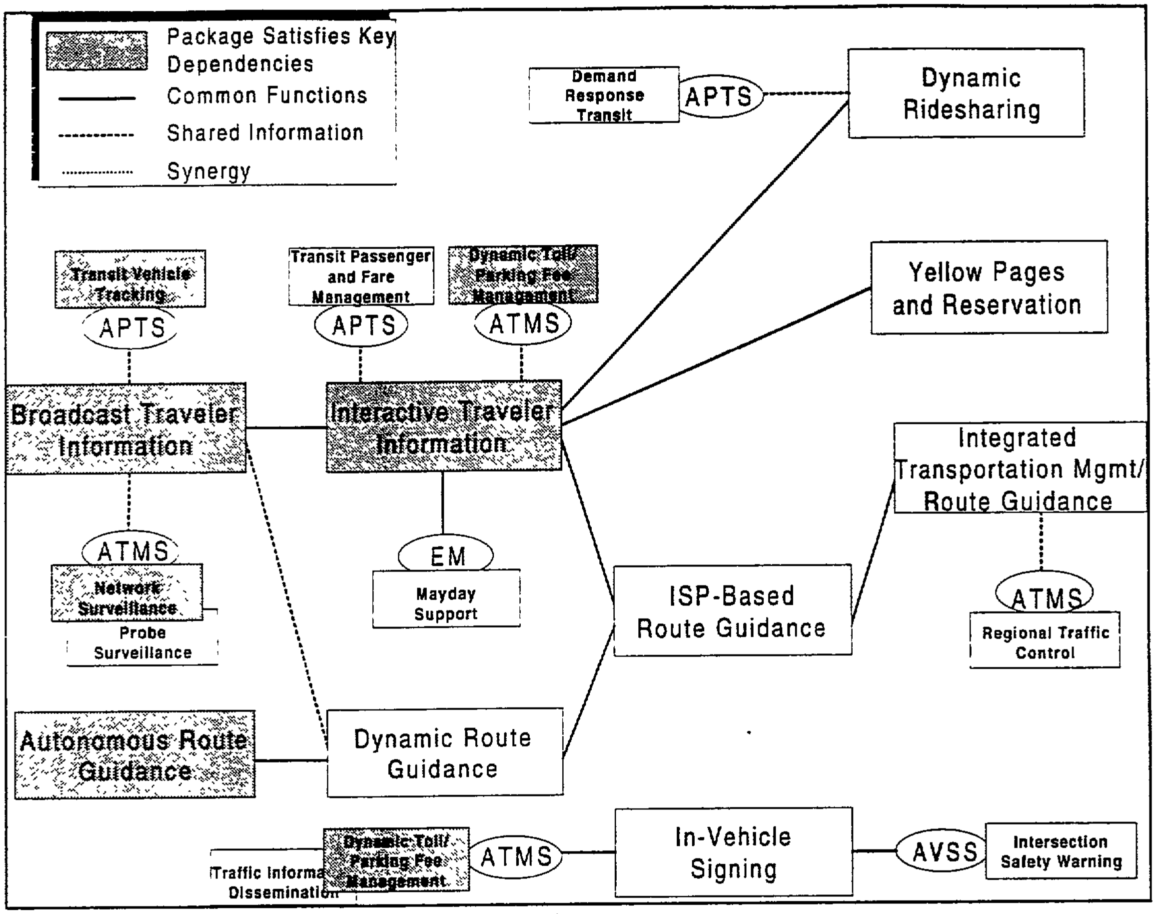


Figure 5.4: ATIS Market Package Synergies.

Advanced Public Transit Systems (APTS)

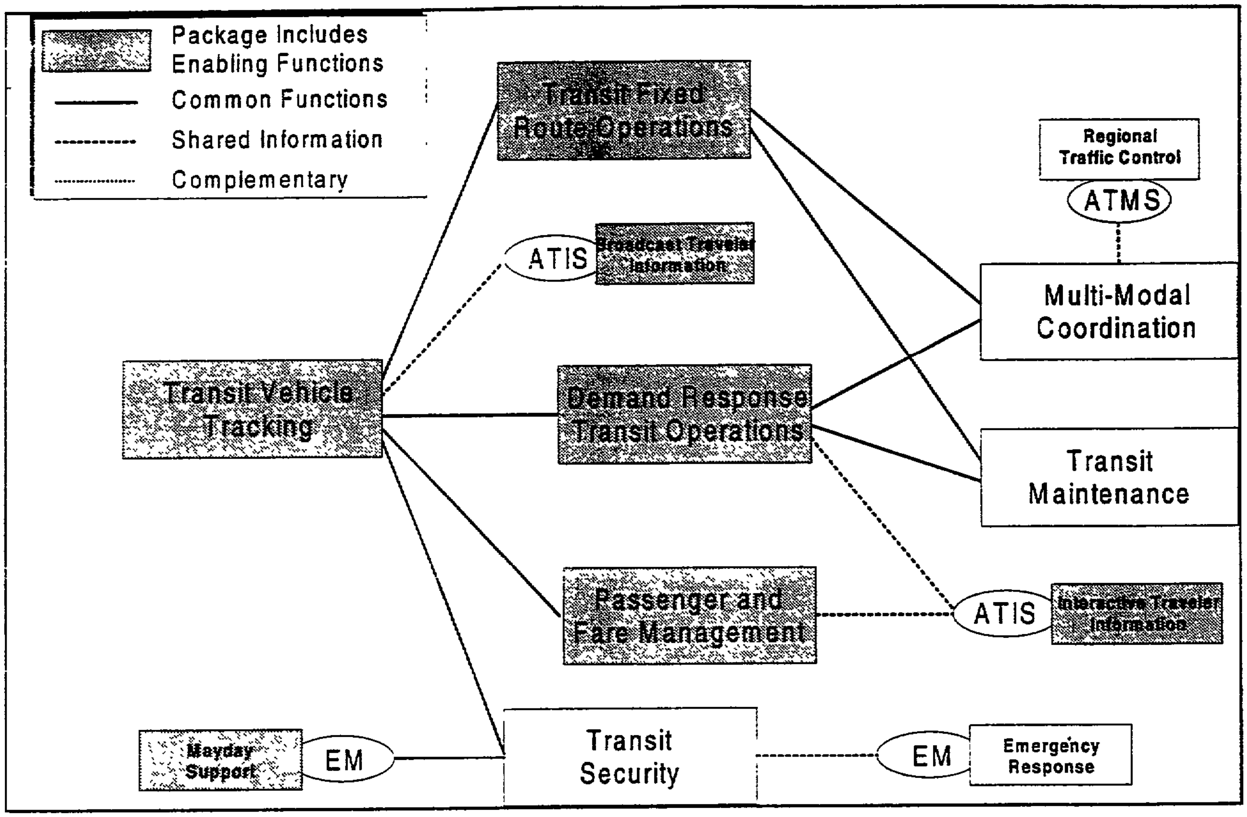


Figure 5.5: APTS Market Package Synergies.

Commercial Vehicle Operations (CVO) and Emergency Management (EM)

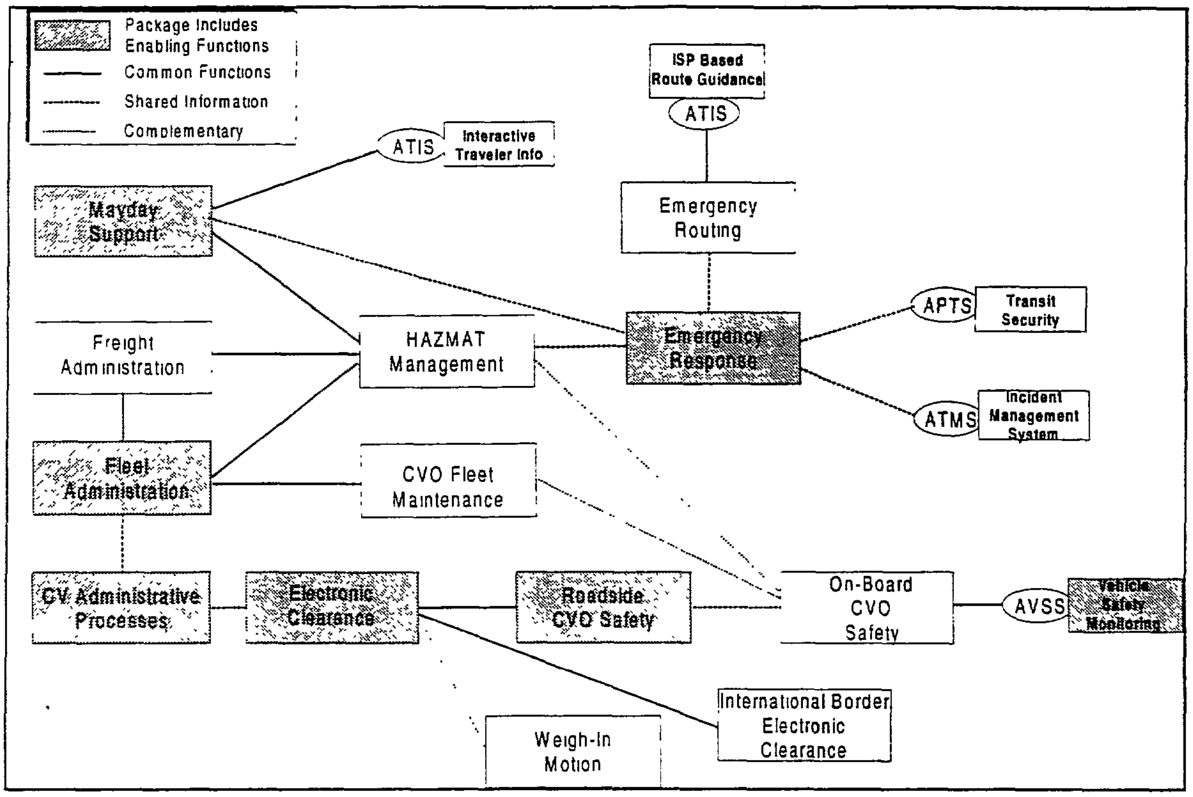


Figure 5.6: CVO and EM Market Package Synergies.

ITS System Architecture Implementation Alternatives

Since a system architecture represents the actual grouping of functions and physical elements that satisfy the purpose of the ITS, there are multiple implementation alternatives and migration paths which can be selected.

Nineteen interconnected subsystems were schematically identified in Figure 2 (Chapter 3). These subsystems align closely with existing jurisdictional and physical boundaries that underscore the operation and maintenance of current transportation systems. Hence, by mirroring the current transportation environment with the identified subsystems, the sub-system boundaries should identify likely candidates for interface standardization at the same time as artificial boundaries potentially imposed by the Logical and Physical Architectures are minimized.

The sub-systems may be grouped into four distinct subsystem classes that share basic functional, deployment, and institutional characteristics. A description of each subsystem is provided in full context in Appendix C and can be grouped as follows:

Center Sub-systems
- *Commercial Vehicle Administration Subsystem*
- *Emergency Management Subsystem*
- *Emissions Management Subsystem*
- *Fleet and Freight management Subsystem*
- *Information Service Provider Subsystem*
- *Traffic Management Subsystem*
- *Toll Administration Subsystem*
- *Transit Management Subsystem*
- *Planning Subsystem*

Roadside Sub-systems
- *Commercial Vehicle Check Subsystem*
- *Parking Management Subsystem*
- *Roadway Subsystem*
- *Toll Collection Subsystem*

Vehicle Sub-system
- *Vehicle Subsystem*
- *Commercial Vehicle Subsystem*
- *Emergency Vehicle Subsystem*
- *Transit Vehicle Subsystem*

Traveler sub-systems
- *Personal Information Access Subsystem*
- *Remote Traveler Support Subsystem*

In terms of organizing the Center subsystems, where the majority of these sub-systems are contained, there are four distinct alternatives which can be fleshed-out. These ITS Architecture implementation alternatives are generically shown in Appendix E and they are:
- *Alternative #I: Completely Distributed*
- *Alternative #2: Highly Centralized*
- *Alternative #3: Moderately Centralized*
- *Alternative #4: Logically Centralized but Physically Distributed (WATM-model)*

Once these Center subsystems in the ITS System Architecture are defined in accordance with implementation alternatives the geographical and functional migration will occur in a easy and natural evolution path towards increased system functionality and integration. (See Appendix B.)

5.3 ITS Evaluation: Project Evaluation

ITS evaluation was conducted in a series of steps described in the material to follow. The outcome of the evaluation process was a comprehensive appraisal of the comparative impacts of potential ITS initiatives in the Portland region. This outcome was useful to the Advisory Committee in preparing a recommended Greater Portland Program of lTS Projects.

5.3.1 Preliminary ITS Projects

A set of five ITS "projects", or sets of applications, prepared by staff was reviewed and revised by the Advisory Committee. Each project comprised typical ITS applications integrated as a market package to serve a common purpose. The initial set of ITS projects included the following:

- *Project 1: Traveler Information*
- *Project 2: Public Transit*
- *Project 3: Traffic Management*
- *Project 4: Electronic Payment*
- *Project 5: Safety*

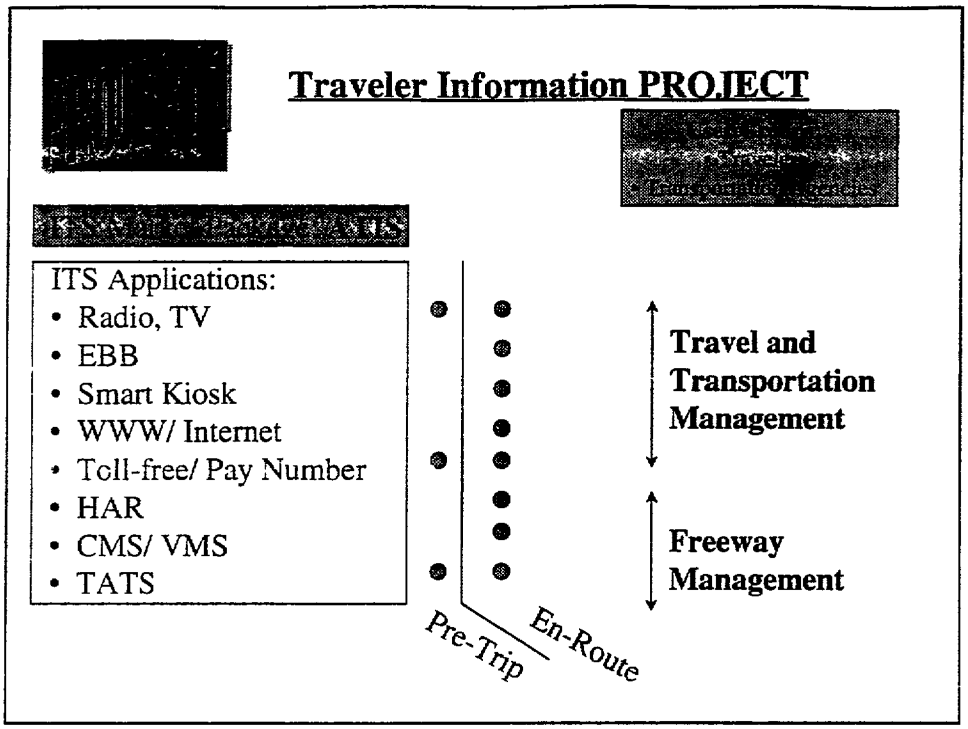
Each Project is summarized in the material to follow by components, users groups, and the both the function and context in which the individual applications operate. A more complete description of the ITS applications found within each project is contained in Chapter 3 of this document.

<u>Project 1 - Traveler Information</u>

Greater Portland ITS Goals Addressed -

    * ***More Accessible and Complete Travel Information***
    * ***Economic Development***

Project 1 presents typical ITS applications under the Advanced Traveler Information Systems (ATIS) Market Package bundle. User groups defined are travelers and transportation system operating agencies. Operators may include municipalities, the Maine Department of Transportation, Maine Turnpike Authority, as well as public and transit agencies. The deployment context identified is either travel and transportation management off the freeway system or freeway system management itself. Broad application functions are classified as either pre-trip or en-route.



acronym notes:
EBB- electronic bulletin board
WWW: world-wide web
HAR: highway advisory radio
CMS: changeable message signs
VMS: variable message signs
TATS: traffic automated telephone system

PROJECT 1. Traveler Information Project

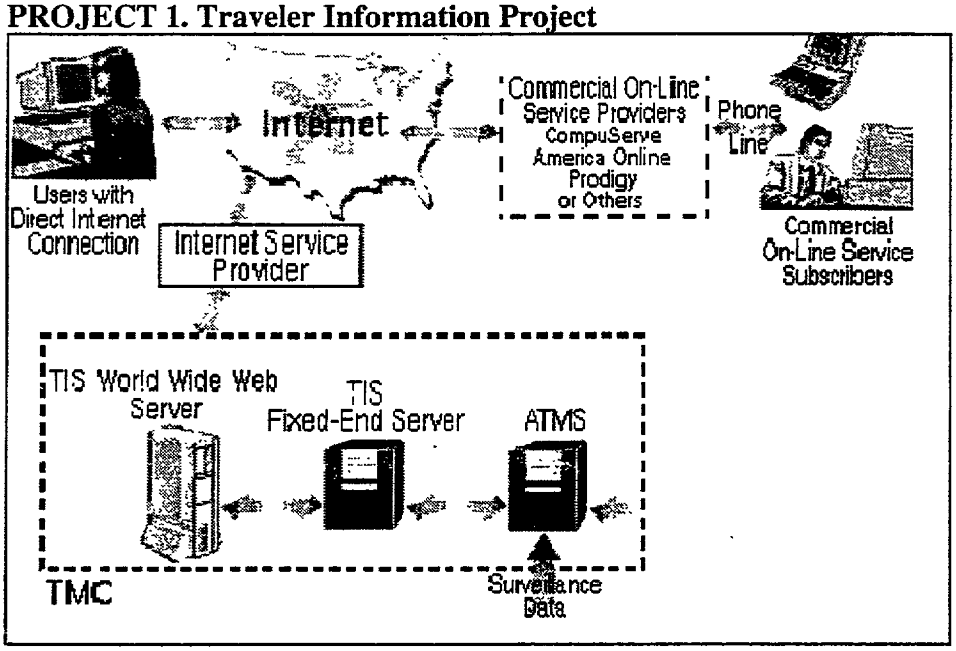


Figure 5.7: Conceptual Architecture of a Pre-Trip ATIS application disseminating traffic information over the Internet.

'ROJECT 1 Traveler Information Project

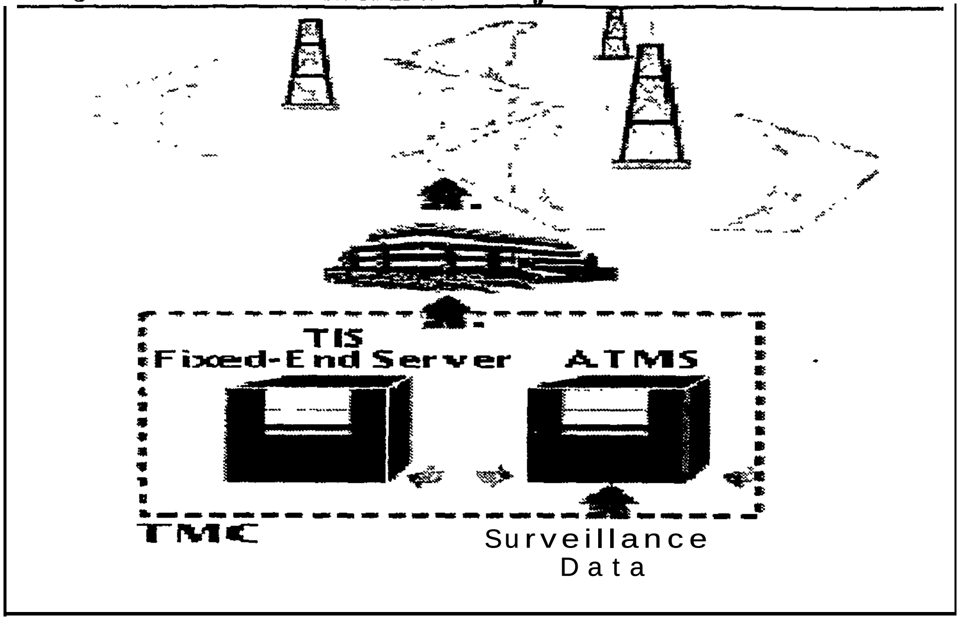


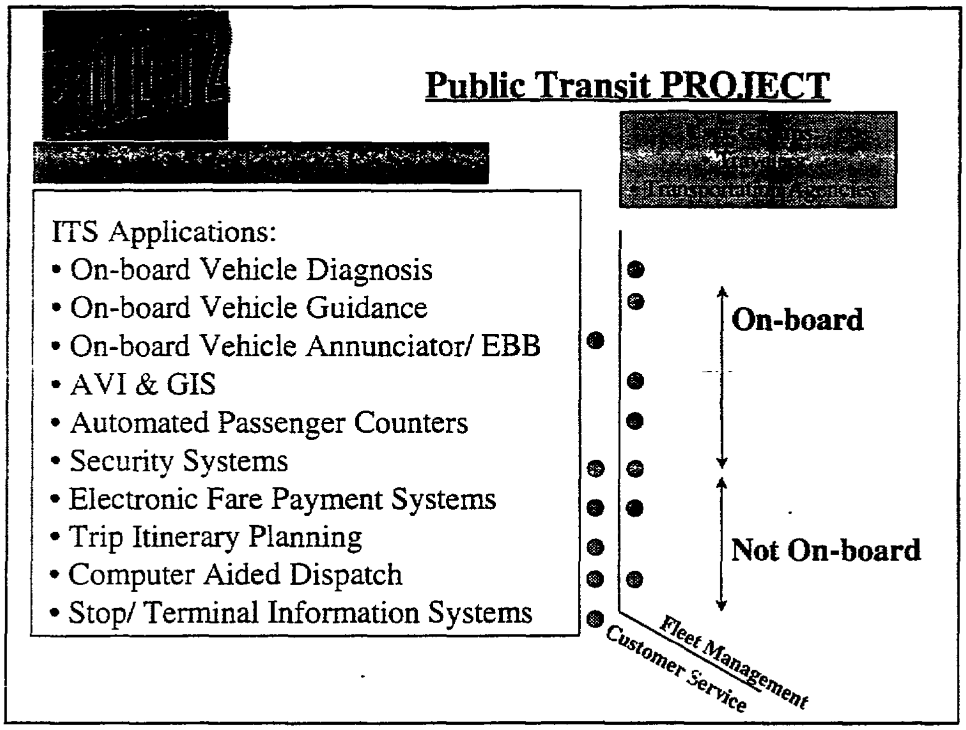
Figure 5.8: Conceptual Architecture of an En-Route ATIS application disseminating traffic information over a HAR network.

Project 2 - Public Transit

Greater Portland ITS Goal Addressed -

* *More Efficient, Cost-Effective Transportation System*
* *More Accessible and Complete Travel Information*
* *Cleaner Air*
* *More Energy-Efficiency*

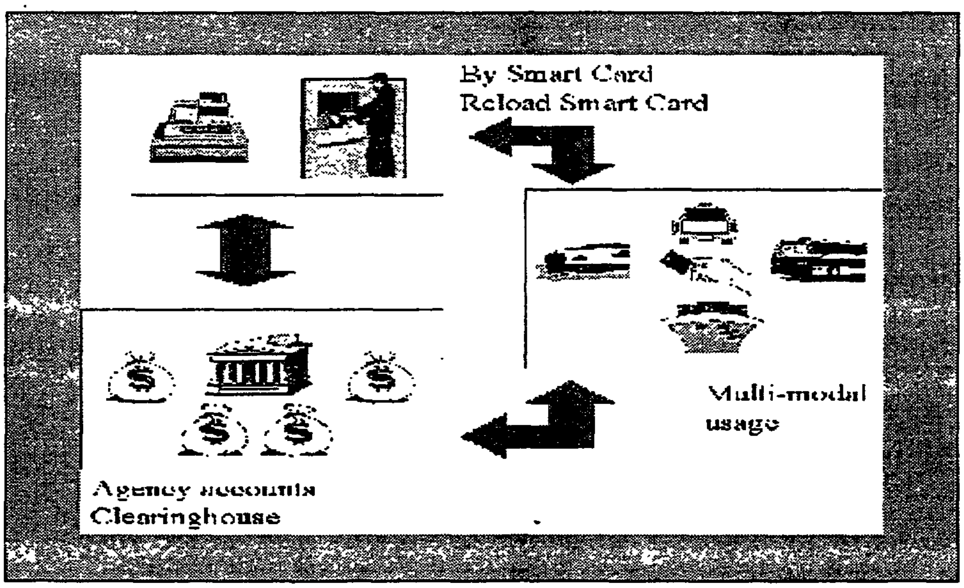
Project 2 presents typical ITS applications under the Advanced Public Transit Systems (APTS) Market Package bundle classified by application area. User groups defined are travelers and transportation system operating agencies. Operating agency user groups may include not only transit providers themselves, but also entities such as municipalities, the Maine Department of Transportation, and the Maine Turnpike Authority that own and maintain the roads and docks that transit services require. as well as public and transit agencies. The deployment context identified is either on-board or not on-board transit vehicles. Broad application functions are classified as either fleet management or customer service.



acronym notes:
EBB: electronic bulletin board
AVI: automated vehicle identification
GIS: geographic information

Project 2 - Public Transit Project

Figure 5.9: Conceptual Architecture for an Electronic Payment application in the Public Transit System and beyond.

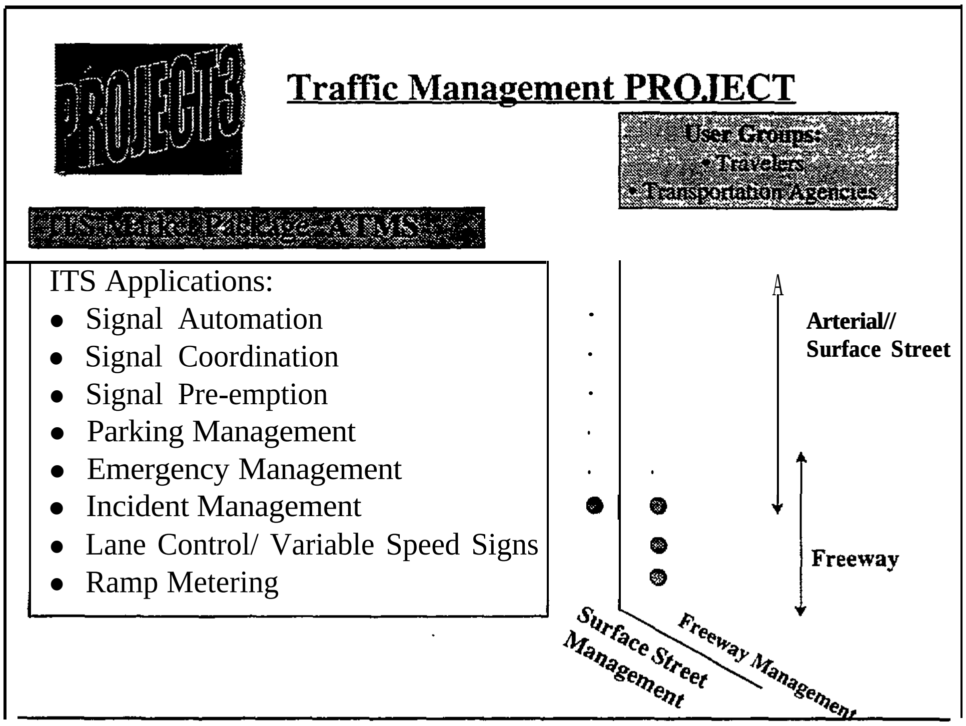


Project 3 - Traffic Management

Greater Portland ITS Goals Addressed -

- *More Efficient, Cost-Effective Transportation System*
- *Cleaner Air*
- *More Energy-Efficiency*
- *Improved Interagency Coordination/Cooperation*
- *Safer Travel*

Project 3 presents typical ITS applications under the Advanced Traffic Management Systems (ATMS) Market Package bundle classified by application area. User groups defined are travelers and transportation system operating agencies. Operating agency user groups may include not only entities such as municipalities, the Maine Department of Transportation, and the Maine Turnpike Authority that own and maintain transportation infrastructure, but also transit providers that depend on this infrastructure. The deployment context identified is either along surface streets and roads or along the freeway system. Broad application functions are classified as either surface street management or freeway management.

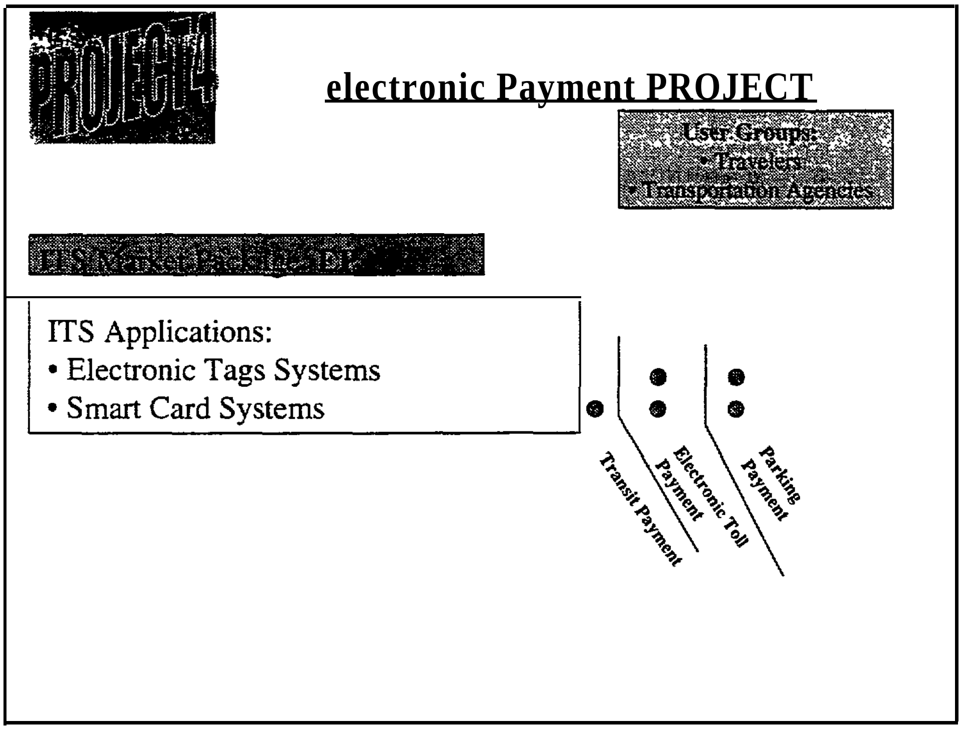


Project 4 - Electronic Payment

Greater Portland ITS Goals Addressed -

- * ***More Efficient, Cost-Effective Transportation System***
- * ***Improved Interagency coordinatin/Cooperations***

Project 3 presents typical ITS applications under the Electronic Payment (EP) Market Package bundle classified by application area. User groups defined are travelers and transportation system operating agencies. Operating agency user groups may include area transit providers themselves and the Maine Turnpike Authority, all of which might wish to collaborate in creating a “cashless” transportation payment system for the region. Application functions are electronic toll payment, transit fare payment, and parking payment.

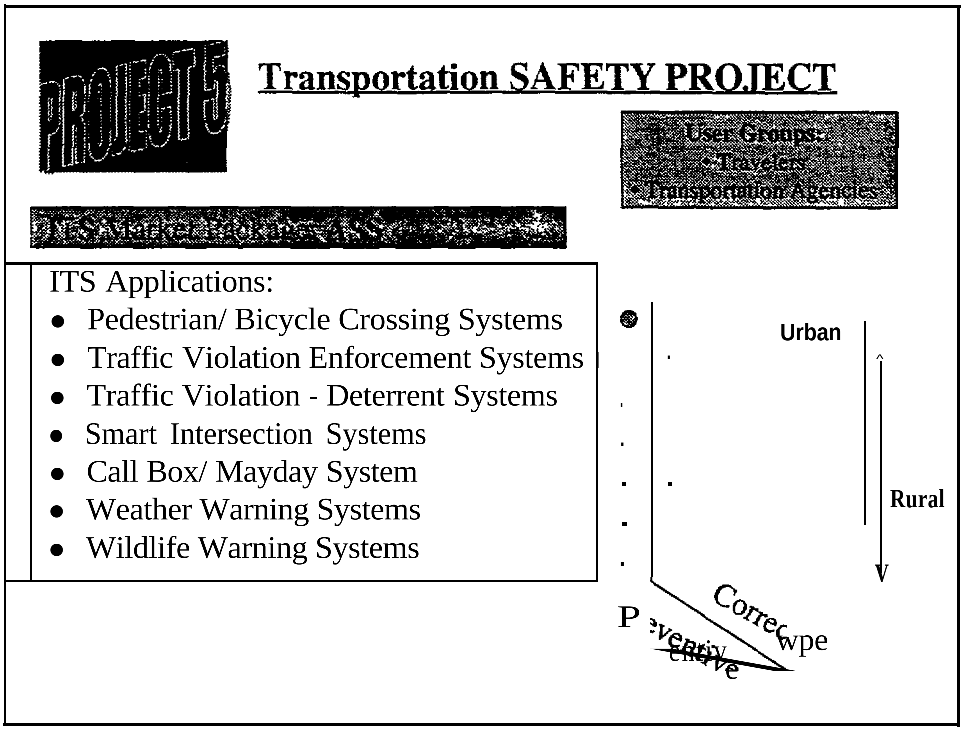


<u>Project 5 - Safety</u>

Greater Portland ITS Goal Addressed -

* ***Safer Travel***
* ***Improved Interagency Coordination/Cooperation***

Project 5 presents typical ITS applications under the custom-made Advanced Safety Systems (ASS) Market Package bundle classified by application area. User groups defined are travelers and transportation system operating agencies. Operating agency user groups may include both road and transit entities. The deployment context is either urban or rural. Application functions are preventive and corrective.



5.3.2 Evaluation of Preliminary ITS Projects

The Advisory Committee reduced the preliminary projects list from five to four by eliminating Project 5 and moving several applications that were from Project 3 to Project 1. All remaining ITS projects and applications within them were then evaluated by the Advisory Committee in accordance with national ITS objectives established by the United State Department of Transportation. These objectives are as follows:

* ***reduced travel time***
* ***increased service reliability,***
* ***cost reductions,***
* ***safety and security improvements,***
* ***idership and revenue increases***
* ***reduced emissions***

A simple evaluation model was adopted by the Advisory Committee to assist in an objective comparison between projects and among applications. This model is based on a 0 to 3 rating scale. as follows:

0 = no impact
1 = marginal impact
2 = moderate impact
3= substantial impact

Table 5.1 shows the composite rankings for each of the remaining four market packages. Table 5.2 presents an ordered ranking - in three tiers - of all component ITS applications. The first tier of this ordered ranking consists of the applications receiving the highest ratings. The second and third tier group applications in descending order of ratings received. Tables 5.3 through 5.6 display detailed ratings for component applications within each market package. Table A in the series of Tables 5.3 through 5.6 shows the actual scores assigned to each application across all scoring attributes. Table B displays weighted versions of these score (i.e. actual score divided by the number of applications rated). Table C lists the weighted average for each application across all scoring attributes. The figure following each group of tables displays Table C information in graphic form.

Overall Ratings

Table 5.1:
Ranking of ITS Projects by Average Score

Project	Score
Traffic Management	1.80
Electronic Payment	1.55
Public Transit	1.20
Traveler Information	1.125

Table 5.2:
Ranking of ITS Individual Applications Three Tiers, by Average Score

Application	Project	Score
AVL/GPS/GIS	Public Transit	2.30
Traffic Signal Preemption	Traffic Management	2.00
Signal Automation/Coordination	Traffic Management	1.60
Changeable/Variable Message Signs	Traveler Information	1.65
Smart Cards	Electronic Payment	1.55
Highway Advisory Radio - Traffic	Traveler Information	1.55
Smart Kiosk/World-Wide Web	Public Transit	1.30
On-board Annunciators	Public Transit	1.20
EBB/Text-TV	Public Transit	1.20
Smart Kiosk/World-Wide Web	Traveler Information	1.15
Highway Advisory Radio - Weather	Traveler Information	1.10
CMS/VMS/Parking	Traveler Information	1.05
EBB/Text TV	Traveler Information	0.95
Highway Advisory Radio - Parking	Traveler Information	0.95
Passenger Counters	Public Transit	0.95
Radio/TV	Traveler Information	0.60
Radio/TV	Public Transit	0.25

Project by Project Ratings -

Project 1: Traveler Information

Table 5.3A: Scores by Rating Attribute for Traveler Information Project Applications

	Travel Time	Service Reliability	Cost Reduction	Safety/ Security	Ridership/ Rwownuw Increases	Emission Reductions
Radio/TV	1	1	0	1	0	1
EBB/Text-TV	2	3	0	1	0	1
Smart Kiosk/ WWW	2	3	0	2	0	1
HAR highway	3	2	0	3	0	2
HAR parking	3	2	0	0	0	2
HAR weather	2	2	0	3	0	0
CMS/ VMS highway	3	3	0	3	0	2
CMS/ VMS parking	3	3	0	0	0	2

Table 5.3B: Weighted Scores by Rating Attribute for the Traveler Information Project Applications

	Travel Time	Service Reliability	Cost Reduction	Safety/ Security	Ridership/ Revenue Increases	Emission Reductions
Radio/TV	0.15	0.10	0	0.20	0	0.15
EBB/Text-TV	0.30	0.30	0	0.20	0	0.15
Smart Kiosk/ WWW	0.30	0.30	0	0.40	0	0.15
HAR highway	0.45	0.20	0	0.60	0	0.30
HAR parking	0.45	0.20	0	0.00	0	0.30
HAR weather	0.30	0.20	0	0.60	0	0.00
CMS/ VMS highway	0.45	0.30	0	0.60	0	0.30
CMS/ VMS parking	0.45	0.30	0	0.00	0	0.30

Table 5.3C: Composite Weighted Scores for Traveler Information Project Applications

Radio/TV	0.07
EBB/Text-TV	0.11
Smart Kiosk/ WWW	0.13
HAR highway	0.17
HAR parking	0.11
HAR weather	0.12
CMS/ VMS highway	0.18
CMS/ VMS parking	0.12

Figure 5.10: Composite Weighted Scores for Traveler Information Project Applications

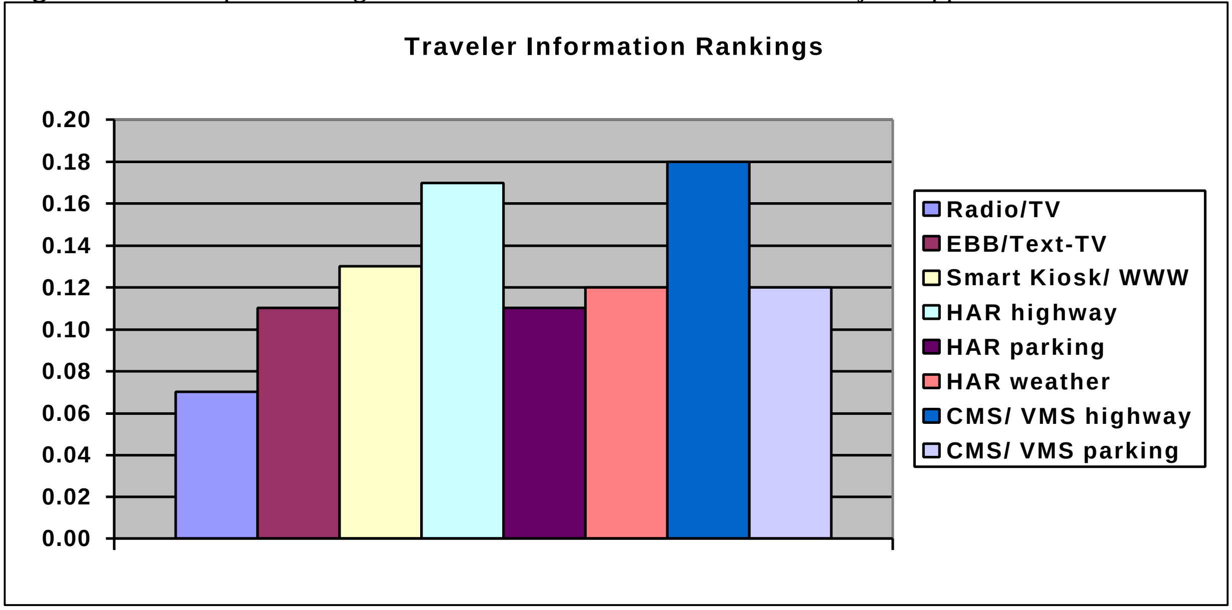


Table 5.3C and Figure 5.10 only reflect the relative importance or suitability of each ITS application or component within the Traveler Information Project as seen by the Advisory Committee. The overall average score ranking summarized in Table 5.3D shows the average score for all ITS applications within the Traveler Information Project on each of the national ITS objectives.

Table 5.3D: Potential Performance Values (Average Ratings) for the Traveler Information Project, by ITS Objective

Goal/ Objective	**Potential Performance Value (Average Ratings)**
Travel Time Reductions	2.85
Service Reliability Improvements	1.90
Cost Reduction	0
Safety/ Security Improvements	2.60
Ridership Revenue Increases	0
Emission Reductions	1.65

Project 2: Public Transit

Table 5.4A: Scores by Rating Attribute forPublic Transit ProjectApplications

	Travel Time	Service Reliability	Cost Reduction	Safety/ Security	Ridership/ Revenue Increases	Emission Reductions
Radio/TV	1	1	0	0	0	0
EBB/Text-TV	2	3	1	1	1	0
Smart Kiosk/ WWW	2	2	1	1	2	0
On-Board Annunciator/EBB	1	3	1	1	1	1
Passenger Counters	1	2	2	0	1	0
AVL/GIS	2	3	2	2	3	2
Smart Cards	2	1	2	1	2	1

Table 5.4B: Weighted Scores by Rating Attribute for Public Transit Project Applications

	Travel Time	Service Reliability	Cost Reduction	Safety/ Security	Ridership/ Revenue Increases	Emission Reductions
Radio/TV	0.15	0.10	0	0.00	0	0.00
EBB/Text-TV	0.30	0.30	0.2	0.20	0.2	0.00
Smart Kiosk/ WWW	0.30	0.20	0.2	0.20	0.4	0.00
On-Board Annunciator/EBB	0.15	0.30	0.2	0.20	0.2	0.15
Passenger Counters	0.15	0.20	0.4	0.00	0.2	0.00
AVL/GIS	0.30	0.30	0.4	0.40	0.6	0.30
Smart Cards	0.30	0.10	0.4	0.20	0.4	0.15

Table 5.4C: Composite Weighted Scores forPublic Transit ProjectApplications

Radio/TV	0.03
EBB/Text-TV	0.14
Smart Kiosk/ WWW	0.15
On-Board Annunciator/EBB	0.14
Passenger Counters	0.11
AVL/GIS	0.26
Smart Cards	0.18

Figure 5.11: Composite Weighted Scores for Public Transit Project Applications

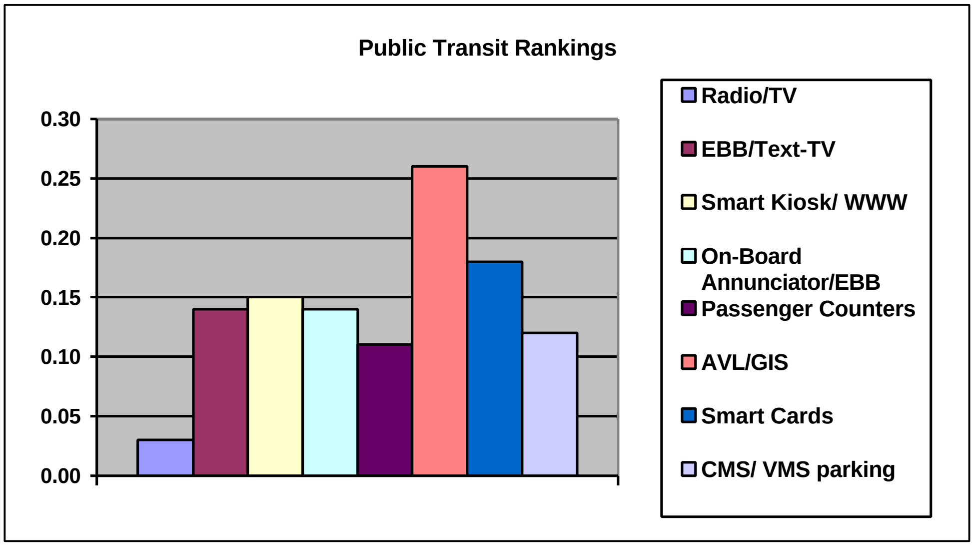


Table 5.4C and Figure 5.11 only reflect the relative importance or suitability of each ITS application or component within the Public Transit Project as seen by the Advisory Committee. The overall average score ranking summarized in Table 5.4D shows the average score for all ITS applications within the Public Transit Project on each of the national ITS objectives.

Table 5.4D: Potential Performance Values (Average Ratings) for the Public Transit Project, by ITS Objective

Goal/ Objective	Potential Performance Value
Travel Time Reductions	1.65
Service Reliability Improvements	1.50
Cost Reduction	1.80
Safety/ Security Improvements	1.20
Ridership Revenue Increases	2.00
Emission Reductions	0.60

Project 3: Traffic Management

Table 5.5A: Scores by Rating Attribute for Traffic Management Project Applications

	Travel Time	Service reliability	Cost Reduction	Safety/ Security	Ridership/ Revenue Increases	Emission Reductions
Signal Auto./Coord.	2	2	1	1	2	2
Signal Pre-emption	2	3	1	3	3	0

Table 5.5B: Weighted Scores by Rating Attribute for Traffic Management Project Applications

	Travel Time	Service reliability	Cost Reduction	Safety/ Security	Ridership/ Revenue Increases	Emission Reductions
Signal Auto./Coord.	0.30	0.20	0.2	0.20	0.4	0.30
Signal Pre-emption	0.30	0.30	0.2	0.60	0.6	0.00

Table 5.5C: Composite WeightedScors for Traffic Management Project Applications

Signal Auto./Coord.	0.44
Signal Pre-emption	0.56

Figure 5.12: Composite Weighted Scores for Traffic Management Applications

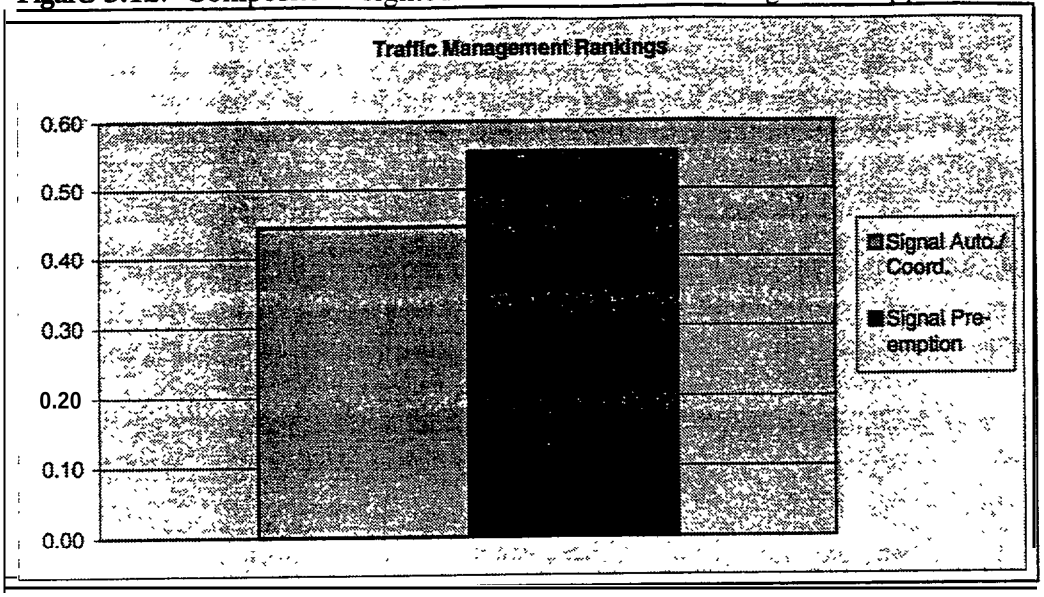


Table 5.5C and Figure 5.12 only reflect the relative importance or suitability of each ITS application or component within the Traffic Management Project as seen by the Advisory Committee. The overall average score ranking summarized in Table 5.5D shows the average score for all ITS applications within the Traffic Management Project on each of the national ITS objectives.

Table 5.5D: Potential Performance Values (Average Ratings) for Traffic Management Project, by ITS Objective

Goal/ Objective	Potential Performance Value
Travel Time Reductions	0.60
Service Reliability Improvements	0.50
Cost Reduction	0.40
Safety/ Security Improvements	0.80
Ridership/ Revenue Increases	1 .00
Emission Reductions	0.30

Project 2: Electronic Payment

Table 5.6A: Score by Rating Attribute for Electronic Payment Project Application

	Travel Time	Service Reliability	Cost Reduction	Safety/ Security	Ridership/ Revenue Increases	Emission Reductions
Smart Cards	2	1	2	1	2	1

Table 5.6B: Weighted Scores by Rating Attribute for Electronic Payment Project Application

	Travel Time	Service Reliability	Cost Reduction	Safety/ Security	Ridership/ Revenue Increases	Emission Reductions
Smart Cards	0.30	0.10	0.4	0.20	0.4	0.15

The overall average score ranking summarized in Table 5.6C shows the average score for the Electronic Payment Project on each of the national ITS objectives

Table 5.6C: Composite Weighted Scores for Electronic Payment Project Application

Goal/ Objective	Potential Performance Value
Travel Time Reductions	0.30
Service Reliability Improvements	0.10
Cost Reduction	0.40
Safety/ Security Improvements	0.20
Ridership/ Revenue Increases	0.40
Emission Reductions	0.15

5.4 Recommended Program of Greater Portland ITS Projects

The Greater Portland ITS Early Deployment Plan Advisory Committee reviewed revised evaluation scores for the second revised list of potential intelligent transportation system projects and further pared both the project and applications lists. This last round of winnowing was based on Advisory Committee views as to overall feasibility and value for the region. The result of Committee deliberations is a **Recommended Program of Greater Portland ITS Projects..** The Program of Projects consists of three broad ITS projects, each consisting of a varying number of more specific ITS applications. Each project and each of the favored applications within projects was ranked by the Advisory Committee in priority order. Applications that the Committee deemed desirable, but not of high priority, were placed in the Recommended Program without a priority ranking. The Advisory Committee assigned all applications a deployment phasing time period: before the year 2003, between the year 2003 and the year 2008, and - for unranked applications - "before 2008 if feasible". Associated with each application of the Program of Projects is one or more suggested implementing entities.

The Recommended Program does not include cost estimates, which are more properly made by implementing agencies once specific deployments are given project scopes. Future cost estimation is problematic in electronics, given trends in the computer and communications markets toward ever higher capability at lower and lower cost. Additionally, ITS project unit costs - like those for conventional transportation projects - vary greatly with quantities purchased and optional feature or enhancements desired. Chapter 4 of this document, however, includes representative costs for various ITS applications.

5.41. First Priority: Automated Public Transit Systems

The Advisory Committee recommends that various public transit applications be given the highest priority for ITS deployment in the Portland region. The Advisory Committee strongly felt that the following significant benefits were obtainable through intelligent transportation systems investments in the Greater Portland transit operations:

- ***Increased operational efficiency***
- ***Better customer service***
- ***Reduced costs***
- ***Improved integration of disparate transit operations***
- ***Increased transit system patronage***

Further, the Committee believed that transit operators in the region were keenly interested in deployment of a number of key ITS applications, including automated vehicle location systems, automated dispatching, and electronic fare payment. In the view of the Advisory Committee, this strong operator interest made more likely in transit than elsewhere in the transportation system the implementation of ITS projects and realization of their benefits.

The highest priority for deployment of ITS public transit applications before the year 2003 was given to automated vehicle location systems for Greater Portland transit fleets, "smart cards" for electronic fare payment, and development of a network of electronic passenger information kiosks linked to the world wide web.

RECOMMENDED GREATER PORTLAND ITS PROGRAM OF PROJECTS			
First Priority: PUBLIC TRANSIT PROJECT			
ITS COMPONENTS	***Component Ranking***	***Deployment Begins By***	***Deployed By***
PRIORITY APPLICATIONS -			
Automated Vehicle Location/Global Positioning Systems/Computer-Aided Dispatch	*1*	*before 2003*	*METRO, RTP, South Portland Bus Service*
Smart Cards	*2*	*before 2003*	*CBITD, METRO, RTP, South Portland* Bus Service
Smart Kiosk/World-Wide Web	*3*	*before 2003*	*CBITS, METRO, RTP, South Portland Bus Service*
Electronic Bulletin Boards/Text TV	*4*	*between 2003 and 2008*	*CBITD.* MFTRO. *Vermont Transit, Concord Trailways, AMTRAK*
OTHER APPLICATIONS -			
On-board Annunciators	*Unranked*	*before 2008 if feasible*	*METRO. South Portland Bus Service*
Passenger Counters	*Unranked*	*before 2008 if feasible*	*METRO. South Portland Bus Service*
Passenger Security Systems	*Unranked*	*before 2008 if feasible*	*METRO, South Portland Bus Service*
Transit Systems Management Center	*Unranked*	*before 2008 if feasible*	*METRO. RTP*
Traffic Signal Pre-emption	*Unranked*	*before 2008 if feasible*	*Portland, South Portland, Westbrook*

Table 5.7: First Priority Project - Public Transit

5.4.2 Second Priority: Automated Traveler Information Systems

The Advisory Committee's second highest project priority is electronic traveler information, with an emphasis on variable message signs (conventionally classified as traffic management tool), highway advisory radio, and an expanded menu of electronic travel information kiosk choices. The Committee recommends that a significant start in deploying these applications be made before the year 2003.

In the view of the Advisory Committee, provision of accurate and timely traveler information is essential both for the Portland region's role as a gateway to Maine and for better-informed daily travel by residents and commuters. Economic benefits flowing from improvements in pre-trip and en route traveler information include travel time savings for residents and increased visitations to – and consequent spending within - the region by tourists.

Second Priority: TRAVELER INFORMATION PROJECT			
ITS COMPONENTS	***Component Ranking***	**Deployment Begins By**	**Deployed By**
PRIORITY APPLICATIONS -			
Changeable/Variable Message Signs, Highway	1	*before 2003*	*Maine DOT, Maine Turnpike Authority, Portland, South Portland*
Highway Advisory Radio	*2*	*between 2003 and 2008*	*Maine DOT, Maine Turnpike Authority, Portland, South Portland*
Smart Kiosks/World-Wide Web	*3*	*before 2003*	*Maine DOT, Maine Turnpike Authority, Port/and, South Portland, Westbrook, Maine Mall, University of Southern Maine*
OTHER APPLICATIONS -			
Highway Advisory Radio, Parking	*Unranked*	*before 2008 if feasible*	*Portland*
Highway Advisory Radio, Weather	*Unranked*	*before 2008 if feasible*	*Maine DOT, Maine Turnpike Authority, Port/and, South Portland*
Changeable/Variable Message Signs, Parking	*Unranked*	*before 2008 if feasible*	Portland

Table 5.8: Second Priority Project – Traveler Information

5.4.3. Third Priority: Automated Traffic Management Systems

The Advisory Committee recommends that two linked traffic management applications be given an overall third project priority: traffic signal pre-emption for emergency vehicles and perhaps also for transit vehicles and comprehensive traffic signal automation as well as signal coordination along corridors and between municipalities. In the Committee's view, implementation of these two measures will reduce emergency response times and improve traffic flow on the region's roadways.

Third Priority: TRAFFIC MANAGEMENT PROJECT			
ITS COMPONENTS	***Component Ranking***	***Deployment Begins By***	***Deployed By***
PRIORITY APPLICATIONS -			
Traffic Signal Pre-emption	*1*	*before 2003*	*Maine DOT, Portland, South Portland, Westbrook, Scarborough*
traffic Signal Automation & Coordination	2	*before 2003*	*Maine DOT, Portland, South Portland, Westbrook, Scarborough*
OTHER APPLICATIONS -			
Trans. Mgt. Center(s)	*unranked*	*before 2008 if feasible*	*MOOT, PACTS*

Table 5.9: Third Priority Project – Traffic Management

5.5 What Next?

The Greater Portland Intelligent Transportation Systems Early Deployment Plan documents ITS capabilities and contains a recommended **Program of Greater Portland ITS Projects.** Advancing ITS deployment in the region, however, requires both raising awareness of ITS on the part of decision-makers and the traveling public as well as actual implementation of ITS projects. The Advisory Committee recommends the following "next steps" for advancement of intelligent transportation systems in the region.

55.1 Outreach and Education

Recommended "next steps" in outreach and education initiatives are as follows:

Activity:
Distribute the Greater Portland ITS Early Deployment Plan and recommended Program of Greater Portland ITS Projects to the Maine DOT, Federal Highway Administration, Federal Transit Administration, Maine Turnpike Authority, PACTS, Portland area municipal managers, and Portland area transit managers

Purpose:
To inform decision-makers about ITS capabilities and recommended deployment program.

Initiators:
Greater Portland Council of Governments staff

Completed by:
March, 1998

Activity:
That Maine DOT Form a Maine Chapter of ITS America

Purpose:
To provide professional and technical support and coordination to ITS project planners

Initiators:
Maine Department of Transportation, Maine Turnpike Authority, Portland Area Comprehensive Transportation Committee, Greater Portland Council of Governments

Completed by:
July, 1998

Activity
Convene an annual meeting of Greater Portland ITS Stakeholders, formed with the ITS EDP Advisory Committee at its core

Purpose:
To review progress in ITS implementation and recommend revisions to the recommended Program of Greater Portland ITS Projects

Initiators:
PACTS and Greater Portland Council of Governments

Completed by:
Annually, beginning in September 1998

Activity:
Further integrate education about intelligent transportation systems into the ongoing educational enrichment efforts in the region

Purpose:
Educate youth on advances in electronics and communications technology in transportation and careers available in these emerging fields

Initiators:
Greater Portland Council of Governments and Portland area teachers

Completed by:
Ongoing, beginning in March, 1998

5.5.3 Implementation

Recommended "next steps" in implementation are as follows:

Activity:
Prepare detailed project scopes for initiatives recommended and ranked for implementation "before 2003" in the Program of Greater Portland ITS Projects

Purpose:
Initiation of ITS project-level planning

Initiators:
Implementing agencies such as municipalities, the Maine DOT, Maine Turnpike Authority, other State agencies, and transit operators.

Completed by:
December 1998

Activity:
Prepare grant applications, capital improvement program requests, and other funding requests or partnerships to support initiatives recommended and ranked for implementation "before 2003" in the Program of Greater Portland ITS Projects.

Purpose:
Initiation of ITS project-level planning

Initiators:
Implementing agencies such as municipalities, the Maine DOT, Maine Turnpike Authority, and transit operators.

Completed by:
December 1998

5.5.4 Recommended Next Steps

A unifying framework that enables ITS infrastructure components to share information and function as an intermodal transportation system needs to be established. Stakeholders in the area still need to build consensus regarding:

- ***Current information sharing needs and future opportunities***
- ***Data descriptions, processing specifications, and process flows***
- ***Subsystem definitions, functionality and standard interface needs***
- ***Telecommunications options for subsystem infer-connections***
- ***Potential institutional roles, responsibilities and relationships***

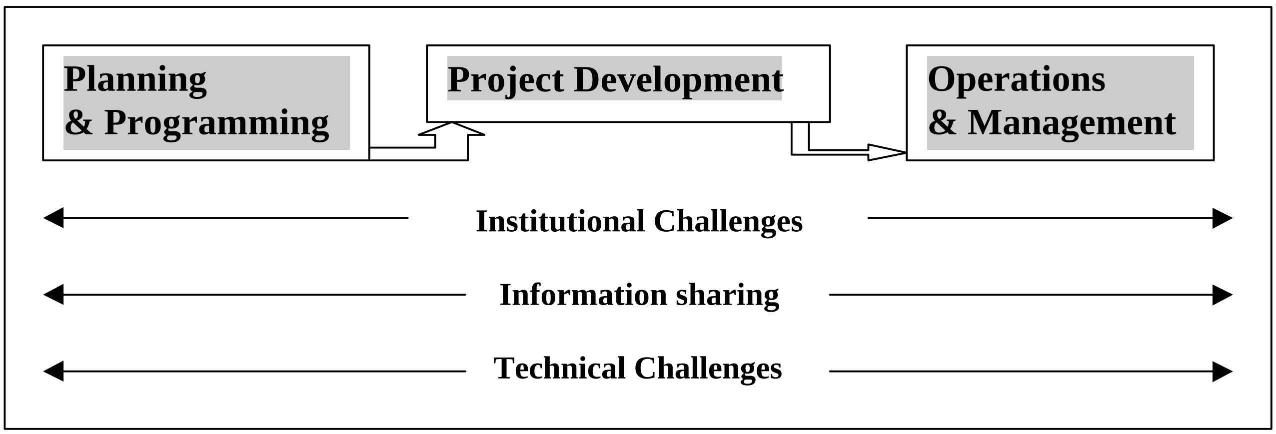


Figure 5.13: Challenges of planning, planning, deploying, and operating ITS within the transportation system

A major key to success will be to implement a productive dialogue between those who recognize, understand, and "own" transportation problems, and those who implement and invent technological solutions. Thus, a regional Technical Coordinating Committee should be formed to advance development of an intelligent transportation systems infrastructure in the region.

- **Project Development - Public Transit**

The Greater Portland Transit District, Regional Transportation Program, Inc., the South Portland Bus Service and the Casco Bay Island Transit District need to develop specific ITS public transit project scopes and grant applications. Greater Portland Council of Governments' staff is available to assist in these activities. Potential funding sources include the following:

- ***Intelligent Transportation Systems Operational Test***
- ***Congestion Mitigation/Air Quality Improvement***
- ***Federal Transit Administration Urban Formula Funds***
- ***Surface Transportation Program .***
- ***State Bond***
- ***Congressional "Earmark"***
- ***Operator Capital Reserve***

- **Project Development - Traveler Information**
-

The Maine Department of Transportation, Maine Turnpike Authority, and the Cities of Portland, South Portland and Westbrook need to develop specific ITS traveler information project scopes and grant applications. Greater Portland Council of Governments' staff is available to assist in these activities within the Portland region. Potential funding sources include the following:

- ***Intelligent Transportation Systems Operational Test***
- ***Congestion Mitigation/Air Quality Improvement***
- ***Surface Transportation Program***
- ***State Bond***
- ***Congressional "Earmark"***
- ***Municipal Capital Improvement Program***

Project Development - Traffic Management

The Maine Department of Transportation, the Cities of Portland, South Portland and Westbrook, and the Town of Scarborough need to develop specific ITS traffic management project scopes and grant applications. Greater Portland Council of Governments' staff is available to assist in these activities within the Portland region. Potential funding sources include the following:

- ***Intelligent Transportation Systems Operational Test***
- ***Congestion Mitigation/Air Quality Improvement***
- ***Surface Transportation Program***
- ***State Bond***
- ***Congressional "Earmark"***
- ***Municipal Capital Improvement Program***

6. PATHS NOT CHOSEN FOR THE GREATER PORTLAND REGION

The Early Deployment Plan recommends that a number of ITS initiatives be undertaken within the Portland area over the next ten years. These initiatives, which comprise the recommended **Program of Greater Portland** ITS **Projects,** are described in Chapter 5 of this document. There are also a number of important ITS Market Packages not included in the Program of Projects. The brief narrative to follow explains why these sets of related ITS applications are not made part of the Early Deployment PIan recommendations.

Typically, the decision to include an ITS application was based on what the Committee felt was within the ability of local and regional decision-makers to accomplish. Thus recommendations in the Early Deployment Plan focus on actions that can be initiated within the region, even if partnerships with other levels of government and/or the private sector are desired for successful project implementation. The Advisory Committee does, however, recognize the value of these Market Packages and urges consideration of them in the appropriate context.

6.1 Commercial Vehicle Operations

Because of the wide geographic scope required for goods movement and the important roIe played by the private sector, the Advisory Committee felt that initiation of ITS deployments in commercial vehicle operations to be a province of the private sector, along with the state and federal governments.

6.2 Emissions Sensing

The Advisory Committee deemed that since Clean Air Act compliance is a state and federal responsibility, initiation of ITS emission sensing deployments should take place at these levels of government.

6.3 Highway/RaiI Grade Crossing Safety

Rail crossing safety is also a responsibility shared by state and federal government alongside the private sector. Thus, ITS projects in this sector would be an initiative of these higher levels of government.

6.4 Wildlife Warning Systems and Other Rural ITS Applications

The Advisory Committee felt that rural ITS deployments were the province of rural communities, the state government, and other entities outside of metropolitan Portland.