Communities working together to
meet Chittenden County's transportation needs

CHITTENDEN COUNTY METROPOLITAN PLANNING ORGANIZATION

Chittenden County
Intelligent Transportation Systems
Strategic Deployment Plan

Approved by CCMPO, September 20, 2000

CCMPO
100 Dorset Street, Suite 22, South Burlington, Vermont 05403
(802) 660-4071 / (802) 660-4079 *Fax*
www.ccmpo.org / info@ccmpo.org

The preparation of this document has been financed through transportation planning funds provided by the U.S. Department of Transportation under the Transportation Equity Act for the 21st Century (TEA-21) and by matching funds provided by Chittenden County's 18 municipalities, the Vermont Agency of Transportation, and the Chittenden County Transportation Authority.

THE CHITTENDEN COUNTY INTELLIGENT TRANSPORTATION SYSTEMS STRATEGIC DEPLOYMENT PLAN

TABLE OF CONTENTS

List of Figures

List of Tables

EXECUTIVE SUMMARY

Intelligent Transportation Systems, or ITS, refers to the application of communications, control, and electronics technologies to transportation problems with the aim of improving the efficiency and safety of the transportation system. To plan for the orderly, timely, and cost efficient deployment of ITS technologies in the region, the Chittenden County Metropolitan Planning Organization (CCMPO) initiated this Intelligent Transportation Systems Strategic Deployment Plan. The development of the CCMPO's ITS Deployment Plan was done under the guidance of a Steering Committee of key transportation stakeholders in the region.

Background

Since the ITS field spans a wide array of technologies – and since the transportation system spans multiple jurisdictional boundaries – the Federal Highway Administration (FHWA) has established the National ITS Architecture to ensure that ITS investments are compatible and conform to national standards. Further, FHWA has set forth a standard planning process for developing regional ITS deployment plans. The CCMPO's ITS Deployment Plan is consistent with the National Architecture, and the process of developing the Plan adhered closely to that recommended by FHWA.

An important early step in the development of the Plan was the identification of the region's transportation problems. The existing Regional Transportation Plan was used as documentation of these problems, and additional quantitative and qualitative data were provided as supplemental information. A third source of information were surveys and interviews conducted with three key stakeholder groups: Emergency Services, Public Transit, and Departments of Public Works. Based on these sources, the key transportation problems identified as addressable through ITS technologies were:

- Traffic Congestion
- Coordination of Incident Management System
- Improvement of Public Transit Service and Efficiency
- Improvement of Transportation Safety
- Improvement of Traveler Information Systems

Market Packages

To ensure cross-jurisdictional compatibility and consistency with the National Architecture, ITS technologies are grouped into Market Packages. A *market package* represents a combination of equipment capabilities that address specific transportation problems or needs. To date, a total of 60 Market Packages have been defined for the following seven major application areas:

- Advanced Traffic Management Systems (ATMS);
- Advanced Public Transportation Systems (APTS);
- Advanced Traveler Information Systems (ATIS);
- Advanced Vehicle Safety Systems (AVSS);
- Commercial Vehicle Operations (CVO);
- Emergency Management Systems (EMS); and
- ITS Planning

For Chittenden County, each Market Package area was evaluated across three key dimensions:

1. How responsive it is to the region's identified transportation problems.
2. How closely it matches the region's transportation objectives.
3. The degree to which a Market Package is a building block for future expansion of the ITS system.

Based on these 3 evaluation criteria, the 60 ITS Market Packages were prioritized. Table ES-1 lists the ITS Market Packages recommended for short-term deployment in the Chittenden region.

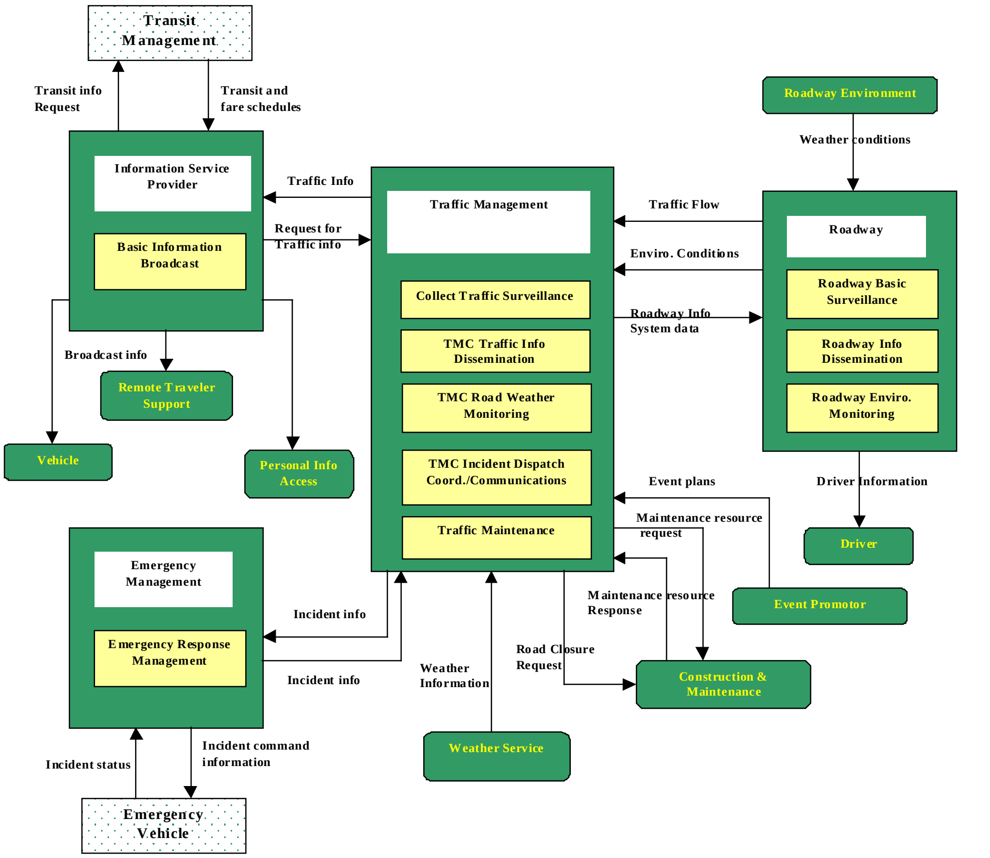
Table ES- 1: Short-Term ITS Market Packages

Market Packages	Key Objective of Package
Network Surveillance	Obtain real-time information about travel conditions.
Surface Street Control	Establish signal coordination along regional arterial roadways.
Incident Management	Improve coordination of emergency services and reduce incident response time.
Transit-Fixed Route Operations	Improve public transit operations.
Demand Responsive Transit Operations	Improve para-transit operations.
Transit Tracking	Provide automated vehicle location capability to transit vehicles.
Transit Fare Management	Facilitate transit fare payments and improve management of fare and transit usage data
Broadcast Traveler Information	Provide Real-Time Information on Travel Conditions, Travel Options, with a Variety of Broadcast Technologies (etc. radio, web site, etc.).
ITS Planning	Develop a mechanism for archiving and retrieving information collected by the ITS system, and make it useable for planning purposes.

Regional ITS Architecture

With the ITS market packages prioritized, the regional ITS architecture was specified. The architecture defines the physical components of the ITS system and the information flows between the system's components. The key feature of the recommended ITS architecture for Chittenden County is a regional Transportation Management and Information Center (TMIC). Figure ES-1 shows the architecture of this central piece of the regional ITS system.

Figure ES- 1: Physical and Logical Architecture of the Transportation Management and Information Center



Similar architectures are set forth in the ITS Deployment Plan for Advanced Traffic Signal Systems, Advanced Public Transportation Systems, and ITS Planning.

Project Deployment and Sequencing

The recommended project deployment plan is based on the need to develop fundamental capabilities first. Once the backbone of an ITS system is established, the system can evolve to include more advanced technologies or projects as they develop. For this reason, the short-term (1-3 years) ITS deployment plan for Chittenden County focuses on developing the foundation ITS capabilities. In addition, clearly identified early winners are recommended for short-term deployment. Table ES-2 lists the ITS projects recommended for the short-term.

Table ES- 2: Short-Term Project Recommendations, Objectives, and Estimated Costs

Project	**Objectives**	**Capital Costs**	**Ongoing Annual Costs**
Automated Vehicle Location	Improve dispatch efficiency of SSTA	$5,000 per installation	$500
Transit Operations Software	Improve operating efficiencies of both CCTA and SSTA	$50,000	$1,000
Transit Fare Management	Improve financial efficiency, increase ridership	Depends upon functionality	Depends upon functionality
ITS Planning	Archive data collected through the ITS system. Make information available for improved transportation planning.	$35,000	Ongoing commitment; part of the TMIC responsibility.
Deploy Network Surveillance Equipment	Obtain real-time information on the performance of the transportation system	$5,000 per installation	5% of Capital Cost
Deploy CMS and HAR	Re-transmit information about travel conditions to the traveling public.	$20,000 to establish HAR; $70,000 per CMS installation	5% of Capital Cost
Advanced Traffic Signal Systems	Improve signal coordination; provide for signal pre-emption capability	$5,000 per signal controller; $40,000 for linking arterial signals	$1,000 per installation for communications costs.
TMIC—Set Up	Establish physical location for TMIC with associated communications infrastructure.	$208,000	$135,000
TMIC Incident Management System	Provide real time information on incidents, provide link with E911 for sharing information.	$30,000	nominal
Pre-Trip Traveler Information System	Provide central locus of travel/traffic information via a web site	$20,000	$2,000 - $5,000 annually.

The sequencing of ITS deployment can occur along three tracks. The first track – public transportation – can begin immediately. The recommended projects should be integrated with planned vehicle purchases. For the AVL project, beginning with a demonstration project, and evaluating its effectiveness before widespread adoption is recommended.

The second track involves the street surveillance and surface street control projects. Nationally, these are the most commonly deployed elements of ITS. These projects have high benefit-to-cost ratios, and have high demonstration value to the public. For this reason, this Plan recommends that traffic signal systems along the key regional arterials be updated in a systematic fashion. This type of updating can be folded into any arterial reconstruction projects, as has been accomplished with the Main Street Improvement Project and as is planned for the Shelburne Road Reconstruction Project. Further, as individual traffic signals are updated throughout the region, they should be replaced with advanced traffic signal controllers that enable interconnection, communication, and coordination.

The timing for network surveillance equipment can be pursued in a similar fashion. Namely, as key arterial intersections are reconstructed or improved, those improvements should include detection technology that is designed not only to inform operations at the intersection, but also to communicate conditions to the TMIC.

The third track involves the Transportation Management and Information Center. The TMIC can be developed as a stand-alone project, or attached to another transportation project, such as a Multi-Modal Center. However, for the TMIC to be truly useful, network surveillance equipment should be installed at key intersections and arterials throughout the region. Once there is a critical mass of real-time travel information that can be transmitted to a central location, and re-transmitted to the traveling public, a TMIC is a necessary component.

Medium Term Projects

The ITS Deployment Plan sets forth medium and long-term ITS investments as well. For the Medium term – 5-10 years – Table ES-3 lists the ITS market packages that are recommended for project definition and deployment.

Funding Investments in ITS

ITS projects can be funded in two ways. The first way is to include ITS components within transportation projects advancing on the region's Transportation Improvement Plan. The sources of funding for TIP projects include the National Highway System (NHS) program, the Surface Transportation Program (STP), and Congestion Mitigation Air Quality (CMAQ) funding. In addition, some FTA 5311 funds can be allocated to ITS investments. All of these are programs funded through TEA-21, the Transportation Equity Act for the 21st Century. In all cases, it is much easier to invest in ITS as part of ongoing transportation investments as opposed to as stand-alone projects. For example, it is easier to implement signal coordination technologies within a corridor reconstruction project than it is as a stand-alone investment. The second way is to advance a specific ITS project through a demonstration project that can receive a special appropriation.

Table ES- 3: Medium-Term ITS Market Packages

Market Packages	Key Objective of Package
Transit Information	This market package provides transit users at transit stops and on-board transit vehicles with ready access to transit information.
Multi-Modal Coordination	Improve service coordination between transit agencies and with traffic management entities.
Traffic Information Dissemination	Provide Real-Time Information on Travel Conditions, Travel Options, with a message signs visible from the roadway, or in vehicles.
Regional Traffic Control	Advances the Surface Street Control Market Package by adding communication links and integrated control strategies that enable integrated inter-jurisdictional traffic control.
Roadway Weather Information Systems	Provide real-time information on weather affecting roadway travel.
Interactive Traveler Information	Provides tailored information regarding traffic conditions, transit services, traveler services, ride share/ride match, parking management, etc. in response to a traveler request.
Emergency Response	Enable the safe and rapid deployment of appropriate resources in response to an emergency

Institutional Issues

A common message in the ITS literature is that institutional barriers are more challenging in ITS implementation than technical issues. Institutional issues arise in almost every facet of ITS. As an example, for traffic signal systems crossing jurisdictional boundaries, the following questions immediately surface: which jurisdiction should control the operation? Who should maintain the system? Who pays and how much? What types of long term agreements should be established?

Each ITS deployment carries with it a similar set of issues that need to be handled in a way that is consistent with the technology and involves the affected parties. Since most of these issues transcend jurisdictional boundaries and stakeholder groups, the CCMPO is the logical organization to act as facilitator.

1.0 INTRODUCTION

Intelligent Transportation Systems, or ITS, refers to the application of communications, control, and electronics technologies to transportation problems with the aim of improving the efficiency and safety of the transportation system. To plan for the orderly, timely, and cost efficient deployment of ITS technologies in the region, the Chittenden County Metropolitan Planning Organization (CCMPO) initiated this Intelligent Transportation Systems Strategic Deployment Plan.

To encourage the deployment of ITS projects, the federal government has, since the 1991 passage of the Intermodal Surface Transportation Efficiency Act (ISTEA), provided grants to state and local transportation agencies to develop ITS strategic deployment plans. Initially, the focus was on large urban areas. However, as time went on, the scope was broadened to include both rural areas[1] as well as small urban areas similar to the Chittenden County Metropolitan area. The successor legislation to ISTEA, the Transportation Equity Act for the 21st Century (TEA-21), allocates $1.3 billion for ITS projects over the next six years.

Besides providing funds for planning studies, the federal government has developed the National ITS Architecture to provide guidance in developing systems that would ensure national and regional interoperability. The national architecture provides a common structure for the design of intelligent transportation, without limiting the design options of the transportation stakeholder. Following the national architecture in developing ITS strategic plans guarantees that ITS services and products would work across the different regions of the country. This helps maximize the potential of ITS technologies.

Chittenden County provides an interesting and challenging context for developing an ITS strategy because it contains distinctly urban, suburban, and rural settings within its planning boundaries. Each of these land use areas has a set of characteristic transportation issues that, in turn, can be approached through the application of appropriate ITS market packages. This plan identifies, recommends, and prioritizes appropriate ITS strategies for both near-term and long-term implementation.

Because of the County's land use mix, there is a fundamental difference between planning for ITS in Chittenden County and that in a large urban area. This difference stems from the fact that *intolerable* congestion, which is the case in regions such as Washington, D.C. or Los Angeles, does not really exist in Chittenden County. **This provides the opportunity to target ITS strategically, without being pressured to identify projects to deal with current congestion problems demanding immediate attention.**

[1] In fact, a separate program, the Advanced Rural Transportation Systems (ARTS), was established for this purpose.

With this opportunity to approach ITS deployment from a proactive rather than a reactive attitude, the strategic plan has been developed with two basic principles in mind:

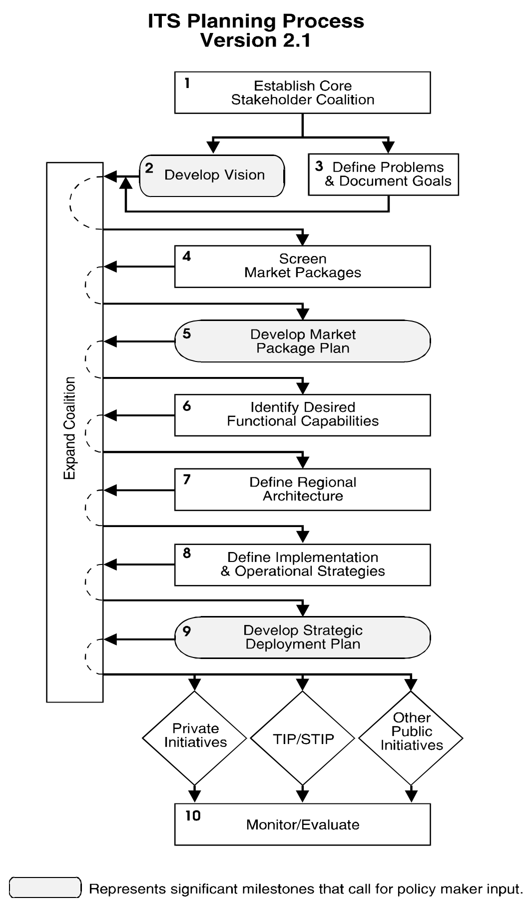
(1) **identify economically-feasible early winners for ITS projects;** and

(2) **build the core infrastructure needed for ITS incrementally using interoperable systems**.

1.1 THE ITS STRATEGIC PLANNING PROCESS

The development of the CCMPO ITS Strategic Deployment Plan followed the *ITS Planning Process* developed by the Federal Highway Administration (FHWA) and researchers at the Virginia Transportation Research Council. The *FHWA Planning Process*, shown in Figure 1, uses the concept of *market packages* and requires the development of a regional architecture that is compatible with the National ITS architecture.

Figure 1: FHWA Recommended ITS Planning Process



Several key stakeholder groups were engaged in this planning process. At the core of the planning process was the CCMPO ITS Steering Committee. Table 1 provides the names and affiliations of the CCMPO ITS Steering Committee

Table 1: Members of the CCMPO ITS Steering Committee

Name	Affiliation
Bruce Bender	ITS Program Manager, VTrans
Jeanette Berry	Chittenden County Transit Authority
Dan Bradley	Burlington Department of Public Works
George Gerecke	Town of Williston
Dick Hosking	VTrans District 9 Administrator
Peter Keating	CCMPO
Chris Jolly	Federal Highway Administration
Dennis Lutz	Town of Essex Department of Public Works
Bob Penniman	CATMA, CCMPO Board
Charles Safford	Village of Essex Junction
Tim Shea	Lake Champlain Chamber of Commerce

The ITS Steering Committee met over the course of 10 months (June 1999 – April 2000). During this time, several meetings were held with the ITS Steering Committee, with special stakeholder groups, and with the public to gain input to the plan. A summary of these meetings is provided in Appendix 1.

1.2 OVERVIEW OF THE REPORT

This report is divided into the following sections:

- 2.0 Transportation Issues/Problems in Chittenden County
- 3.0 Vision of the Regional ITS System
- 4.0 ITS Market Package Plan
- 5.0 ITS System Architecture
- 6.0 Recommended ITS Projects
- 7.0 ITS Program Evaluation

In addition, this report contains 5 sections of support material, as follows:

- Appendix 1: Meetings of the ITS Planning Process
- Appendix 2: Transportation Issues/Problems in Chittenden County
- Appendix 3: Market Packages Listed in the National ITS Architecture (v. 3.0)
- Appendix 4: Examples of ITS Market Packages Deployed in Other Regions
- Appendix 5: Market Packages Mapping Against Goals and Objectives
- Appendix 6: Signal Pre-emption Background and Policy
- Appendix 7: Glossary of Acronyms Used in the Report

2.0 TRANSPORTATION ISSUES/PROBLEMS IN CHITTENDEN COUNTY

The ITS Process established by FHWA suggests that an ITS Deployment Plan be devised after a region's transportation problems have been defined. To a large extent, the CCMPO's annual work plan, and their ongoing review and revision of the region's Long Range Transportation Plan provide the foundation for defining the region's transportation problems. In addition, the members of the ITS Committee, and the project's stakeholders, represent a repository of knowledge of the region's transportation issues. To inform the strategic planning process, and to have a common base of data regarding the region's transportation system, a sampling of macro-level information about the region was assembled. This is provided in Appendix 2.

To gain more current input on the transportation problems experienced by key stakeholder groups, a simple paper survey was administered. The survey focused on the following ITS user groups:

- ▲ Transit (CCTA, CATMA, SSTA)
- ▲ Emergency Response (Area Police & Fire Departments, Emergency Response Agencies)
- ▲ Departments of Public Works and Road Agents
- ▲ Travel & Tourism

Table 2 summarizes the problems and issues obtained from the surveys. The problems and issues are grouped by the applicable ITS area.

Table 2: Transportation Problems/Issues in Chittenden County

ITS Area	Problems, Issues, and Opportunities
Travel and Transportation Management	Traffic congestion and lack of signal co-ordination on US 7 between Imperial Drive and I-189. Lack of signal co-ordination on US 2A between Tafts Corners and I-89. Too much traffic along minor arterials that really should function more as a local road Lack of pedestrian facilities. The real need for co-operation among the parties involved in the incident management process. Presently, each party works independently and does not take into account the impact of its actions on its neighbors. Jericho highway department is in the process of bringing together all agencies involved to develop an incident/emergency management process. Many groups in Jericho desire to slow and calm traffic along the town's traffic corridors, including VT RT 15. This road cannot be slowed or calmed unless a limited-access highway were to take its place. Intersection geometry and traffic control for several key locations .
Public Transportation Operations	The need for transit vehicles to stay on schedule. The need for better systems for fare collection. The need for real-time information on transportation system status. The need to determine the most efficient route and schedule.
Emergency Management	Congestion and the lack of signal preemption. Congestion is the number one problem especially during holiday period on Dorset Street. On a daily basis, 189-Rt 7 is the worst area. Even with signal preemption, sometimes there is just no place to move the vehicles. There is a need to investigate alternate routes for traffic during an incident. Shelburne fire department is currently investigating CAD and signal preemption.
Infrastructure Management	Deteriorating infrastructure.

2.1 ITS TECHNOLOGY IN CHITTENDEN COUNTY

Another purpose of the survey described above was to develop a comprehensive inventory of ITS technologies currently deployed in the region. Table 3 summarizes the results of this survey.

Table 3: ITS Technologies Currently Deployed in Chittenden County

Area	Technologies
Surveillance	Most traffic signals installed with at least partial actuation. Loop detectors at most signalized intersections Detector on I-89 to determine if long queues are forming on the off-ramp (Exit 14). Limited fiber optic network in Burlington.
Traffic Operations	Signal Coordination on Main Street, Burlington; Dorset Street, South Burlington. Variable Turn Prohibition Signs (Main/Winooski)
Traveler Information Systems	CCMPO Travel Information line. Traveler Information Kiosks at Williston Rest Stop. VAOT Variable Message Signs (Main St. Reconstruction)
Vehicle Tracking	Open radio communications between all CCTA and central dispatch. Radio communication for SSTA vehicles and central dispatch. Emergency response agencies use radio and cell phones - no Automatic Vehicle Location (AVL).
Routing and Scheduling	SSTA uses dispatching software.
Emergency Management	Signal preemption exists along Dorset St. (So. Burlington). Signal preemption to be installed on Main Street. Manual signal preemption at Mansfield/Colchester and at Carrigan/East. Shelburne police department uses CAD, signal preemption and emergency notification and routing.
Incident Management Systems	South Burlington fire department has a plan.
GIS Capabilities	VAOT and CCRPC have extensive GIS capabilities. Some municipalities have GIS capability as well.
Vehicle Maintenance Software	SSTA and CCTA have vehicle maintenance software.
Fare Collection Systems	CCTA has electronic download of fare and ridership information. SSTA has a punch card fare payment system.

3.0 VISION OF THE REGIONAL ITS SYSTEM

To develop an ITS Vision Statement, the following sources were consulted:

1. The Chittenden County Long Range Transportation Plan (LRTP) was consulted to identify those goal statements documented in the plan that can be addressed using ITS technologies.
2. Several ITS Early Deployment Plans were reviewed for different regions of the country to get a feel for the vision and goals these regions had for their regional system.
3. The results of a November 1998 ITS kick-off meeting held at the University of Vermont were reviewed to understand the vision that the ITS stakeholders in the region had for an ITS system.

The insights gained from these three steps were then combined to come up with the following set of vision and goal statements for the County.

3.1 VISION STATEMENT

> Chittenden County envisions an Intelligent Transportation System that deploys cost-effective technologies designed to enhance travel efficiency, accessibility, and safety for all residents and visitors with a reduction in energy use and improvement in the environment. The implementation of ITS technologies within the region will occur in an incremental manner. ITS technologies will be introduced gradually, and expanded as their costs and benefits are demonstrated and justified for the region.

The vision includes the following elements.

Traveler Information:

Information regarding the transportation system within the region will be made available to travelers through a variety of devices including radio broadcasts, variable message signs, personal computers (internet access), and public kiosks. This information will allow users to choose the best travel time, mode and route. Special outreach to tourists will be accomplished through the same technologies, deployed at appropriate locations to facilitate ease of use by tourists.

Traffic Management:

The traffic on selected corridors will be monitored through an integrated system that will enable communication of congestion problems, incidents, etc. to travelers and agencies who need to know. An incident management system will identify incidents, dispatch the appropriate response services, and serve to remove and mitigate the effects of incidents throughout the area. Advanced traffic control signals will help smooth traffic flow through signal coordination.

Transit Systems:

Public transportation will be made more attractive by offering improved service resulting from the use of technology to track vehicles, accurately maintain schedules, predict demand and operate fleets more efficiently with a minimum of downtime and delay. Users of transit systems will receive information regarding the status of their chosen route using a variety of devices such as telephones, public kiosks and personal computers. Fare collection will be made easier, more accessible and efficient, through ITS technologies such as electronic card readers.

Emergency Management:

Technologies and methods will be established to speed up the process of dispatching emergency vehicles to the site of a collision or incident. Systems will co-ordinate the response from fire, police and medical agencies. The transportation system will facilitate the travel of emergency vehicles through the use of signal preemption technologies.

3.2 GOALS AND OBJECTIVES

Table 4 provides a listing of goals and objectives in support of the ITS Vision Statement.

Table 4: Goals and Objectives Supporting the ITS Vision Statement

Goal		Objective
1. Increase Efficiency	1.1	To minimize the cost in time and money for transporting people and goods in the region.
	1.2	To relieve existing congestion and prevent future congestion.
	1.3	To meet transportation needs by using existing facilities more efficiently.
	1.4	To optimize the operation of the transportation system.
	1.5	To reduce time lost in intermodal interchange.
	1.6	To improve the ability of users and operators to perform travel planning using real-time travel information.
	1.7	To reduce the costs and improve the quality of data collection for transportation system planning, use, operations, maintenance and installations.
2. Enhance Mobility and Accessibility	2.1	To improve the accessibility and availability of travel options information to users of all transportation facilities.
	2.2	To reduce the variability and to simplify the use of public transportation.
	2.3	To improve the predictability of travel time for all transportation modes.
3. Improve Safety	3.3	To reduce the number and severity of motor vehicle collisions and associated injuries and fatalities.
	3.2	To improve the average response time of emergency services.
	3.3	To improve the ability to identify, respond, remove and mitigate the effects of incidents.
	3.4	To enhance personal security on all modes of transportation.

This section has presented the Vision, Goals, and Objectives of the ITS system for Chittenden County. This provides the basis for selecting the components of ITS that are applicable to the region's transportation problems.

4.0 APPLYING ITS MARKET PACKAGES TO CHITTENDEN COUNTY

To provide an accessible, deployment-oriented perspective to ITS, the National Architecture uses the concept of *market packages*. A *market package* represents a combination of equipment capabilities that address the specific service requirements of a different ITS stakeholder. To date, a total of 60 *market packages* have been defined for the following seven major application areas:

- Advanced Traffic Management Systems (ATMS);
- Advanced Public Transportation Systems (APTS);
- Advanced Traveler Information Systems (ATIS);
- Advanced Vehicle Safety Systems (AVSS);
- Commercial Vehicle Operations (CVO);
- Emergency Management Systems (EMS); and
- ITS Planning and Data Archiving

Appendix 3 provides a complete list of the ITS market packages, as specified by the most recent version of the National Architecture (Version 3.0).

4.1 SCREENING OF ITS MARKET PACKAGES IN CHITTENDEN COUNTY

There are many reasons why a certain package may not be suitable for a particular region. A package, for example, may not relate to the region's identified problems, or may not address its goals and objectives. A package may also be excluded on financial grounds, if its expected costs are likely to fall beyond the financial capabilities of the region.

To screen the market packages, four steps were taken. First, ITS market packages were mapped to the region's transportation goals and objectives. Second, ITS market packages were mapped to the identified regional transportation problems. The third task then focused on studying the extent to which the different market packages enable other functions, as well as on studying the extent to which the technology required to implement the packages has been proven. Finally, the insights gained from the previous three tasks were combined to select as well as to prioritize ITS market packages for the region. A brief description of each of these tasks follows.

4.1.1 Mapping against Goals and Objectives

In this step, each market package was matched against the region's goals and objectives. This was a three-step procedure. In the first step, a ranking system of High-Medium-Low was utilized to indicate the extent to which a particular market package is addressing a given objective. This assignment was based on the experience of deploying these specific market packages in other regions, modified by professional judgment. Each market package was considered, and a series of ratings was assigned to that package based upon how well it satisfies each of the regional objectives. The results of this analysis are provided in Appendix 5.

In the second step, weights were assigned to the different goals based upon their relative importance and their relationship to one another. All objectives were given a weight of 1.0 with the exception of objectives 1.3 and 1.4[1], which were assigned a weight of 0.5 since they are shared objectives. A compliance score was then computed for each market package by calculating the sum of the products of the goal weights and the compliance ratings, with a "low" assumed to be equivalent to a 1, a "medium" to a 2, and a "high" to a 3.

Finally, in step three, the compliance score was scaled to a range of 0 to 5, with a 5 indicating the highest degree of compliance, and the different market packages were ranked. The final results are summarized in Table 5 below.

[1] These refer to the following objectives: to optimize the transportation system and to reduce the time lost in intermodal exchange.

Table 5: Market Packages Ranking Based Upon Degree of Responsiveness to the Region's Transportation Goals and Objectives

Market Package (Descending Order)	Compliance Score
Network Surveillance (ATMS01)	4.23
Transit-Fixed Route Operations (APTS2)	4.23
Demand Responsive Transit Operations (APTS3)	4.23
Transit Tracking (APTS1)	4.04
Surface Street Control (ATMS03)	3.27
Regional Traffic Control (ATMS07)	3.27
Multi-modal Coordination (APTS7)	3.94
Broadcast Traveler Information (ATIS1)	3.37
Interactive Traveler Information (ATIS2)	3.37
Incident Management (ATMS08)	3.46
Traffic Information Dissemination (ATMS06)	3.27
Roadway Weather Information Systems (ATMS18)	3.46
ITS Planning (ITSP)	2.5
Transit Information (APTS8)	2.88
Traffic Prediction and Demand Management (ATMS09)	2.88
Emergency Routing (EMS2)	2.12
Emergency Response (EMS1)	2.12
Freeway Control (ATMS04)	1.92
Transit Passenger and Fare Management (APTS4)	1.73
MayDay Support (EMS3)	1.54
Standard Railroad Grade Crossing (ATMS13)	1.73
Transit Maintenance (APTS6)	1.54
Railroad Operation Coordination (ATMS15)	1.35
Parking Facility Management (ATMS16)	1.35
Transit Security (APTS5)	1.15
Emissions Monitoring and Management (ATMS11)	0.77

It is noted that two market package groups were excluded from this analysis, namely the Advanced Vehicle Safety Systems (AVSS) cluster, and the Commercial Vehicle Operations (CVO) cluster. The CVO cluster was excluded since most of the CVO-related services are under the purview of the state and federal government. The AVSS cluster was excluded since it is mainly a private sector (the auto industry) initiative. Moreover, many of the technologies needed to implement the packages belonging to this cluster are still in the Research and Development (R&D) stage.

In addition to the CVO and AVSS market package clusters, several other market packages were deemed to be inappropriate or unsuitable for deployment in Chittenden County. These market packages are listed in Table 6.

Table 6: Market Packages Excluded from Analysis

Market Package	Description
ATMS02	Probe Surveillance
ATMS05	HOV Lane Management
ATMS10	Electronic Toll Collection
ATMS12	Virtual TMC and Smart Probe Data
ATMS14	Advanced Railroad Grade Crossing
ATIS3	Autonomous Route Guidance
ATIS4	Dynamic Route Guidance
ATIS5	ISP Based Route Guidance
ATIS6	Integrated Transportation Management/Route Guidance
ATIS8	Dynamic Ride Sharing
ATIS9	In-Vehicle Signing

4.1.2 Mapping ITS Market Packages to the Identified Transportation Problems

In this step, the study focused on identifying the set of market packages that can be used to address each of the problems previously identified. The results of this mapping process are shown in Table 7. The last row of Table 7 also gives the total number of problems addressed by each market package. This number can be used to assess how beneficial each package is in addressing the region's transportation problems.

Table 7: Mapping of ITS Market Packages to Identified Problems

Transportation Problem	APTS1	APTS2	APTS3	APTS4	APTS5	APTS6	APTS7	APTS8	ATMS01	ATMS03	ATMS04	ATMS06	ATMS08	ATMS09	ATMS11	ATMS13	ATMS15	ATMS16	ATMS18	ATIS1	ATIS2	EMS1	EMS2	ITS
Traffic Congestion	✔	✔	✔				✔	✔	✔	✔	✔	✔	✔	✔						✔	✔			✔
Lack of Signal Coordination									✔	✔														✔
Too much traffic along minor arterials	✔	✔	✔						✔	✔		✔	✔							✔	✔			✔
Need for cooperation among parties involved in incident management									✔	✔	✔	✔	✔						✔			✔	✔	✔
Traffic control for key locations									✔	✔		✔												
Need for transit to stay on schedule	✔	✔					✔													✔	✔		✔	✔
Need for real-time information on transportation system status	✔		✔					✔	✔										✔	✔	✔			
Need for better systems for fare collection				✔																				
Need to determine the most efficient route and schedule for transit	✔	✔	✔	✔																				✔
Lack of Signal Preemption																							✔	
Deteriorating infrastructure						✔				✔														✔
Total Number of Problems Addressed by the Market Package	**5**	**4**	**4**	**2**	**0**	**1**	**2**	**2**	**6**	**6**	**2**	**4**	**3**	**1**	**0**	**0**	**0**	**0**	**2**	**4**	**4**	**1**	**3**	**7**

4.1.3 Interrelationships among Market Packages and their Implementability

A key concept related to market packages is the fact that the packages are inter-related. This means that as ITS deployment is initiated and basic market packages are implemented, the deployment of more advanced packages, which build upon the basic existing capabilities, becomes possible. To illustrate, consider the example of the Network Surveillance package. This package implements the basic roadside sensors and communications infrastructure equipment needed to monitor the status of the transportation system. The information provided by this package (e.g. traffic counts, speeds, etc) can be used for many purposes, including control and management of the traffic signals, incident management and traveler information.

Moreover, the deployment of several ITS packages is dependent upon a number of external factors. These include factors such as technology advancements, policy changes and the development of common interface standards. By taking into account the above factors, a subset of the market packages can be recognized as important early deployments. The National Architecture refers to these packages as *key market packages*. In identifying these packages, the architecture evaluates each package against five criteria, as shown in Table 8. These criteria are briefly described below.

> *Core Function* - Market packages that are checked in this column satisfy fundamental requirements that enable implementation of a range of more advanced packages, which can selectively be implemented over time.
>
> *Technology Available* - While the majority of market packages require only relatively mature, commercially available technologies, some, especially those under the area of Advanced Vehicle Systems, still await the development of more advanced technologies. Packages checked in this column are identified as not relying on an identified critical technology area.
>
> *Standards Not Required* - The checked market packages in this column are not dependent upon forthcoming national standards for basic implementation. In reviewing standards requirements, distinction has been made between interfaces that are fundamental to the operation of the package and optional interfaces.
>
> *Institutionally Feasible* – Market packages that have associated inter-jurisdictional issues, liability implications, antitrust issues, privacy issues, or regulatory constraints are not checked in this column.
>
> *Established Benefit* - This column identifies those market packages with existing or emerging implementations, which have shown tangible benefits.

The key market packages are those that best satisfy the combination of the above five criteria, are indicated in the last column of Table 8. It should be noted that certain packages, due to their compelling benefit, are identified as *key* packages even though there may be remaining standards or institutional issues associated with them.

Table 8: Key Market Packages (adapted from the National ITS Architecture Documents)

Market Package	Core Function	Technology Available	Standards Not Reqd.	Institutionally Feasible	Established Benefit	Key Package
TRAFFIC MANAGEMENT						
Network Surveillance	T	T	T	T	T	T
Probe Surveillance	T	T				
Surface Street Control	T	T	T		T	T
Freeway Control	T	T	T		T	T
HOV & Reversible Lane Management		T	T			
Traffic Information Dissemination		T	T	T		T
Regional Traffic Control	T	T			T	T
Incident Management System		T	T		T	T
Network Performance Evaluation		T	T			
Dynamic Toll/Parking Management	T	T			T	T
Emissions Sensing					T	
Virtual TMC & Smart Probe Data		T				
TRANSIT MANAGEMENT						
Transit Vehicle Tracking	T	T	T	T	T	T
Transit Fixed-Route Operations	T	T	T	T	T	T
Demand Responsive Transit	T	T	T	T	T	T
Passenger and Fare Management	T	T		T	T	T
Transit Security		T			T	T
Transit Maintenance		T	T	T		T
Multi-model coordination		T				
TRAVELER INFORMATION						
Broadcast Traveler Information	T	T		T	T	T
Interactive Traveler Information	T	T	T	T	T	T
Autonomous Route Guidance	T	T	T	T	T	T
Dynamic Route Guidance		T		T	T	
ISP Based Route Guidance		T				
Integrated Transportation Management						
Yellow Pages and Reservation		T		T		
Dynamic Ridesharing		T				
In Vehicle Signing		T				
ADVANCED VEHICLE SYSTEMS						
Vehicle Safety Monitoring	T	T	T	T	T	T
Driver Safety Monitoring			T			
Longitudinal Safety Warning			T	T		
Lateral Safety Warning			T	T		
Intersection Safety Warning			T			

Market Package	**Core Function**	**Technology Available**	**Standards Not Reqd.**	**Institutionally Feasible**	**Established Benefit**	**Key Package**
Pre-Crash Restraint Deployment			T	T		
Driver Visibility Improvement			T			
Advanced Vehicle Long. Control			T			
Advanced Vehicle Lateral Control			T			
Intersection Collision Avoidance						
Automated Highway System						
COMMERCIAL VEHICLE OPERATIONS						
Fleet Administration	T	T	T	T	T	T
Freight Administration		T	T	T	T	
Electronic Clearance	T	T		T	T	T
Electronic Clearance Enrollment	T	T		T	T	T
International Border Elec. Clearance		T			T	
Weigh-In Motion		T	T	T	T	
Roadside CVO Safety	T	T		T	T	T
On-Board CVO Safety		T				
CVO Fleet Maintenance		T	T	T		
HAZMAT Management		T			T	T
EMERGENCY MANAGEMENT						
Emergency Response	T	T			T	T
Emergency Routing		T	T	T	T	T
Mayday Support	T	T			T	T
ITS PLANNING	T	T			T	T

4.2 MARKET PACKAGE SELECTION & PRIORITIZATION

In this task, the insights gained from the previous three tasks were combined and used to select and prioritize market packages for Chittenden County. As a first step toward this end, a combined index (CI) was developed to reflect the following two criteria:

1. The degree of responsiveness of the package to the region's goals and objectiveness, as measured by the compliance score previously defined; and
2. The capacity of the package to address the region's problems (as quantified by the number of problems a package address) was developed.

In developing this index, the degree of responsiveness to the goals (i.e. the compliance score) was weighed more heavily than the number of problems addressed, since the former addresses a broader evaluation process than just the relevance to a problem. **Thus, this market package screening is largely driven by the region’s goals and objectives rather than by identified transportation problems.** The CI ranges from a value of 10 to 0, with 10 indicating the highest level of responsiveness to goals and capacity to address problems. The following equation illustrates the process.

Combined Index = (Compliance Score X CS Weighting) + (# of Problems Addressed X Problem Weighting)

For example, for the top-ranked market package, Network Surveillance (ATMS01), the Composite Index is calculated as follows:

Combined Index = [(80% Weighting Factor X 4.23 Compliance Score X 2 Scale Factor)

+ (20% Weighting Factor X 6 Problems Addressed X 1.43 Scale Factor)] = 8.5

The value of CI was then computed for each market package, and used to rank the packages. Table 9 shows the results of this analysis. The table also indicates whether or not the package has been identified by the National Architecture as a key market package, as discussed under Task 3.

Table 9: Combined Index Market Packages Ranking

Market Packages (Descending Order)	Compliance Score	Problems Addressed	Combined Index	Key package
Network Surveillance (ATMS01)	4.23	6	8.5	Y
Transit-Fixed Route Operations (APTS2)	4.23	4	7.9	Y
Demand Responsive Transit Operations (APTS3)	4.23	4	7.9	Y
Transit Tracking (APTS1)	4.04	5	7.9	Y
Surface Street Control (ATMS03)	3.27	6	6.9	Y
Regional Traffic Control (ATMS07)	3.27	6	6.9	Y
Multi-modal Coordination (APTS7)	3.94	2	6.9	N
Broadcast Traveler Information (ATIS1)	3.37	4	6.5	Y
Interactive Traveler Information (ATIS2)	3.37	4	6.5	Y
Incident Management (ATMS08)	3.46	3	6.4	Y
Traffic Information Dissemination (ATMS06)	3.27	4	6.4	Y
Roadway Weather Information Systems (ATMS18)	3.46	2	6.1	N
ITS Planning (ITSP)	2.5	7	6.0	Y
Transit Information (APTS8)	2.88	2	5.2	N
Transit Passenger and Fare Management (APTS4)	2.69	2	4.9	Y
Traffic Prediction and Demand Management (ATMS09)	2.88	1	4.9	N
Emergency Routing (EMS2)	2.12	3	4.2	Y
Emergency Response (EMS1)	2.12	1	3.7	Y
Freeway Control (ATMS04)	1.92	2	3.6	Y
MayDay Support (EMS3)	1.54	2	3.0	Y
Standard Railroad Grade Crossing (ATMS13)	1.73	0	2.8	Y
Transit Maintenance (APTS6)	1.54	1	2.7	Y
Railroad Operation Coordination (ATMS15)	1.35	0	2.2	Y
Parking Facility Management (ATMS16)	1.35	0	2.2	N
Transit Security (APTS5)	1.15	0	1.8	Y

Emissions Monitoring and Management (ATMS11)	0.77	0	1.2	N

Finally, the results documented in Table 9 were used to prioritize the market packages into a proposed short-term, medium-term, and long-term implementation deployment plan, as listed in Table 10.

Table 10: Summary of Recommended Short-Term, Medium-Term, and Long-Term ITS Market Packages for Chittenden County

	APTS	ATMS	ATIS	ITSP	EMS
Short-Term Packages	Transit Tracking Transit Fixed-Route Operations Transit Demand-Responsive Operations Transit Fare Management	Network Surveillances Surface Street Control Incident Management	Broadcast Traveler Information	ITS Planning	
Medium Term Packages	Transit Information Multi-Modal Coordination	Traffic Information Dissemination Regional Traffic Control Roadway Weather Information Systems	Interactive Traveler Information		Emergency Response
Long-Term Packages		Traffic Prediction and Demand Management Freeway Control Railroad Grade Crossing		Emergency Routing MayDay Support	

As can be seen out of the 26 market packages that survived the initial screening, 21 are recommended for deployment in this plan. To illustrate the practical applications of the different market packages, Appendix 4 contains descriptions of actual implementations of the selected market packages from around the country.

Table 11 lists the six *market packages* that were not selected. This is followed by a brief narrative, explaining the reasons behind their exclusion.

Table 11: Excluded Market Packages

Market Package	***Description***
APTS6	Transit Maintenance
ATMS15	Railroad Operation Coordination
ATMS16	Parking Facility Management
APTS5	Transit Security

ATMS11	Emissions Monitoring and Management

APTS6 – Transit Maintenance: This package was excluded primarily because of its low score.

ATMS15 – Railroad Operation Coordination: This package was excluded because of its low score. In addition, delay at HRI in the region does not appear to be a huge problem at the current time.

ATMS16 - Parking Management: A complete deployment of this package would require vehicle tags, a billing mechanism, an on-line reservation mechanism, and an information dissemination mechanism. The study team felt that parking problems in downtown Burlington do not warrant all this. In addition, there are not many examples of this package elsewhere in the country.

APTS5 – Transit Security: Transit security does not seem to be a problem in the region.

ATMS11 - Emissions Monitoring and Management: This package is primarily applicable to large, heavily congested metropolitan areas such as Washington, D.C. and Los Angeles. Given this and given the fact that the package received the lowest score, the package was excluded.

5.0 MARKET PACKAGE PLAN

5.1 SHORT-TERM PACKAGES

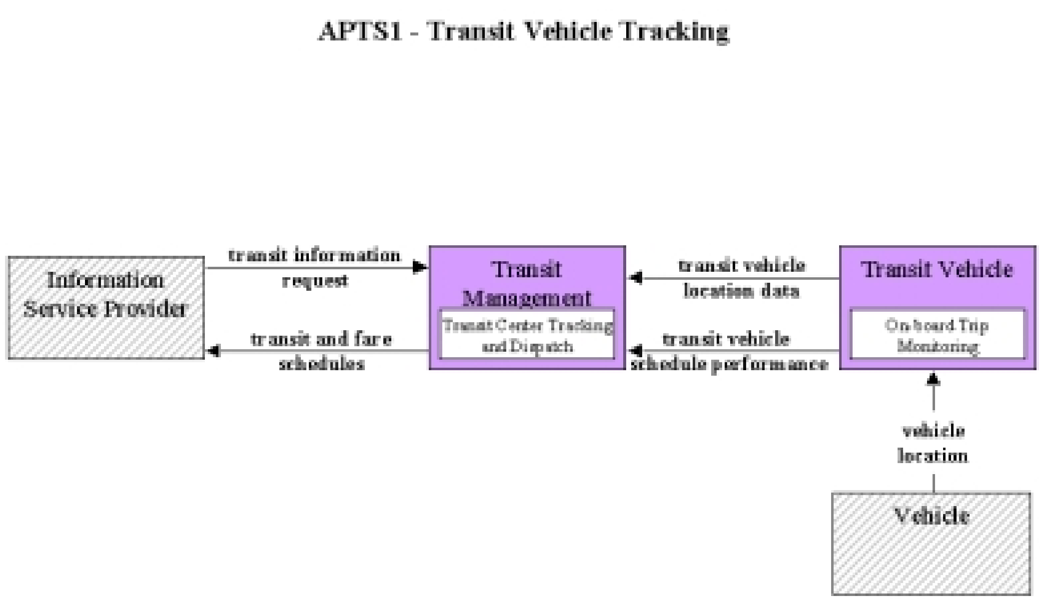
Short-term packages are intended for deployment within a 1 – 3 year period from adoption of the Strategic Deployment Plan.

5.1.1 APTS Packages:

Transit Tracking (APTS1)

This market package provides for an Automated Vehicle Location (AVL) System to track the transit vehicle's real time schedule adherence and updates the transit system's schedule in real-time. Vehicle position may be determined either by the vehicle (e.g., through GPS) and relayed to the infrastructure or may be determined directly by the communications infrastructure. A two-way wireless communication link with the Transit Management Subsystem is used for relaying vehicle position and control measures. The Transit Management Subsystem processes this information, updates the transit schedule and makes real-time schedule information available to the Information Service Provider Subsystem via a wire-line link.

Figure 2: Transit Vehicle Tracking Market package

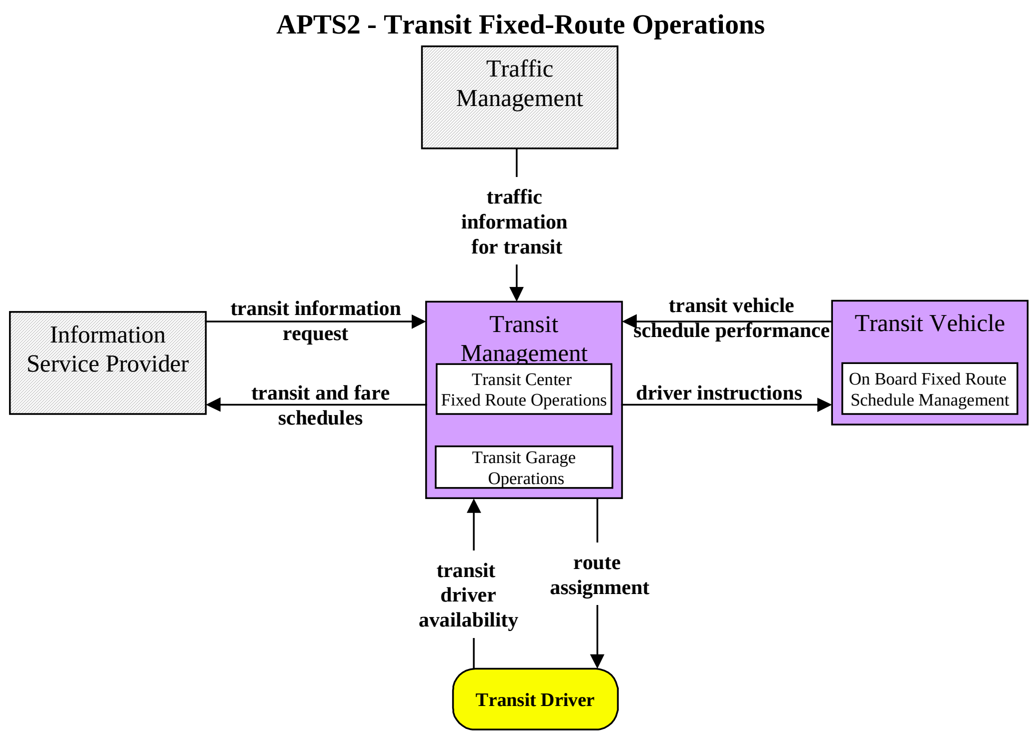


The potential benefits of an AVL system are improvement in vehicle on-time performance and reductions in field supervision.

Transit Fixed-Route Operations (APTS2)

This market package performs automatic driver assignment and monitoring, as well as vehicle routing and scheduling for fixed-route services. This service uses the existing AVL database as a source for current schedule performance data, and is implemented through data processing and information display at the transit management subsystem. This data is exchanged using the existing wire-line link to the information service provider where it is integrated with that from other transportation modes (e.g. rail, ferry, air) to provide the public with integrated and personalized dynamic schedules.

Figure 3: Transit Fixed-Route Operations Market Package

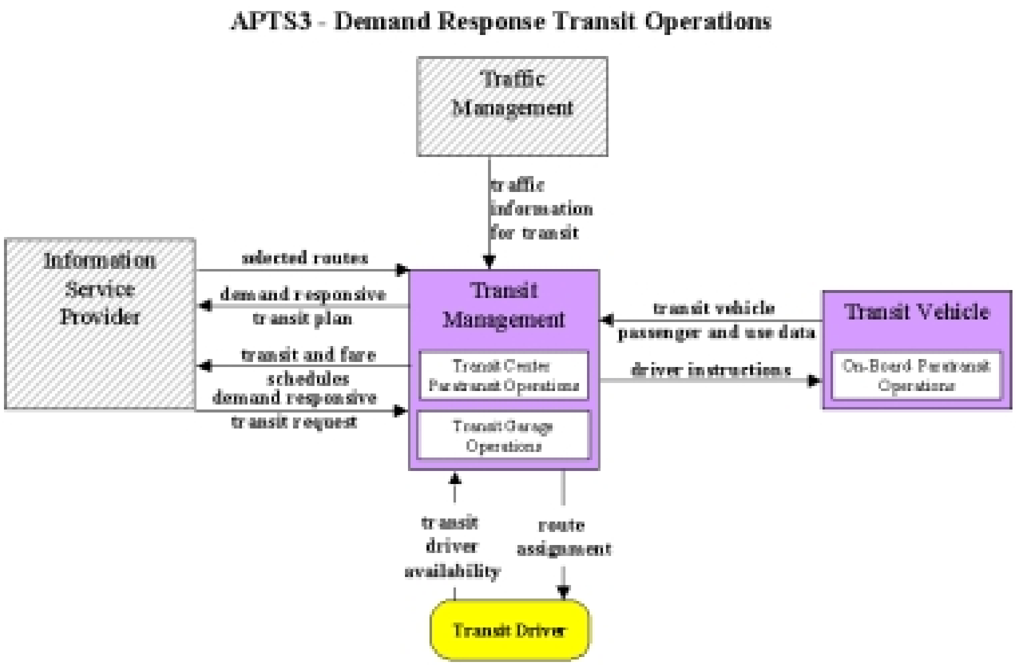


The potential benefits of this market package include improved productivity of vehicles and labor, improved mobility of customers and employees, improved travel time, reduced wait times, and increased ridership.

Demand-Response Transit Operations (APTS3)

This market package performs automatic driver assignment and monitoring as well as vehicle routing and scheduling for demand response transit services. This package uses the existing AVL database to monitor current status of the transit fleet and supports allocation of these fleet resources to service incoming requests for transit service while also considering traffic conditions. The Transit Management Subsystem provides the necessary data processing and information display to assist the transit operator in making optimal use of the transit fleet. The Information Service Provider Subsystem may be either be operated by transit management center or be independently owned and operated by a separate service provider.

Figure 4: Demand Response Transit Operations Market Package



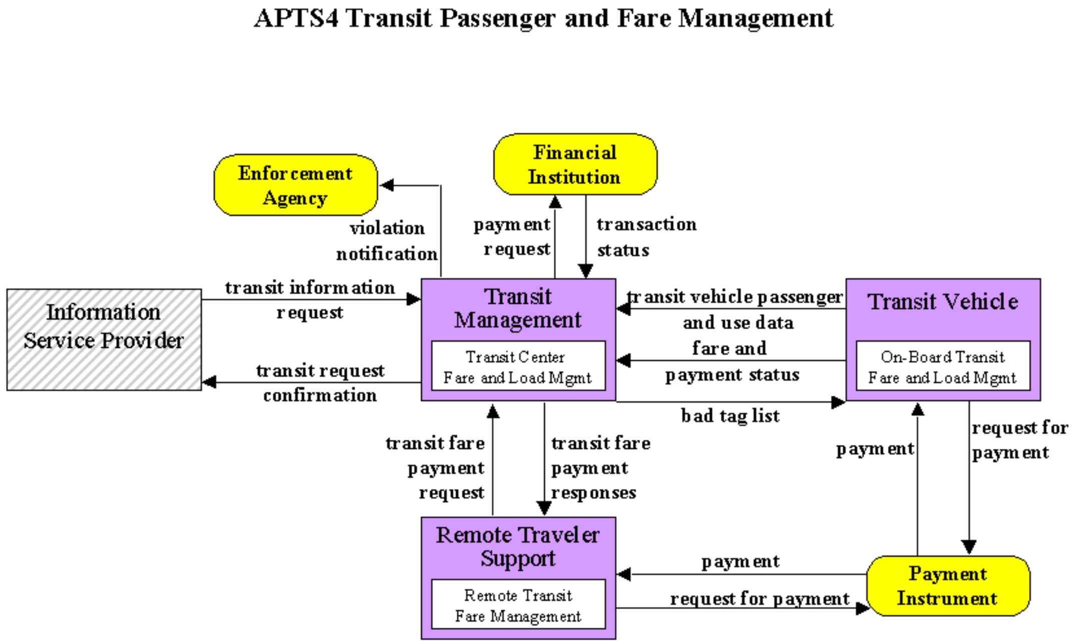
Potential benefits include improved productivity of vehicles and labor, and efficiencies in routing and trip scheduling.

Transit Passenger and Fare Management (APTS4)

This market package allows for the management of passenger loading and fare payments on-board vehicles using electronic means. The payment instrument may be either a stored value card, debit card, or credit card. This package is implemented with sensors mounted on the vehicle to permit the driver and central operations to determine vehicle loads, and readers located either in the infrastructure or on-board the transit vehicle to allow fare payment. Data is processed, stored, and displayed on the transit vehicle and communicated as needed to the Transit Management Subsystem.

The use of smart cards works best if the region has a number of transit options, and if travelers will ultimately be able to use their cards to pay for services other than just transit for purposes. This, however, requires securing agreements with financial institutions in the region. Given this, the study team recommends starting with a more limited version of the package. This package could then be built upon in the future.

Figure 5: Transit Passenger and Fare Management Market Package

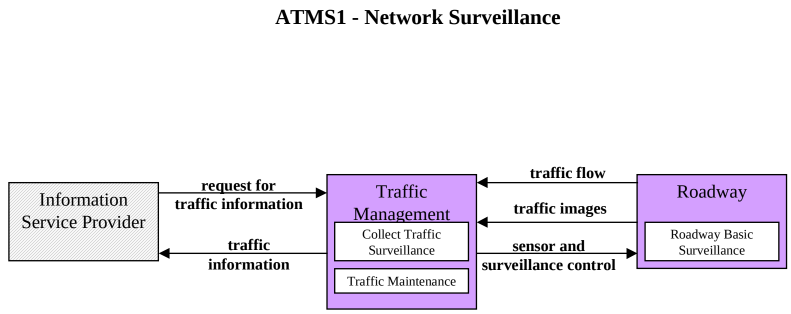


5.1.2 ATMS Packages:

Network Surveillance (ATMS01)

This market package includes traffic detectors, environmental sensors, other surveillance equipment, the supporting field equipment, and wire-line communications to transmit the collected data back to the Traffic Management Subsystem. The derived data can be used locally such as when traffic detectors are connected directly to a signal control system or remotely (e.g., when a closed circuit television, CCTV, system sends data back to the Traffic Management Subsystem). The data generated by this market package enables traffic managers to monitor traffic and road conditions, identify and verify incidents, detect faults in indicator operations, and collect census data for traffic strategy development and long range planning. The collected data can also be analyzed and made available to users and the Information Service Provider Subsystem.

Figure 6: Network Surveillance Market Package

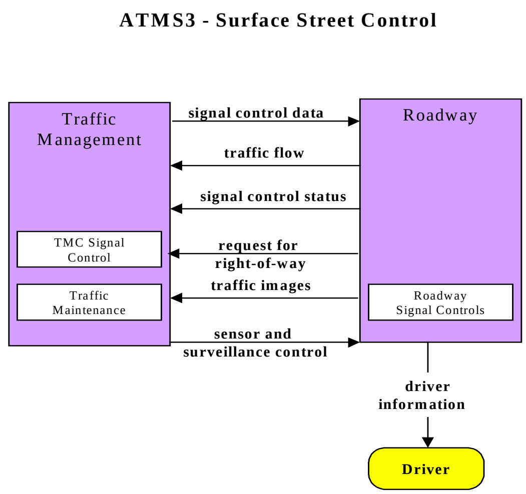


The benefit behind this package is providing data support for other applications.

Surface Street Control (ATMS03)

This market package provides the central control and monitoring equipment, communication links, and the signal control equipment that support local surface street control and/or arterial traffic management. A range of traffic signal control systems are represented by this market package ranging from static pre-timed control systems to fully traffic responsive systems that dynamically adjust control plans and strategies based on current traffic conditions and priority requests. Additionally, general advisory and traffic control information can be provided to the driver while en-route. Systems that achieve coordination across jurisdictions by using a common time base or other strategies that do not require real time coordination would be represented by this package. This package is consistent with typical urban traffic signal control systems.

Figure 7: Surface Street Control Market Package

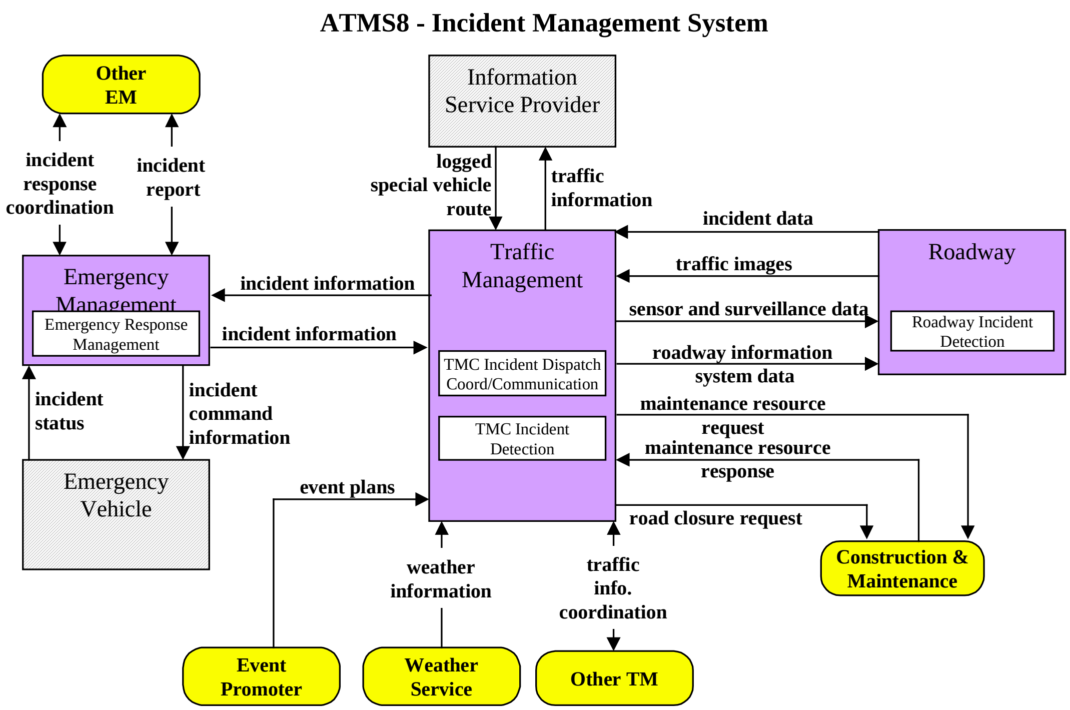


The benefits of this market package include: reduction in travel time, reduction in queue time, increase in average travel speed, reduction in stops, reduction in fuel consumption, reductions in VMT, HC and CO emissions, and reduction in intersection-related accidents.

Incident Management Systems (ATMS08)

This market package manages both predicted and unexpected incidents so that the impact to the transportation network and traveler safety is minimized. Requisite information could be obtained through regional coordination with other traffic management and emergency management centers, weather service entities, and event promoters. Information from these diverse sources are collected and correlated by this market package to detect and verify incidents and implement an appropriate response. This market package provides Traffic Management Subsystem equipment that supports traffic operations personnel in developing an appropriate response in coordination with emergency management and other incident response personnel to confirmed incidents. The response may include traffic control strategy modifications and presentation of information to affected travelers using the Traffic Information Dissemination market package. The coordination with emergency management might be through a CAD system or through other communication with emergency field personnel. The coordination can also extend to tow trucks and other field service personnel.

Figure 8: Incident Management Market Package



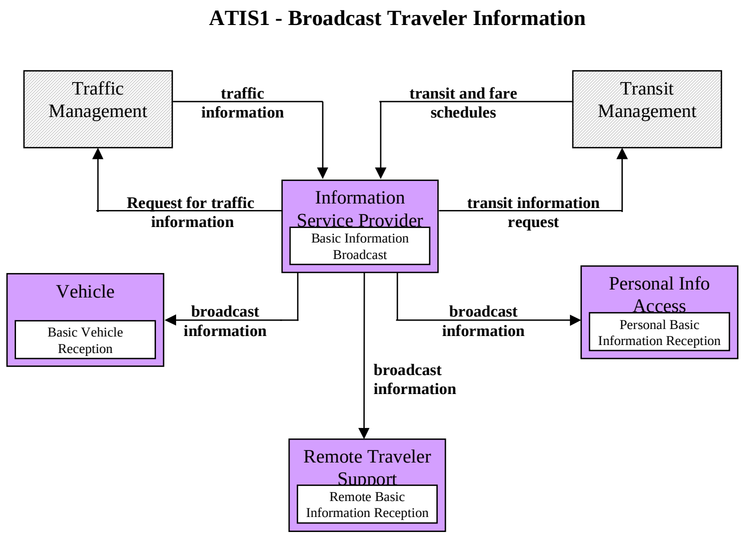
The potential benefits of this market package include reduced delay, reduction of secondary incidents, and reduction in accident response time.

5.1.3 ATIS Packages

Broadcast Traveler Information (ATIS1)

This market package provides the user with a basic set of ATIS services; its objective is early acceptance. It involves the collection of traffic conditions, advisories, general public transportation and parking information and the near real-time dissemination of this information over a wide area through existing infrastructures and low cost user equipment (e.g., FM sub-carrier, cellular data broadcast). Different from the market package ATMS6—Traffic Information Dissemination, which provides the more basic HAR and CMS information capabilities, ATIS1 provides the more sophisticated digital broadcast service. Successful deployment of this market package relies on availability of real-time transportation data from roadway instrumentation, probe vehicles or other means.

Figure 9: Broadcast Traveler Information Market Package



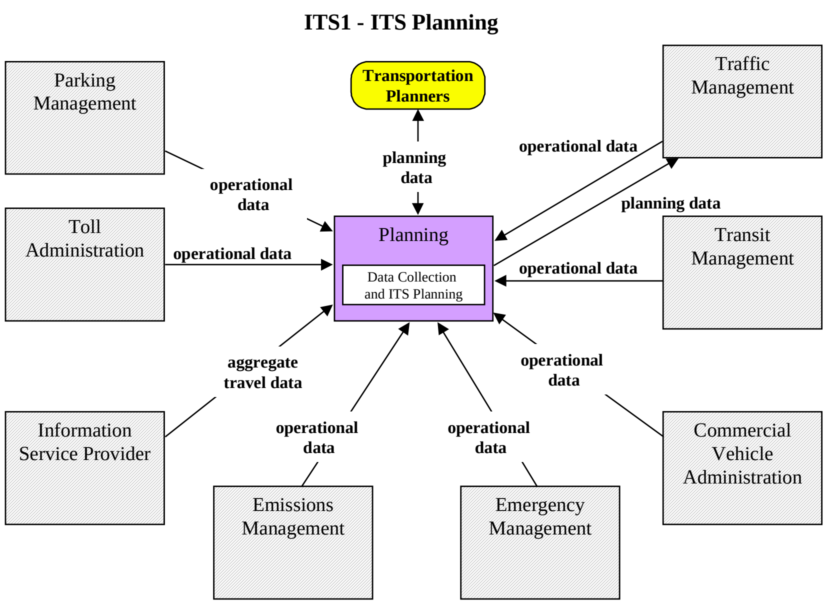
Potential benefits include reduction in travel time, with primary value for incident-related (i.e. accidents, weather, special events) traffic delays, predictable travel time. It is estimated that higher benefits will accrue to travelers with long trips, multiple mode and route alternatives.

5.1.4 ITSP Packages

ITS Planning (ITSP1)

This market package supports ITS planning functions. It accepts data from every center subsystem, archives the data in ways that are easy to access, and uses this data to plan new deployments. The data also supports policy decision making, allocation of funding, allocation of resources and other planning activities.

Figure 10: ITS Planning System



Potential benefits of this market package include reducing the cost of collecting transportation data and more effective transportation planning.

5.2 MEDIUM-TERM PACKAGES

Medium-term packages are to be implemented over a 3 – 10 year time frame (2003 – 2010).

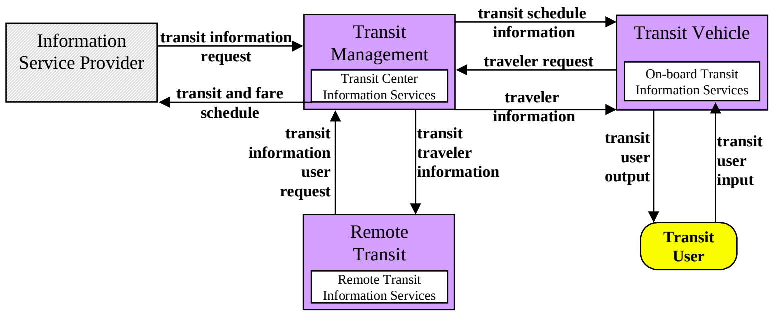
5.2.1 APTS packages:

Transit Information (APTS8)

This market package provides transit users at transit stops and on-board transit vehicles with ready access to transit information. The information services include transit stop annunciation, imminent arrival signs, and real-time transit schedule displays that are of general interest to transit users. Systems that provide custom transit trip itineraries and other tailored transit information services are also represented by this market package.

Figure 11: Transit Traveler Information Market Package

ATPS8 - Transit Traveler Information

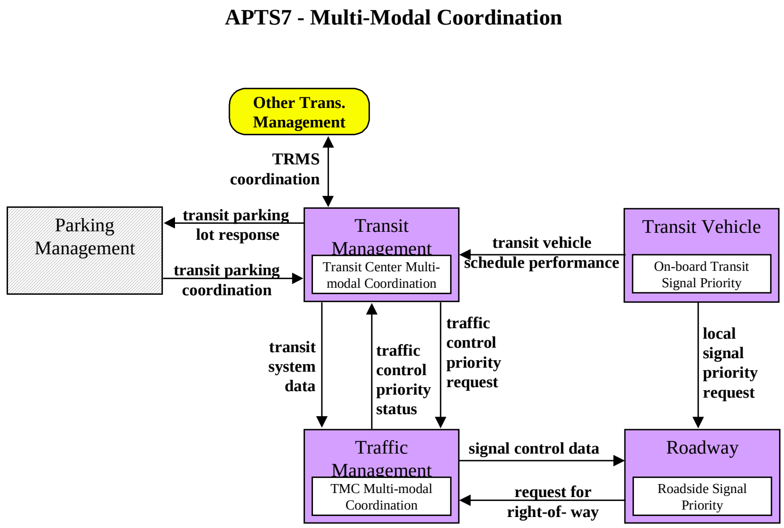


Potential benefits include increased customer satisfaction, increased ridership, and reduced wait time.

Multi-modal Coordination (APTS7)

This market package establishes two-way communications between multiple transit and traffic agencies to improve service coordination. Intermodal coordination between transit agencies can increase traveler convenience at transfer points and also improve operating efficiency. Coordination between traffic and transit management is intended to improve on-time performance of the transit system to the extent that this can be accommodated without degrading overall performance of the traffic network. <u>Local coordination between the transit vehicle and the individual intersection for signal priority is also supported by this package.</u>

Figure 12: Multi-Modal Coordination Market Package



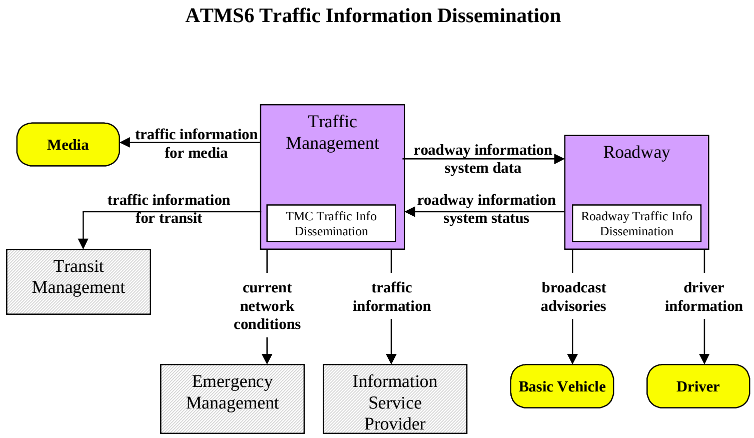
Potential benefits include improved on-time performance for transit and increased ridership

5.2.1 ATMS Packages:

Traffic Information Dissemination (ATMS06)

This market package allows traffic information to be disseminated to drivers and vehicles using roadway equipment such as dynamic message signs or highway advisory radio. This package provides a tool that can be used to notify drivers of incidents; careful placement of the roadway equipment provides the information at points in the network where the drivers have recourse and can tailor their routes to account for the new information. This package also covers the equipment and interfaces that provide traffic information from a traffic management center to the media (for instance via a direct tie-in between a traffic management center and radio or television station computer systems), transit management center, emergency management center, and information service provider.

Figure 13: Traffic Information Dissemination Market Package

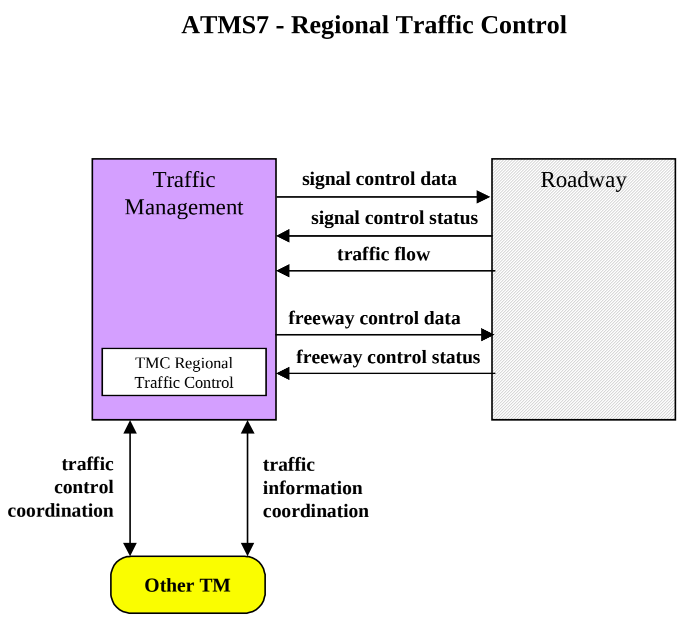


Potential benefits include reduced travel time, reduced delay, and fewer secondary incidents.

Regional Traffic Control (ATMS07)

This market package advances the Surface Street Control Market Packages by adding the communications links and integrated control strategies that enable integrated inter-jurisdictional traffic control. This market package provides for the sharing of traffic information and control among traffic management centers to support a regional control strategy. The nature of optimization and extent of information and control sharing is determined through working arrangements between jurisdictions. This package relies principally on roadside instrumentation supported by the Surface Street Control packages.

Figure 14: Regional Traffic Control Market Package

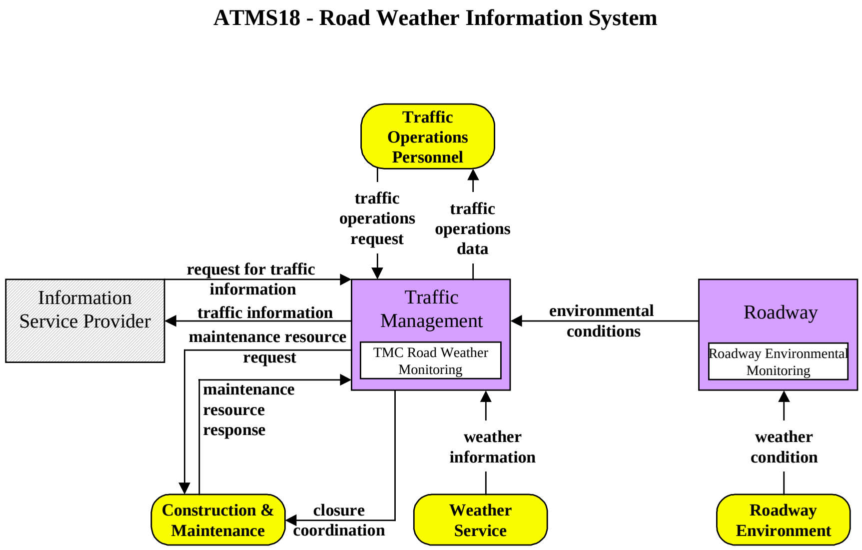


Potential benefits include reduction in travel time, reduction in queue time, increase in travel speed, reduction in stops, reduction in fuel consumption, and reductions in VMT, HC and CO emissions.

Roadway Weather Information Systems (ATMS18)

This market package monitors current and forecast road and weather conditions using a combination of weather service information and data collected from environmental sensors deployed on and about the roadway. The collected road weather information is monitored and analyzed to detect and forecast environmental hazards such as icy road conditions, dense fog, and approaching severe weather fronts. This information can be used to more effectively deploy road maintenance resources, issue general traveler advisories, and support location specific warnings to drivers using the Traffic Information Dissemination Market Package.

Figure 15: Roadway Weather Information System



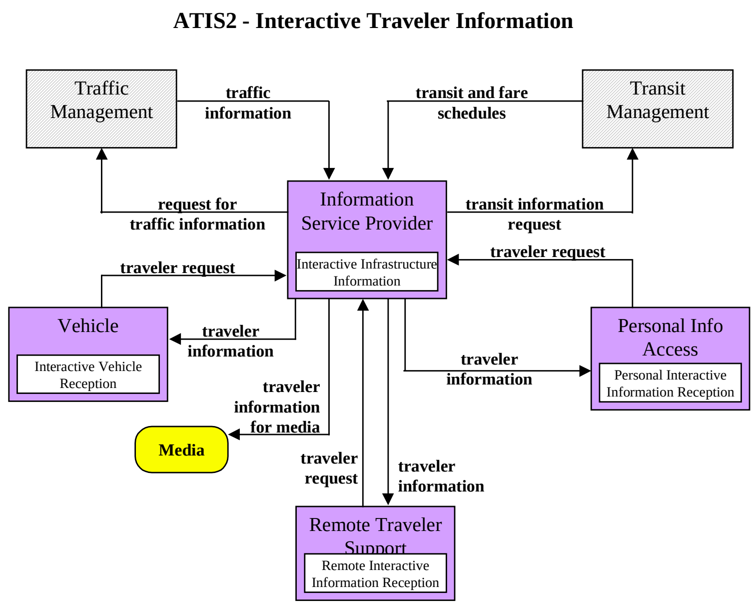
Potential benefits include improved productivity and efficiency, and reduction in weather-related accidents.

5.2.2 ATIS Packages

Interactive Traveler Information (ATIS2)

This market package provides tailored information in response to a traveler request. The traveler can obtain current information regarding traffic conditions, transit services, traveler services, ride share/ride match, parking management, and pricing information. A range of two-way wide-area wireless and wire-line communications systems may be used to support the required digital communications between traveler and the information service provider. A variety of interactive devices may be used by the traveler to access information prior to a trip or en-route, including phone, kiosk, Personal Digital Assistant, personal computer, and a variety of in-vehicle devices. Successful deployment of this market package relies on availability of real-time transportation data from roadway instrumentation, probe vehicles or other means.

Figure 16: Interactive Traveler Information System

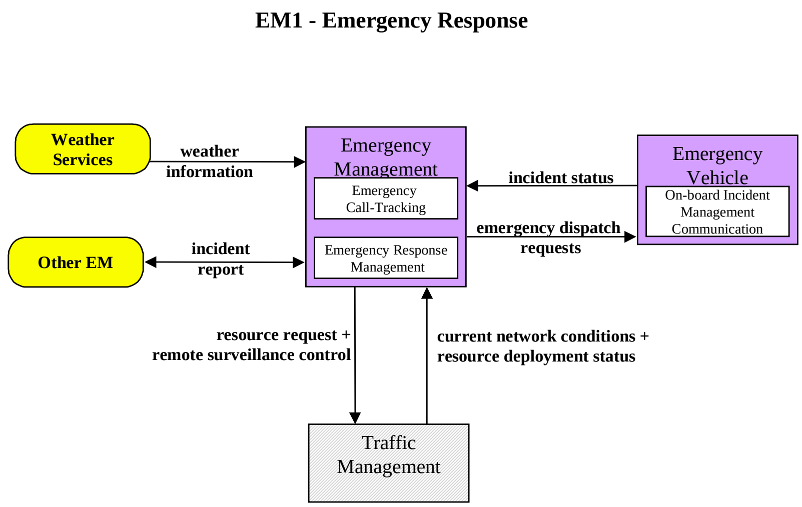


5.2.3 EMS Packages

Emergency Response (EMS1)

This market package provides the computer-aided dispatch systems, emergency vehicle equipment, and wireless communications that enable safe and rapid deployment of appropriate resources to an emergency. Coordination between Emergency Management Subsystems supports emergency notification and coordinated response between agencies. Existing wide area wireless communications would be utilized between the Emergency Management Subsystem and an Emergency Vehicle to enable an incident command system to be established and supported at the emergency location. The Emergency Management Subsystem would include hardware and software for tracking the emergency vehicles. Public safety, traffic management, and many other allied agencies may each participate in the coordinated response managed by this package.

Figure 17: Emergency Response System



Potential benefits include a reduction in response time through system-coordinated response. Higher level of benefit realized in areas with multiple jurisdictions and independent response agencies.

5.3 LONG-TERM PACKAGES

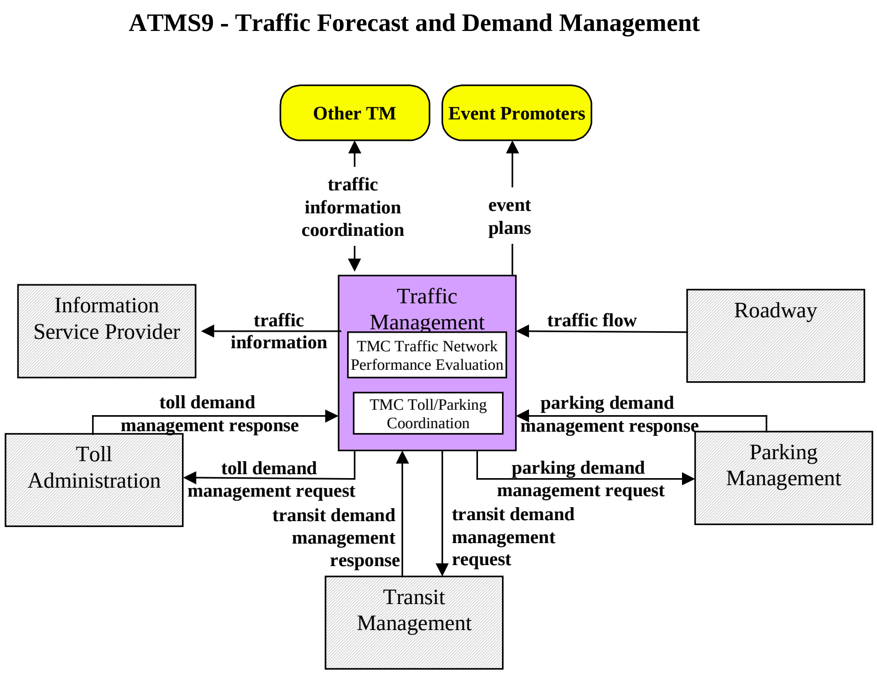
Long-term packages are to be implemented over a 10 – 20 year time frame.

5.3.1 ATMS Packages

Traffic Prediction and Demand Management (ATMS09)

This market package includes advanced algorithms, processing, and mass storage capabilities that support historical evaluation, real-time assessment, and forecast of the roadway network performance. This includes the prediction of travel demand patterns to support better link travel time forecasts. The source data would come from the Traffic Management Subsystem itself as well as other traffic management centers and forecasted traffic loads derived from route plans supplied by the Information Service Provider Subsystem. In addition to short-term forecasts, this market package provides longer-range forecasts that can be used in transportation planning. This market package provides data that supports the implementation of TDM programs, and policies managing both traffic and the environment.

Figure 18: Traffic Forecast and Demand Management Market Package

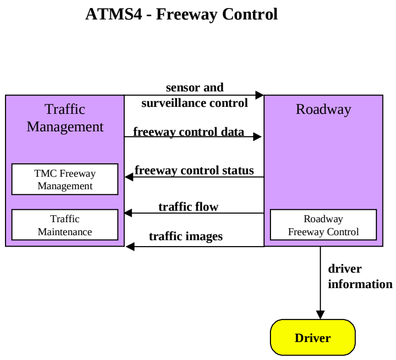


Potential benefits include reduced travel time and delay, more effective demand management, and more effective transportation planning.

Freeway Control (ATMS04)

This package incorporates the instrumentation included in the Network Surveillance Market Package to support freeway monitoring and adaptive strategies as an option. This market package also includes the capability to utilize surveillance information for detection of incidents. Typically, the processing would be performed at a traffic management center; however, developments might allow for point detection with roadway equipment. For example, a CCTV might include the capability to detect an incident based upon image changes. Additionally, this market package allows general advisory and traffic control information to be provided to the driver while en-route.

Figure 19: Freeway Control System



Potential benefits include reduction in travel time and delay, reduction in fuel consumption, and reductions in VMT, HC and CO emissions.

Standard Railroad Grade Crossings (ATMS13)

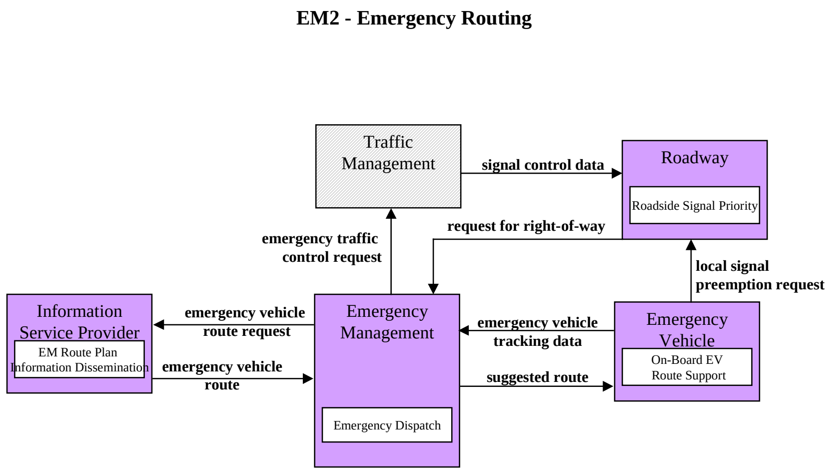
This package is responsible for managing highway traffic at highway-rail intersections (HRIs). Both passive (e.g. the crossbuck sign) and active (e.g. flashing lights and gates) warning systems are supported. The warning systems are activated on notification of an approaching train. The equipment at the intersections may be interconnected with adjacent signalized intersections so that local control can be adapted to highway-rail intersection activities. The package also provides for health monitoring of the HRI equipment.

Potential benefits include improved safety at highway-rail crossings, and increased efficiency through the co-ordination of traffic signal plans.

Emergency Routing

This market package supports dynamic routing of emergency vehicles and coordination with the traffic Management Subsystem for special priority on the selected route(s). The Information Service Provider Subsystem supports routing for the emergency fleet based on real-time traffic conditions and the emergency routes assigned to other responding vehicles. In this market package, the Information Service Provider Subsystem would typically be integrated with the Emergency Management Subsystem in a public safety communications center. The Emergency Vehicle would also optionally be equipped with dedicated short-range communications for local signal preemption.

Figure 20: Emergency Routing System

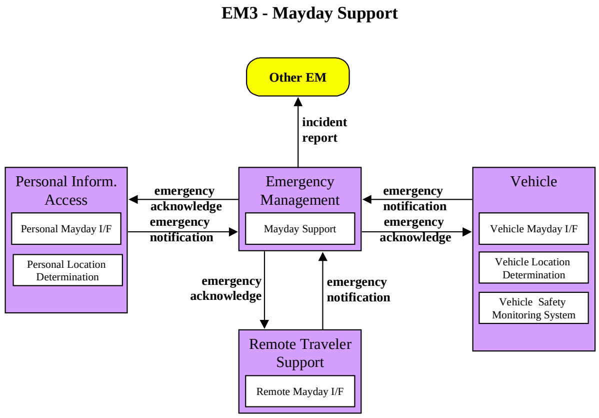


Potential benefits include anticipated shorter response times. However, no formal evaluation of benefits is currently available.

MayDay Support (EMS3)

This package allows the user (driver or non-driver) to initiate a request for emergency assistance and enables the Emergency Management Subsystem to locate the user and determine the appropriate response. The request from the traveler needing assistance may be manually initiated or automated and linked to vehicle sensors. The data is sent to the Emergency Management subsystem using wide area wireless communications with voice as an option. Providing user location implies either a location technology within the user device or location determination within the communications infrastructure.

Figure 21: MayDay Support System



Potential benefits include reduction in response time, and improved safety and security.

6.0 ITS SYSTEM ARCHITECTURE

An ITS regional architecture can generally be defined as a blueprint for the deployment of ITS technologies in a particular region. It specifies how the different ITS components would interact with one another to help address regional transportation problems. An ITS architecture thus provides a general framework upon which to plan, design, deploy and integrate ITS in a particular region. It is important to appreciate, however, that a system architecture is different from a system design. An architecture defines a general framework, around which several design options can be developed while still conforming to a common architecture; it does not dictate a specific design approach. The following sections describe the development of the short-term regional architecture for Chittenden County.

6.1 FUNCTIONAL REQUIREMENTS

The first step in the development of the regional architecture for Chittenden County was to define the *desirable* functional requirements for each of the selected short-term market packages. Defining these requirements involved reviewing the list defined by the National Architecture, and identifying those functions that fit the needs of Chittenden County. The following tables (Tables 12 through 20) summarize the functional requirements for the selected market packages.

Table 12: Functional Requirements for the Transit Tracking Package (APTS1)

Functional Requirements
Process the data provided by the different sensors on-board the vehicle, including vehicle location from a GPS for example, mileage, trip length and fuel usage
Determine the vehicle’s current location
Monitor the transit vehicle location and the vehicle’s schedule adherence
Furnish users with real-time travel related information, including transit routes, schedules, transfer points, fares, real-time schedule adherence, current incident conditions, weather conditions and special events.
Support the capability for 2-way voice and data communication between the transit vehicle driver and the transit operations center
Provide the database capabilities for storing and retrieving data
Provide the capability for updating the digitized map used as a background for displays of transit services

Table 13: Functional Requirements for the Transit Fixed Route Operations (APTS2)

Functional Requirements
Provide the database capabilities for storing and retrieving data related to the transit vehicle operations
Provide an interface to the current regular transit plans (i.e. routes and schedules) and demand-responsive transit schedules
Generate new transit routes based upon operational data for the current routes and schedules, and the parameters set by the transit fleet manager
Provide a transit fleet manager interface to control the generation of new routes and schedules
Provide the database capabilities for storing and retrieving transit operational data
Distribute transit routes and services data internally to other processes in the Manage Transit function
Assess the driver’s performance at previous work assignments
Assess the driver’s availability based upon previous work assignments and health and vacation commitments
Assign transit drivers to transit schedules based upon eligibility, route preference, seniority and availability
Provide for an interface for the operations manager to access the store of driver information

Table 14: Functional Requirements for the Demand-Responsive Operations Package (APTS3)

Functional Requirements
Provide an interface through which a transit driver will be sent instructions about the demand responsive schedule.
Forward driver’s acknowledgements to operations center.
Provide data on the vehicle’s availability.
Provide an interface to support the receipt of trip requests, the transfer of the requests to the processes responsible for schedule generation, the output of the schedule.
Calculate the location and availability of transit vehicles.
Provide dynamic routing and scheduling of transit vehicles.
Provide for the confirmation of demand responsive transit schedule and route.
Assign transit drivers to transit schedules based upon eligibility, route preference, etc.

Table 15: Functional Requirements for Passenger and Fare Management Package (APTS4)

Functional Requirements
Provide the capability to collect and process data required to determine ridership levels
Provide the capability to implement variable and flexible fare structures
Support the use of a fare medium for all applicable transportation services that allows for paying without stopping, and allows for eligibility verification
Provide for the capability to expand into other uses for the payment medium such as retail
Support the capability for two-way voice and data communication between the driver and a facility, and for transmitting sensor data from the vehicle to a facility

Table 16: Functional Requirements for the Network Surveillance Market Package (ATMS1)

Functional Requirements
1.1.1.1 Process and collect traffic sensor data - convert into digital format
1.3.1.3 Process raw traffic images, and transform into images that can be sent to other processes
1.1.2.1 Process traffic data for storage into the long-term and current data stores. The data would include sensor data, data sent to control indicators, parking lot management data, indicator status data, planned events, current incidents, parking lot states, link travel times, and selected traffic control strategy.
1.1.2.2 Process traffic data received from sensors and distribute to other processes
1.1.2.3 Update data source static data. This would include data showing the relationship between sensors and the highway network, as well as information regarding the ownership of each link.
1.1.4.1 Retrieve traffic data on request from the data stores, including requests originating from traffic operations personnel and the media.
1.1.4.2 Provide traffic operations personnel traffic data interface that would allow access to the stored data and would allow for setting up the parameters that govern the data available to non-traffic operations people. Where appropriate, the data output could be in the form of an overlay onto a map.
1.1.4.3 Update traffic data map display which is used as the background for displays of the requested traffic data.
1.1.1.2 Collect and process sensor fault data, identify and log faults
1.2.8.1 Collect indicator (signals, CMS, HAR) fault data. It should be possible to detect faults locally at the indicators, or centrally through communication links.
1.2.8.2 Maintain indicator fault data store, pass on new fault data for communication to C&M, and receive fault clearances. The process should enable traffic operations personnel to review and update the current fault status of all indicators.
1.2.8.3 Provide indicator fault interface for C&M. The interface should provide for sending data containing details of indicator equipment faults, and for receiving clearances when faults are corrected.
1.2.8.4 Provide traffic operations personnel indicator fault interface through which operators can access data about indicator faults.

Table 17: Functional Requirements for the Surface Street Control Package (ATMS3)

Functional Requirements
1.1.1.1 Process and collect traffic sensor data - convert into digital format
1.2.7.1 Process indicator output data for roads
1.2.7.2 Monitor roadside equipment operation for faults
1.1.2.2 Process traffic data received from sensors and distribute to other processes
1.1.4.2 Provide traffic operations personnel traffic data interface that would allow access to the stored data and would allow for setting up the parameters that govern the data available to non-traffic operations people. Where appropriate, the data output could be in the form of an overlay onto a map.
1.2.1 Select appropriate traffic control strategy to be implemented. The strategy should be selected from a number of available strategies, e.g. adaptive control, fixed time control, local operations. The process shall make it possible for the current strategy selection to be modified to accommodate the effects of unusual events such as incidents, emergency vehicle preemption, and equipment failures.
1.2.2.2 Determine indicator state and implement selected traffic control strategy for road management
1.2.3.1 Transfer data to control roadside equipment

Table 18: Functional Requirements for the Incident Management Package (ATMS08)

Functional Requirements
1.1.1.1 Process and collect sensor data – convert into digital format
1.3.1.1 Analyze traffic data for anomalies that could indicate the occurrence of an incident
1.3.1.2 Maintain static data (data about the location and features of the highway network) for incident management
1.3.2.1 Store possible incident data
1.3.2.2 Review input data about possible incidents and provide verification of the incident – classify an incident as current incident or a planned event – load the data into the store of possible incidents – report unverified incidents to operators for manual verification
1.3.2.3 Review planned events to determine when the planned event needs to be re-classified as an incident
1.3.2.4 Provide the interface needed to manage the use of the store containing the details of planned events. The process should provide for entering the details of all new planned events, retrieving details upon request, and deleting the event after being re-classified as a current incident
1.3.4.5 Provide the interface needed to manage the use of the store containing the details of current incidents. The process should provide for entering the details of all new incidents, retrieving details upon request, and deleting the incident after it ceases to be a current incident
1.3.4.2 Provide traffic operations personnel incident data interface
1.3.4.3 Provide media incident data interface

Table 19: Functional Requirements for the Incident Management Package (ATMS08) - Continued

Functional Requirements
1.1.4.4 Exchange data with other traffic centers
1.2.4.1 Transfer data to control roadside equipment
1.2.4.2 Transfer data to control freeway equipment
1.3.2.3 Review planned events to determine when the planned event needs to be re-classified as an incident
1.3.3 Respond to current incidents. Three general strategies can be supported by this process: (1) response entered by operator; (2) the operator selects a strategy from a set of pre-determined responses; and (3) the process automatically determines the appropriate response.
1.3.4.1 Retrieve incident data on request from traffic operations personnel or the media
1.3.4.2 Provide traffic operations personnel incident data interface
1.3.4.4 Update the background incident display map data
1.3.4.5 Manage resources for incidents, thereby allowing traffic operations to request resources from C&M to respond to the incident
1.3.5 Manage the store containing the possible predetermined responses
1.3.6 Manage predetermined incident response data
1.3.7 Analyze incident response log so that possible standard predetermined incident responses can be identified from the data
5.1.2 Determine coordinated response plan for a verified emergency. This process should classify, prioritize and respond to emergencies accordingly
5.1.3 Communicate emergency service response plan status to other ITS functions according to pre-arranged rules. Communication should only be initiated after a response plan had been determined, since only verified incidents will have response plans.
5.1.4 Manage emergency response by receiving emergency calls and routing the distress calls to pre-designated responding agencies and vehicles
5.1.5 Manage the store of data that defines the way in which the emergency service resources should be deployed in response to emergencies.
5.2 Provide operator's interface for emergency data. This interface should enable the operator to review and update the data used to allocate emergency services to incidents, to override current emergency service allocations to suit the special needs of a current incident and to request an output of the log of emergency services.
5.3.1 Select response mode to respond to incidents. The process would include the type and number of vehicles to be dispatched, and would provide the vehicles with information on the type and location of the incident
5.3.4 Assess response status to an incident.
5.5 Update emergency display map data

Table 20: Functional Requirements for the Broadcast Traveler Information Market Package (ATIS1)

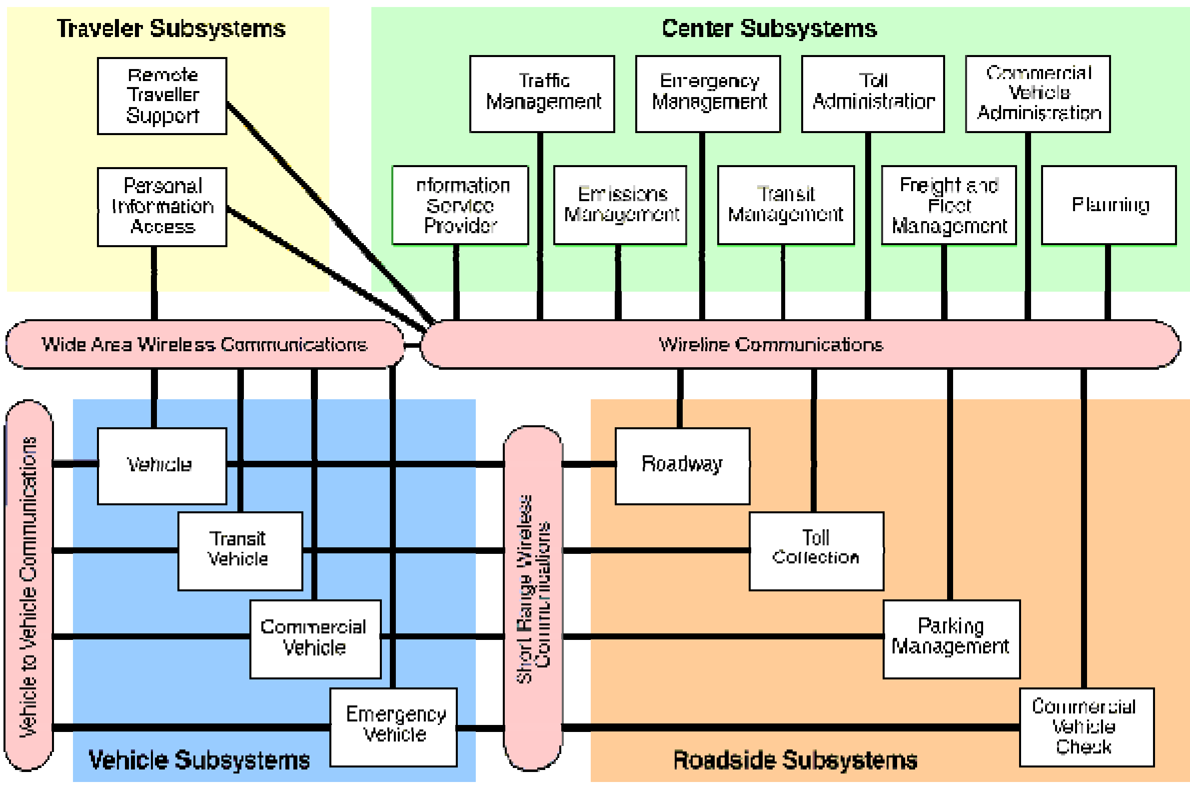
Functional Requirements	
1.1.4.5	Provide the interface through which traffic and incident data can be output to the media.
1.1.4.6	Provide the traffic data retrieval interface. This interface should provide customized sets of traffic data for broadcast and advisories to travelers, traveler information data archive, and the media.
4.1.8	Provide customized sets of transit vehicle schedule deviations to travelers, the traveler information data archive and to the media.
6.1.1	Provide trip planning information to traveler. The process should support the request for trips that require the use of one or more modes of transport
6.2.1.1	Collect and fuse traffic data that will be used to create broadcast or advisory messages to travelers
6.2.1.3	Collect and fuse transit data that will be used to create broadcast or advisory messages to travelers
6.2.1.4	Provide traffic and transit broadcast messages
6.2.1.5	Provide the interface through which the ISP operator can manipulate the data used to define the scope and rate of wide area broadcast messages
6.2.4	Collect and fuse data about yellow pages services in order to provide information to users
6.5.1	Collect and update data about incidents, road construction, weather, events and yellow pages data
7.4.2	Collect data about the prices being charged for tolls, parking lots and transit fares
6.8.3.2	Provide the traveler using a personal device with data about all requested trip, traffic, transit, yellow pages services information, confirmation of any requested reservations, and payments made as part of confirmed trip plans.
6.8.3.3	Provide an interface in a personal device through which travelers can plan and confirm trips, as well as obtain current traffic and transit information. This process should be able to load in the traveler_personal_regular_data store frequently used information such as traveler identity, home and work locations.
6.3.2	Provide the traveler located at a kiosk with data about all requested trip, traffic, transit, yellow pages services information, confirmation of any requested reservations, and payments made as part of confirmed trip plans
6.3.3	Provide an interface at a kiosk through which travelers can input and receive data
6.2.2	Provide in-vehicle advisory and broadcast data for output to drivers and transit users. Data broadcast to the driver shall include traffic related data (incidents, link data and in-vehicle signage), as well as data from the vehicle itself including vehicle conditions, smart probe data, safety and position warnings.
6.2.5	Provide a user interface for a driver through which traffic and travel advisory information can be obtained. The process should enable traffic and travel advisory information to be requested and output to the driver, and should also support the automatic output of wide area broadcast information, as well as the output of safety and vision enhancement information.

6.2 PHYSICAL REGIONAL ARCHITECTURE

With the functional requirements of each market package developed, the next step was to develop the regional physical architecture. The *physical architecture* helps define the physical components of the ITS system where the different functions (identified in the previous section) are to reside. The architecture also defines the interfaces (information flows) between the system's components.

Figure 22 shows a high-level view of the National ITS architecture, and its 19 subsystems. These subsystems are grouped into four basic classes of subsystems; these are (a) the centers subsystem; (b) the roadside subsystem; (c) the vehicles subsystem; and (d) the travelers subsystem.

Figure 22: National ITS Physical Architecture



The subsystems represent aggregations of functions that serve the same transportation need, and closely correspond to the physical elements of transportation management systems. For example, the Traffic Management subsystem (one of the 9 centers' subsystems) represents the functions typically performed by a traffic control center. The Roadway subsystem (one of the four roadside subsystems) is made up of roadside devices such as traffic controllers, traffic signals, loop detectors and CCTV cameras. The vehicles' subsystems correspond to the four different types of vehicles using the transportation system; that is, passenger cars, transit vehicles, commercial vehicles (i.e. trucks) and emergency vehicles (ambulances, police cars and fire trucks). The Travelers' subsystems represent the different ways a traveler can access information on the status of the transportation system.

Figure 22 also shows the different communications systems (indicated in the form of a sausage) connecting the different subsystems. As can be seen, four different types of communications systems are used (a) wireline communications; (b) wide-area wireless communications; (c) dedicated short range communications (DSRC); and (d) vehicle-to-vehicle communications. Wireline communications are used to connect the centers' subsystems to the roadside subsystems; an example of such system would include the fiber-optics networks used to connect traffic control centers to the freeway loops and variable message signs. Wide area wireless communications are used to connect remote travelers to the different components of the transportation system. DSRC involves communications between vehicles and roadside equipment; an example would include communications between a tag-mounted vehicle with a roadside reader. Finally, vehicle-to-vehicle communications refer to communications between the vehicles - a feature of the automated highway concept.

As can be seen, not all these 19 subsystems are needed for defining the short-term ITS architecture for Chittenden County. For example, the short-term architecture does not include any packages related to commercial vehicles, which would mean that the freight and fleet management system is not defined yet. The Figures below define the physical architecture for Chittenden County, and illustrate the information flows among the different system's components. For ease of presentation, the architecture was broken down into four sub-architectures. These are:

1. Transportation Management and Information Center Architecture
2. Advanced Traffic Signal Systems Architecture
3. Advanced Public Transportation Systems Architecture
4. ITS Planning and Data Archiving Architecture.

An architecture diagram was then developed for each sub-architecture (Figures 23 – 26).

Figure 23: Transportation Management and Information Center Architecture

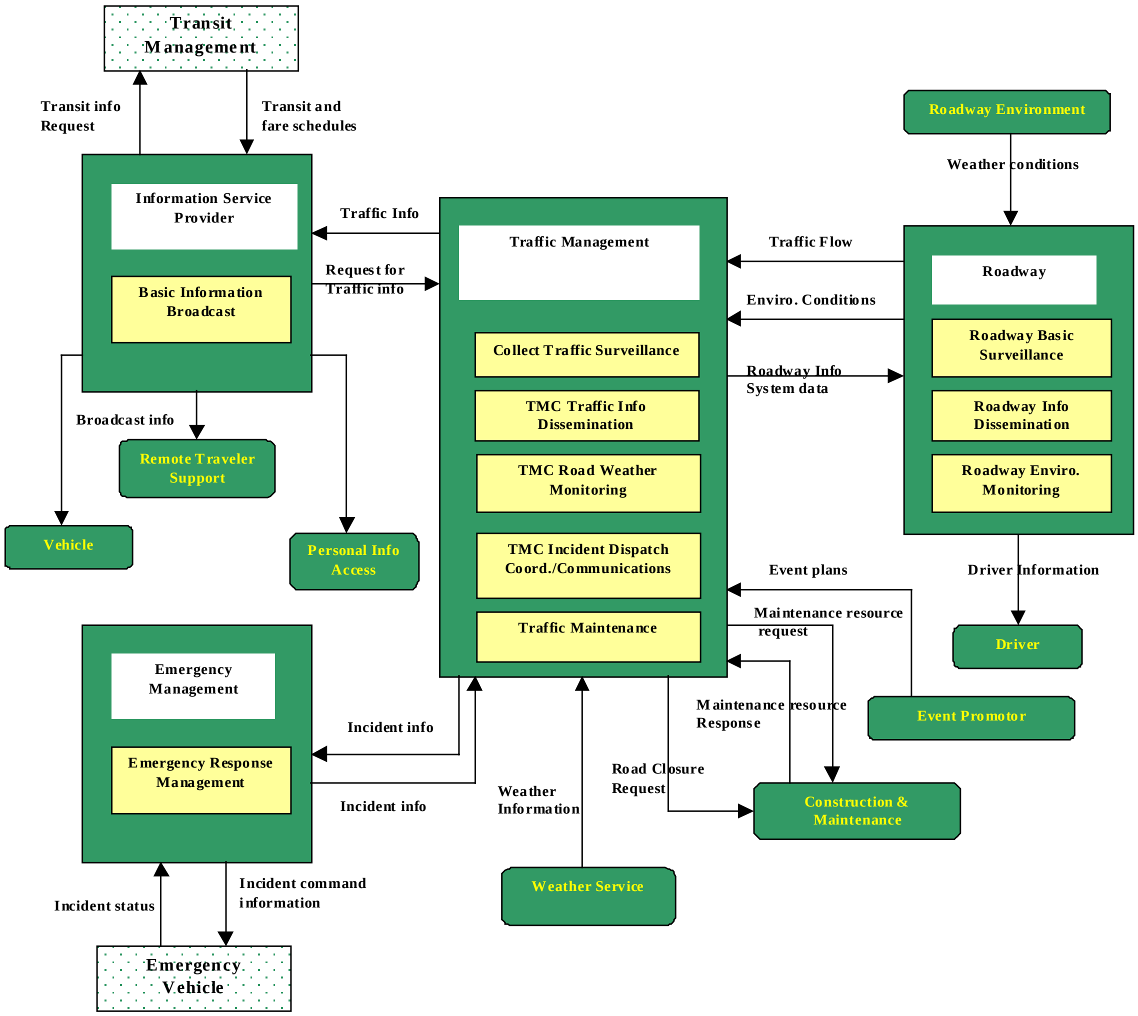


Figure 24: Advanced Traffic Signal Systems Architecture

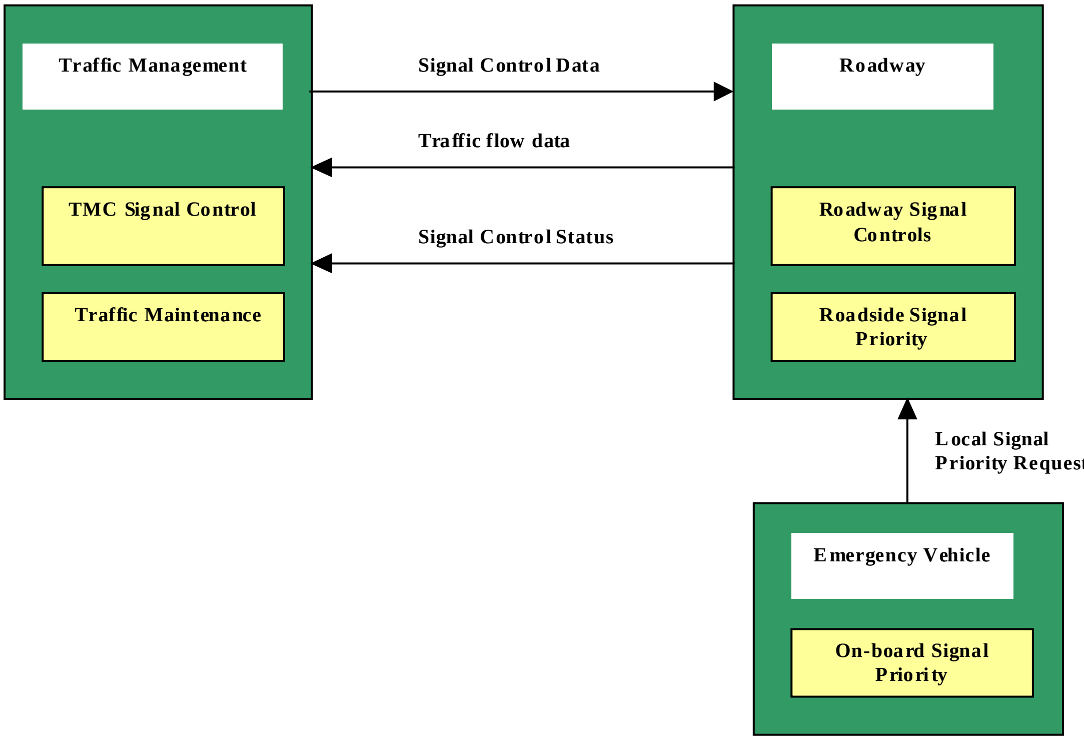


Figure 25: Advanced Public Transportation Systems Architecture

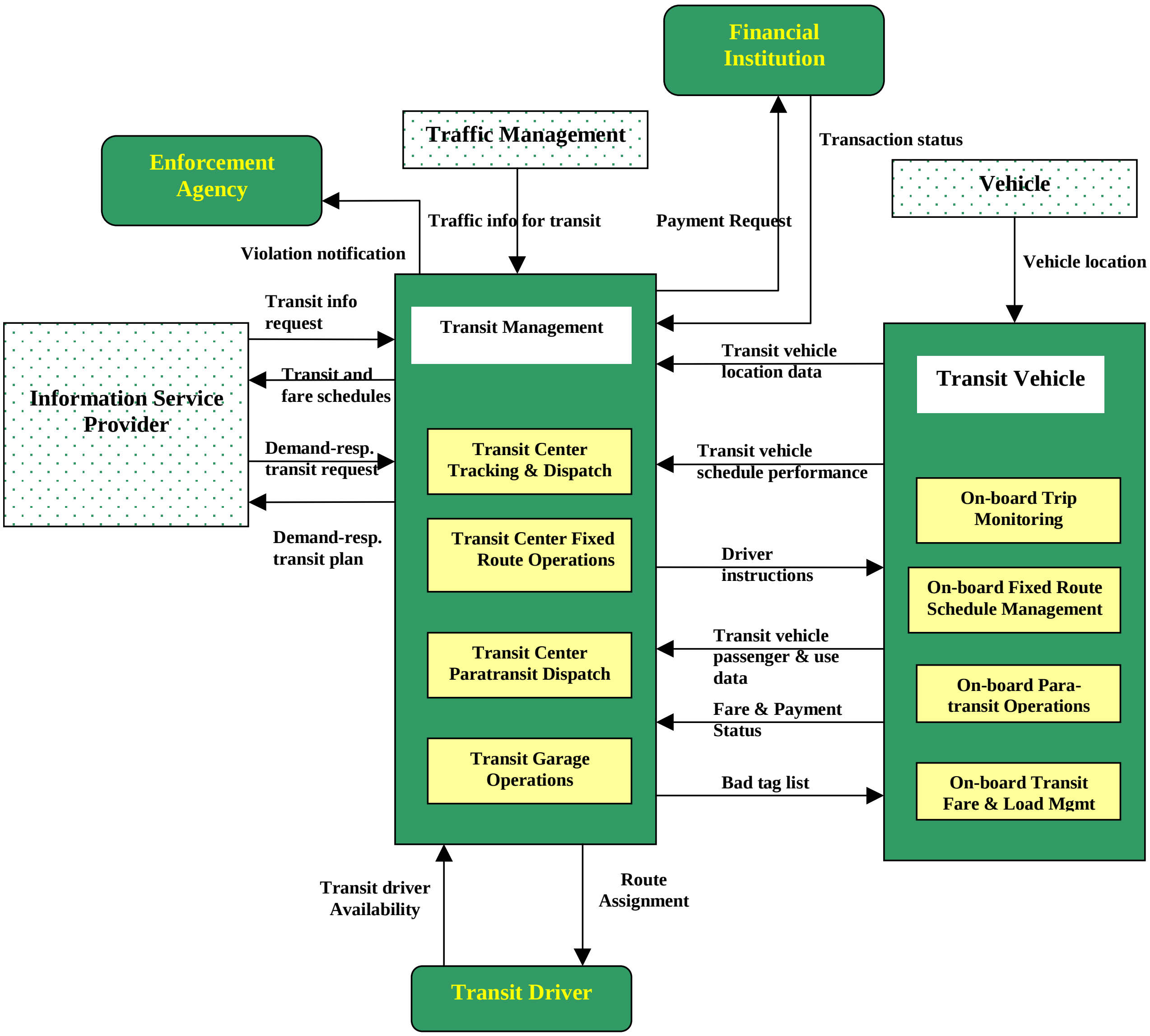
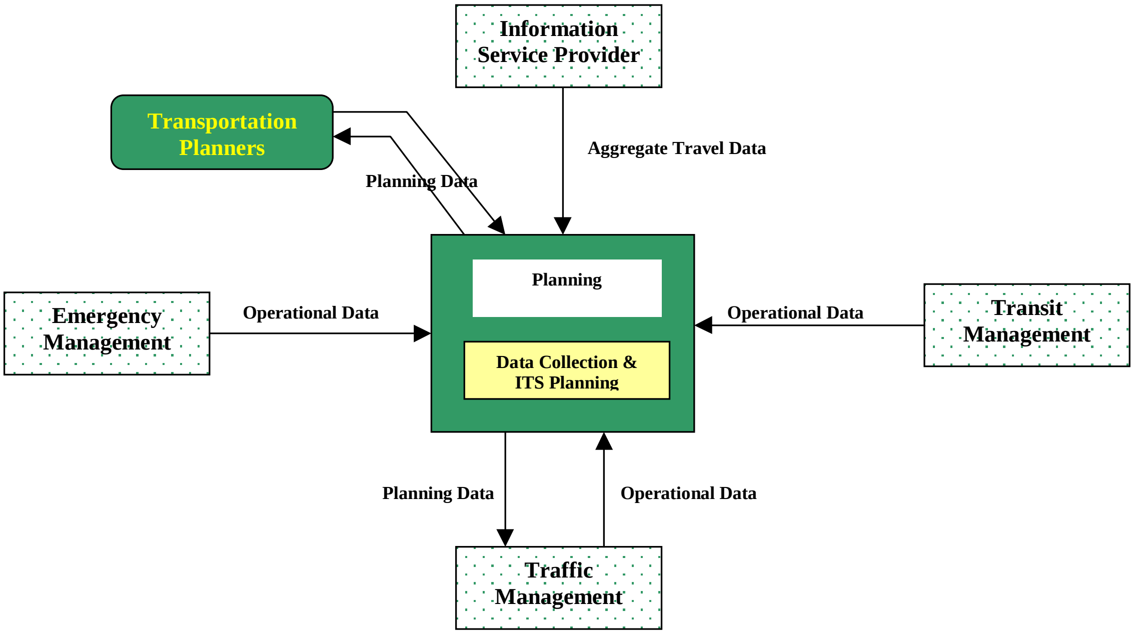


Figure 26: ITS Planning and Data Archiving Architecture



7.0 RECOMMENDED ITS PROJECTS

This section describes a recommended project list for short-term (2000 – 2003) deployment of ITS technologies in Chittenden County. This project list has been developed in a methodical fashion, adhering to the guidelines of the National Architecture, while also acquiring input from local stakeholders who would be affected by these projects.

The focus of short-term deployment is on building the backbone of an ITS system that can evolve smoothly in the future as improvements in technology are made. It can be said with confidence that any future ITS system will need three basic components:

1. the ability to sense travel conditions real time;
2. the ability to communicate travel conditions back to a central location where they can be processed; and,
3. the ability to disseminate travel conditions back out to the traveling public

The recommended short-term project plan is designed to establish these 3 capabilities in a cost effective manner. Since it is a certainty that these types of technologies will continue to improve, the short-term plan is seen as the most parsimonious set of ITS elements that will achieve an ITS system that can easily and cost-effectively be modified as the technology improves. In this way, obsolescence of the ITS system can be minimized.

There are 4 project areas discussed in this section, as follows:

1) Advanced Traffic Signal Systems
2) Chittenden County Transportation Management and Information Center (TMIC)
3) Advanced Public Transit Systems
4) ITS Planning and Data Archiving

7.1 ADVANCED TRAFFIC SIGNAL SYSTEMS

Under the umbrella of advanced traffic control systems, three ITS projects are identified. These are:

- ▲ Signal co-ordination along major arterials in Chittenden County;
- ▲ Communication links between controllers, along select corridors, and the TMIC
- ▲ Allowing for signal preemption / priority along congested corridors

Each of these projects is described in some detail below

7.1.1 Signal Coordination along Major Arterials in Chittenden County

Equipment Needs

This project will involve updating traffic controllers and communication links to allow for communications between the controllers in order to improve the coordination of signals along major arterials in the County. There are a number of methods for linking controllers for the purpose of signal coordination. The simplest form of coordination relies on power lines to feed the individual controllers. However, since a power interruption requires that signal offsets be re-set manually, this method is generally not practical. Other traditional forms of interconnecting controllers require the use of communication equipment, such as cable, coaxial cable, radio or fiber optics.

Communication channels may be leased from the telephone company or installed by the using agency. For Chittenden County, it is recommended that communication channels be leased in order to avoid high initial capital costs. However, it has to be kept in mind that the annual costs will be higher in this case compared to the case where the communication links are owned by the agency. The following corridors are logical candidates for initiating signal coordination projects:

- VT 15, including Susie Wilson Road and Kellogg Road
- US 7, North and South
- Route 2 (Main Street/Williston Road)
- Route 2A

Other arterials of the region may emerge as good candidates for advanced signal technology as traffic patterns change over time.

The types of improvements necessary for implementing signal coordination have typically been accomplished as part of reconstruction projects. In this way, signal improvements can be installed when other types of construction are occurring, thus minimizing overall traffic disruption, and potentially gaining some cost efficiencies. This Strategic Plan recommends that this approach be used in the Chittenden region as well.

For example, Main Street in Burlington will be equipped with state-of-the-art signal controller and communications equipment (including fiber optic lines) with the completion of the Main Street Reconstruction Project (2000). Similar improvements have been specified as part of the Shelburne Road Reconstruction project.

In some cases, traffic conditions may warrant that a signal coordination project be implemented as a stand-alone ITS investment, separate from any other improvements in the corridor. However, the nature of this technology is that smaller pieces of it can be installed opportunistically, as roadway improvements or development projects allow. Once all of the pieces are installed, the entire coordination system can be set in motion.

For example, for US 7 north of Burlington, portions of a signal coordination system can be installed as parts of several development projects proposed for the corridor[1]. At the point where a critical mass of traffic signal technology has been deployed, a backbone coordination system can be initiated.

[1] Pending private development proposals include the Winooski Redevelopment project and the Watertower Hill project in Colchester.

Institutional Issues

A common message in the ITS literature is that institutional barriers are more challenging in ITS implementation than technical issues. For coordinating traffic signal systems, this is also potentially the case. Experience nationwide has shown that memoranda of understanding among affected jurisdictions are critical for continued smooth operation of this technology. Standard agreements cover issues such as standards, interoperability, maintenance responsibility, and cost sharing arrangements is the common way of establishing clear institutional responsibility for coordinated traffic signal systems that cross jurisdictional boundaries.

Estimated Costs

It is estimated that the cost of upgrading controllers would be between $5,000 and $10,000 per controller. The initial capital cost of a linked signal system is about $ 40,000 with annual maintenance costs of about $1,000. Annual communication costs for the linked system could be estimated at $1,000.

Anticipated Benefits

The benefits to be expected from signal coordination include: (1) travel time reduction benefits; (2) environmental benefits resulting from improved traffic flow conditions, lower emissions rates and less fuel consumption; and (3) safety-related benefits resulting from lower accident rates under improved travel conditions. Below is a brief discussion of each of these benefits.

Travel Time Benefits

Evaluation studies conducted throughout the United States indicate that signal coordination could result in travel time reduction in the range of 8 to 25%. The exact value of time reduction will depend upon a number of factors including: (1) the variability of travel demand; (2) the overall level of congestion; (3) the time interval between signal timing plan modifications; and (4) the density of traffic signals. Given the traffic conditions in Chittenden County, a conservative estimate of 10% reduction in travel time could be made.

Environmental Benefits

Studies show that signal coordination could result in a reduction in air pollutants (such as hydrocarbons and carbon monoxide) that ranges between 16% and 19%. It could also result in a reduction in between 4% and 12% reduction in fuel consumption.

Safety Benefits

Some studies show that signal coordination could also result in a reduction in the frequency of injury-related accidents ranging from 6% to 27%. A conservative estimate of 10% could be made for Chittenden County.

Benefits Calculation Example

For the sake of illustration, this section will discuss how the benefits from signal coordination along Rt. 7 in Shelburne, for example, could be estimated. The average annual daily traffic (AADT) volume on this route segment is about 20,000 vehicles per day. Assuming that the average trip length for this segment is about 10 miles, and using the conservative estimate of a 12% reduction in travel time as discussed, the time savings resulting from signal co-ordination could be estimated at (0.10 x 10 = 1.0 minute/vehicle/day). Given that the value of time is typically assumed to be equal to $8.90/hour, the benefits could be computed as follows:

Benefits = (# of vehicles) x (time saved) x (time value) x 365

= 20,000 x (1.0/60) x ($8.90) x 365 = $ 1,082,833/year

Assuming a coordinated system of 10 intersections, and assuming an initial capital cost of $10,000 per intersection and $ 40,000 for the linked system, the total initial cost will be equal to:

($10,000 x 10) + $ 40,000 = $ 140,000

Assuming an interest rate of 5%, and a service life of 10 years for the system, the equivalent annual cost for the initial investment is equal to:

$ 140,000 x 0.129505 = $ 18,130.7

Assuming annual operating and maintenance costs of $ 2,000 for the system, the total annual cost for the system could be estimated as:

$ 18,130.7 + $ 2,000 = $ 20,130.7

That is to say, the Benefit-Cost (B/C) ratio for the project is estimated at:

$ 1,082,833/20,130.7 = 54 to 1

It is noted that this number is consistent with other studies around the country. For example, a recent study in Iowa indicates that the B/C ratio of signal co-ordination projects could reach values as high as 64 to 1, with an average value of 14.2 to 1. It also should be noted that the actual benefits are likely to exceed the estimated value. Since the calculations shown above only took into account the travel time reduction benefits (i.e. the environmental and safety-related benefits were not considered).

7.1.2 Communication Links Between Controllers, Along Select Corridors, and a Central Location

Equipment Needs

The purpose of this project is to deploy an advanced traffic signal control system along select corridors in the County. A prime feature of this project would be to establish communication links between the controllers and a central location (i.e. the TMIC that will be discussed in the following section) to allow for remotely updating the signal plans. The ability to update signals from a central location offers a number of advantages including the ability to have multiple plans for the different hours of the day, and days of the week, as well as special plans for special events such as road construction and snow events. In addition to central control, advanced signal control systems are typically capable of automatically detecting traffic signal malfunctions.

If it is anticipated that changes to signal plans will only be made infrequently, these plans may be adjusted manually. In recent years, however, a number of adaptive traffic control algorithms were developed to allow for the automatic adjustment of traffic plans at very short time intervals (as short as 1 minute in some systems). The purpose of these algorithms is to make the traffic control system as responsive as possible to existing conditions. Examples of adaptive traffic control systems include SCOOT by the Transport and Road Research Lab in the U.K., SCATS developed in Australia, and RT-TRAC developed by Farradyne, Inc. for the FHWA, among others.

However, it should be noted that adaptive traffic control systems are quite demanding in terms of surveillance requirements (inductive detection loops will have to be installed at each intersection approach) as well as in terms of computational requirements. For Chittenden County, it is thus recommended that such systems only be considered, if traffic conditions warrant such a high level of responsiveness. Some of these conditions include high seasonal traffic, frequent accidents, or an arterial that can serve as a diversion route for freeway traffic. During the last steering committee meeting, it was suggested that US 2 (Main St./Williston Rd.) and VT 15 might be a candidate route for a centrally controlled traffic signal control system.

Estimated Cost

The cost of the system varies depending upon the level of sophistication of the system, and upon whether traffic plans are adjusted manually, or whether a fully responsive traffic system is deployed. Tables 21 and 22 below show some estimates for the different cost items that such a system may include.

Table 21 : Estimated Initial Capital Investment for a Central Traffic Control System

Item	Unit Cost
Software and Integration	$ 180,000
Hardware	$ 15,000
Detection Equipment / intersection	$ 10,000
Communication Lines (leased)	$ 1,000
TOTAL	$ 196,000 + 10,000 x*

* x = number of intersections

Table 22: Estimated Annual Costs for a Central Traffic Control System

Item	Unit Cost
Communication Costs	$ 6,000
Transportation Engineer	$ 40,000
TOTAL	$ 46,000*

*It is assumed that the TMIC operators would be able to handle the signal system, in addition to their other responsibilities. It is further assumed that the agency's maintenance technicians will be able to deal with the advanced system's maintenance issues.

Anticipated Benefits

Adaptive traffic control systems offer a higher degree of control responsiveness to traffic conditions, and therefore, *if applied in the right context*, should be expected to result in benefits that are similar yet somewhat higher than those discussed in relation to signal coordination projects. The following paragraphs briefly list some examples of real-world systems along with their reported benefits.

Oakland County, Michigan - As a part of the FAST-TRAC program, the Sydney Coordinated Adaptive Traffic System (SCATS) for signal control became operational in Troy, Michigan in 1992. Preliminary floating car studies showed a decrease of 33% in the number of stops, as well as increased average speeds, particularly during off-peak periods. 72% of the drivers said they are better off with FAST-TRAC.

Los Angeles, California - A computerized system has been in operation since 1984. As of 1994, the system includes 1,170 intersections and 4509 detectors for signal timing optimization. It has been reported that the system resulted in a 13% decrease in fuel consumption, 14% decrease in emissions, 41% reduction in vehicle stops, 18% reduction in travel time, a 16% increase in average speed, and a 44% decrease in delay.

Toronto, Canada - In Toronto, the SCOOT adaptive traffic signal control system was used to control 75 signals within the metropolitan area. When compared to a best effort fixed timing plan, the evaluation showed an 8% decrease in travel time, 22% decrease in vehicle stops and a 17% decrease in vehicle delay.

Signal Preemption/Priority along Congested Corridors

The purpose of this project is to equip traffic controllers along heavily congested corridors in the County with the ability to pre-empt the signal for an oncoming emergency vehicle. The same technology could also be used to provide preferential treatment (signal priority) to transit vehicles, particularly when they are running behind schedule. There are several means of activating signal preemption, including: (1) Mobile Radio; (2) Siren Activated Signal Preemption; (3) Modulated Strobe Light; and (4) Activation form a control center (such as a switch at the Vehicle Home Base). However, Modulated Strobe Light technologies seem to be the most widely deployed technology at the present time. The cost of signal preemption is estimated to be $5,000 per intersection. Appendix 6 provides a detailed description of this technology and recommends a policy to ensure compatibility of signal preemption systems across jurisdictional boundaries.

Institutional Issues

As with signal coordination, signal pre-emption raises issues requiring institutional cooperation. Appendix 6 to this Strategic Plan provides a recommended policy for adopting a regionally interoperable signal pre-emption system. Stakeholders include the municipalities through which major arterials with signal pre-emption run, the emergency services sector, and the public transit sector. The CCMPO is the logical organization to convene a group to develop and approve regional standards for this technology.

Anticipated Benefits

Studies indicate that signal preemption could result in an average reduction in response time of 8.45 minutes. However, this value was obtained by averaging time reductions over a number of large metropolitan areas around the country that are significantly more congested than Chittenden County. Given this, it should be expected that the reduction in response time from implementing signal preemption in the region is likely to be less than the reported 8.45 minutes. Nevertheless, it should be noted that this 8.45 minute time reduction could lead to an 11% reduction in fatality rate.

7.2 CHITTENDEN COUNTY TRANSPORTATION MANAGEMENT AND INFORMATION CENTER (TMIC)

This project represents a combination of five market packages namely:

ATMS01 – Network Surveillance	(short-term)
ATMS06 – Traffic Information Dissemination	(medium-term)
ATMS08 – Incident Management	(short-term)
ATMS18 – Roadway Weather Information System	(medium-term)
ATIS1 – Broadcast Traveler Information	(short-term)

The project will involve the establishment of a Transportation Management and Information Center (TMIC). The TMIC will be responsible for gathering, fusing, and disseminating information on the state of the transportation system. The information will be collected from a wide array of sources, some generating short-term, real time information from traffic sensors, weather sensors, and links to

911 calls, and others generating longer term, predictable information (e.g. anticipated construction delays). The TMIC will then be responsible for the dissemination of this information to the appropriate agencies, the public, and the media via a number of en-route, as well as pre-trip, information dissemination devices.

The establishment of the TMIC can be viewed as an encompassing project that includes the following 5 projects:

1) Setting up the TMIC
2) Deploying network surveillance equipment
3) Deploying Changeable Message Signs (CMS) and Highway Advisory Radio (HAR)
4) Developing a TMIC Incident Management Information System
5) Developing a Pre-trip Traveler Information System

Each of these projects is described below.

7.2.1 Setting Up the Transportation Management and Information Center (TMIC)

Facility Needs

A physical location is needed for setting up the TMIC. The CCMPOis a possible host, although the MPO's status as a planning organization rather than an operations organization may make the CCMPO a less obvious choice. A more conventional choice for a TMIC host would be a state entity such as VTrans or the Vermont State Police.

Regardless of the final decision concerning the location of the TMIC, agreements between municipalities and the eventual operator of the TMIC would need to be established to clarify roles and responsibilities. It should be noted that the vision for the Chittenden County's TMIC is a relatively simple center with enough room space for three computers, desks and office equipment for use by one or two people at the most. Initially, the space requirements for the TMIC may not exceed 500 square feet.

Equipment Needs

The TMIC will require three computers, along with the software needed for the processing of the traffic data collected. One of these computers would act as the TMIC's server, and would be the locus for receiving surveillance data as well as for publishing the TMIC's web site. Communication links will have to be established between the TMIC and the roadway devices, as well as between the TMIC and other centers in the region such as the emergency management center and the transit management center. It is recommended that initially leased telephone lines be used initially. In the future, fiber optic cable may be considered, if a need arises.

Staffing Requirements

Since the purpose of having a TMIC is to provide accurate information to travelers so they can make informed decisions about their travel, it is critical that the information disseminated by the TMIC be reliable and up to date. This underscores the importance of having the TMIC staffed. The TMIC would require at least one person to staff the facility during weekday operating hours (e.g. 6:30 a.m. – 6:30 p.m.). Another staff member may be needed to organize special events and update construction schedules.

Estimated Cost

It is assumed that the TMIC will be located within an existing building. Given this, the capital cost will be limited to the cost of the hardware and software, and the office furniture. A rough estimate of the needed non-recurring costs is given in Table 23. The costs provided are averages based on examples from other projects across the country.

Table 23: Estimated Initial Capital Investment for the TMIC

Item	Unit Cost
Processor and Software	$ 80,000*
Communication Lines	$ 6,000
Furniture	$ 2,000
System Integration	$ 120,000*
TOTAL	$ 208,000

* Given the envisioned size of the Chittenden County's TMIC, the estimated cost is lower than the values assumed by the National Architecture.

The annual operating and maintenance costs, on the other hand, will involve such items as the salaries of the center operators, the cost of leased communication lines, and the maintenance costs for the processor and the software. Table 24 shows the estimated annual costs of the TMIC.

Table 24: Estimated Annual Operating Costs for the TMIC

Item	Unit Cost
TMIC Personnel	$ 100,000
Communication Costs	$ 30,000
Maintenance costs	$ 5,000
TOTAL	$ 135,000

Anticipated Benefits

The TMIC can be considered the backbone of the County's envisioned ITS system, where traffic information will be collected, processed and disseminated. Since the center will provide data support for other ITS elements, the benefits will be indirect, and will result from the use of the information provided by the TMIC by other ITS applications.

Institutional Issues

Since the TMIC is at the nexus of transportation information, it presents the most challenging institutional arrangements in the ITS Plan. A regional or statewide entity should be designated as an operator of the TMIC. For the TMIC to be effective, significant cross-agency cooperation will be needed. Affected stakeholders include: municipalities, E911, State Police, and VTrans. A committee or board including, by not limited to, these entities should oversee the TMIC operation:

As with other elements of the ITS Plan, the TMIC will require a set of agreements among affected parties. These agreements will need to specify decision-making responsibility, information privacy policies, and cost sharing agreements.

7.2.2 Deploying Network Surveillance Equipment

Equipment Needs

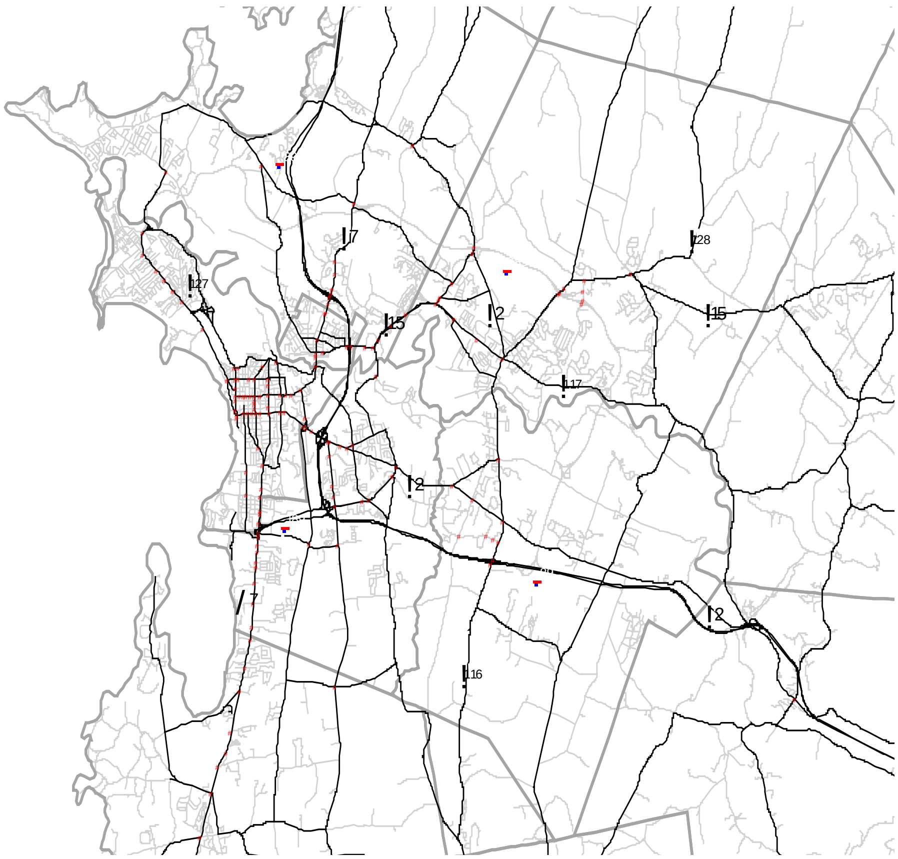
This project deploys the surveillance and detection equipment needed to monitor the status of the transportation system. Current vehicle detection is based predominantly on inductive loop detectors (ILDs) installed in the roadway subsurface. Recently, however, alternative detector technologies have been developed to provide direct measurement of a wider variety of traffic parameters, including traffic density, travel time, and vehicle turning movements. These advanced detectors supply more accurate data, and measure several parameters that were not typically measured with previous instruments. In addition, many of the advanced detector systems can be installed and maintained without disrupting traffic flow (non-intrusive technologies). Several types of non-intrusive vehicle detection technologies are currently available including microwave radar detectors, infrared detectors, ultrasonic detectors, and acoustic detectors. Recent studies conducted to evaluate the different technologies do not strongly favor one technology over another, but typically point to the advantages and disadvantages of each type.

Given the harsh winter weather of Vermont, it is strongly recommended that the County seriously consider non-intrusive detection devices, rather than the more common ILDs. The following locations/corridors are logical candidates for surveillance equipment installations:

- I89 interchange areas, especially ramps
- Main Street/Williston Road
- US 7, North and South
- VT 15, including Susie Wilson Road and Kellogg Road
- Route 2
- Route 2A
- Circumferential Highway
- Southern Connector

Figure 27 shows the locations of these arterial roadways in the region.

Figure 27: Major Arterial Roadways of Chittenden County



Ultimately, specific decisions regarding the locations of detectors within each arterial will need to be made. This level of detail is outside the scope of this planning study.

In addition to the aforementioned detection technologies, video surveillance and video image processing (VIP) can also be used for more effective monitoring. The real advantage of video surveillance lies in its ability to provide traffic operators with visual data, thereby allowing for the confirmation and the interpretation of accident information to determine the correct response. Nevertheless, video surveillance is much more expensive than the aforementioned non-intrusive detection technologies, and requires significant bandwidth, especially if full-motion video is to be communicated. Given this, it is recommended, in case it is deemed desirable to deploy video surveillance, that they be strategically located at high accident locations.

Estimated Cost

With the exception of video surveillance and VIP, the unit-price of the non-intrusive types of detectors is not likely to exceed $5,000. However, if the device is to be mounted on a pole on the side of the road (side-fire configuration), the cost of the pole and the other equipment needed to support the detector will have to be considered. A recent ITS study estimates the total cost of the entire installation to be around $24,000. For video surveillance, the total cost of a video camera, mounted on a pole, with full pan, tilt, and zoom capabilities is about $40,000. This includes the cost of the device, as well as other items such as foundation work and electrical conduit and trenching.

Anticipated Benefits

This project is intended to provide data support for other ITS applications including incident management, traveler information systems, and advanced traffic signal control systems. The project is thus expected to result in reductions in travel time, reduced delay and lower response time.

Institutional Issues

Installment of surveillance equipment will require the cooperation of the managing agency, which will be either VTrans or the municipality.

7.2.3 Deploying Changeable Message Signs (CMS) and Highway Advisory Radio (HAR)

Equipment Needs

This project deploys the equipment needed to disseminate real-time information to travelers, while en-route. Two types of equipment are recommended for deployment: Highway Advisory Radio (HAR) and Changeable Message Signs (CMS).

HAR is a low output radio transmitter, and many commercial units are designed to transmit in a 5-mile radius from the antenna. Some models can cover an area of up to 15 miles in radius. Given this, two to five HAR systems would be adequate to cover most of the region. Most ITS deployment plans nationally include HAR as a low-cost addition to their travel information dissemination system. National ITS standards for HAR are still being developed. However, many states are allocating AM 1610 as the HAR station of choice.

CMS can be used to display messages regarding current traffic conditions, congestion, accidents, as well as suggested alternate routes. The more advanced CMS technology permits remote computer control (i.e. from the TMIC). CMS may be permanently mounted, or may be of the mobile type. The permanent CMS have to be strategically located ahead of possible diversion points, and ahead of points of recurrent congestion (e.g. on US 7 north of Swift Street to allow diversion of southbound US 7 traffic to other routes). The mobile CMS, on the other hand, can be easily moved from one place to another, and are particularly useful around work zone areas. This Plan favors the acquisition of mobile CMS for use in the County.

VTrans currently houses two CMS at their Colchester facility, but these are available for use throughout the State. If VTrans acquires more CMSs for use in Chittenden County, the priority will be for emergency uses. On rare occasions, Vtrans permits municipalities to borrow the signs for local use. However, VTrans lends their CMSs with the understanding that they can take them back if an emergency situation arises where they are needed.

For the short-term, it is not necessary that the Chittenden region have CMSs outside those controlled by VTrans. In the longer term, the region should decide whether individual municipalities should operate their own CMSs. At this point in time, these devices are available for short-term lease from private companies, and this should continue to be an acceptable means of acquiring the technology in the foreseeable future.

Estimated Cost

There is a wide range for the unit cost of HAR systems, depending upon the capabilities of the system. However, the cost is typically around the $20,000 range. For CMS, the unit cost varies depending upon the size of the CMS. Given the fact that most CMS in Chittenden County will be deployed along arterials, where motorists will be traveling at speeds much lower than speeds on freeways, compact CMS may be used. The average unit cost of a compact CMS is around $ 70,000.

Anticipated Benefits

This project will provide the capabilities needed to disseminate real-time information to motorists. It is therefore expected to result in lower delays, higher travel time reliabilities and fewer accidents. Studies indicate that HAR and CMS could result in between 5% to 10% diversion to alternate routes, as well as between 7 and 12% reduction in volumes upstream of an incident.

Institutional Issues

As mentioned above, VTrans currently owns and operates Changeable Message Signs in the state. In rare circumstances, they will allow municipalities to borrow a sign for a traffic control or safety purpose. They reserve the right to take the CMS back if an emergency presents itself. The use of CMSs has not been so great such that this arrangement has not worked. However, it is foreseeable that individual municipalities would want more flexibility in the use of CMSs for local purposes, including special event traffic management. In such cases, municipalities have the option of leasing a device from a private company, or acquiring their own. The leasing option is attractive because the municipality will not be required to maintain the device. It is unattractive because the device won't be immediately available as needed in an emergency.

7.2.4 Developing a TMIC Incident Management Information System

Equipment Needs

Initially, this project will focus on establishing a link to the existing 911 system. This could be as simple as having an E911 system operator or dispatcher publish the information on a web page that would be integrated with the TMIC. A protocol for disseminating incident information would need to be established. The parties to the protocol could include the regional TMIC operators, the E911 Board, and the State Police.

As the system matures, there might be a chance to develop a more sophisticated incident management information system that uses Internet technologies to link together the incident management stakeholders in Chittenden County. The central piece of such a system would be a graphical map, that each stakeholder can access, with icons indicating the locations of current incidents. Each icon would be linked to a page with more detailed information about the incident. TMIC personnel, along with other incident management stakeholders, would be given the access privileges to update the status of the incidents.

Estimated Costs

The cost of developing the incident management information system would vary depending upon the level of sophistication of the system. However, given that the system will use Internet technologies, it is expected that the software development costs would be in the range of $ 30,000.

Anticipated Benefits

There is ample evidence in the transportation literature that clearly indicates that improving the incident management process results in significant travel time savings, reduced delays and lower response times. For example, a recent ITS study for a medium-sized city indicates that reducing the incident response and clearance time by one third would result in annual economic benefits of 4 million dollars.

Institutional Issues

Institutional issues in the emergency management sector require cross-agency cooperation among the TMIC, police, towing services, fire departments, and emergency medical services.

7.2.5 Developing a Pre-trip Traveler Information System

Equipment Needs

The central piece of this project will be developing a web site to post the traffic information collected by the TMIC. The web site would include a color-coded map of the major highways in the region depicting the average speeds (see http://www.georgia-navigator.com/tview.html), the locations of any incidents, and the scheduled work zones. Links could also be provided to transit schedules, ridesharing information, bicycle paths, airports, as well as places of attractions (yellow pages). If desired, the web page could be augmented with a phone service, providing both long-term (i.e. scheduled construction delays) and short-term (i.e. incident information).

The site should be accessible through web browsers on a personal computer and through kiosks. The kiosks should be strategically located, with candidate locations including Burlington International Airport, Fairgrounds, the multi-modal center to be established in downtown Burlington, and selected parking garages. However, it should be noted that kiosks are expensive and require routine inspection and maintenance.

Estimated Costs

Developing and maintaining the website is expected to cost around $20,000. Costs would be higher, however, if kiosks were to be deployed. A standard kiosk's cost is typically in the range of $5,000 - $20,000, depending on the sophistication of the software (e.g. automatic reboot software, remote diagnostic software) and the design features of the kiosk station (e.g. inclusion of printer, telephone handset, swipe card reader, backlit signage, etc.).

Anticipated Benefits

The anticipated benefits include reduction in travel time, with primary value for incident-related (i.e. accidents, weather, special events) traffic delays, and more predictable travel time. Simulation results in Boston (assuming a 100% market penetration level) indicate that pre-trip information systems could result in 21% reduction in delay when an incident occurs, and between 15% and 30% reduction in emissions. Customer surveys, conducted as a part of the SmartTraveler program in Boston, indicate that the majority of customers are happy with the system. The system's benefits reported by customers included helping them avoid travel problems, saving time, and reducing anxiety-levels.

Institutional Issues

For an effective travel information system, cooperation between the TMIC and a wide variety of local media outlets is critical. The TMIC should be well connected to local radio, television, newspaper, and internet provider service organizations.

7.3 ADVANCED PUBLIC TRANSIT SYSTEMS (APTS)

7.3.1. Transit Fare Management

Electronic fare payment systems facilitate the collection and management of transit fare payments by using electronic media rather than cash or paper transfers. These systems consist of two main components: a card and a card reader. Cards could be of the magnetic-stripe type, where the reader does most of the data processing. They could also be equipped with a microprocessor (smart cards). In this case, data processing could occur on the card itself.

There are basically two types of electronic fare payment systems: (a) closed systems; and (b) open systems. Closed systems are limited to one main purpose (i.e. paying transit fares) or to a few other applications such as paying parking fees. However, the value stored on the card cannot be used outside the defined set of activities, and hence the name "a closed system". Open systems, on the other hand, can be used outside the transit system. A prime example of an open system is a credit card, which naturally can be used with multiple merchants.

Open systems are more complex than closed systems. An open system requires the establishment of agreements with financial institutions for the payments processing. Given the size of the transit users market in Chittenden County and the lack of immediate banking partners, this project will focus on implementing a closed system that uses magnetic-stripe cards. The best initial model to go forward with is to have the transit provide, CCTA, act as the financial institution. As such, CCTA issues the fare cards with stored value. CCTA is currently investing in this type of system.

The next step in sophistication allows the use of other magnetic stripe debit cards. In this case, a holder of the debit card will insert the card into the card reader upon entering the bus. Validation is not conducted at the time of the card swipe. Instead, an electronic transfer of funds occurs at the end of the business day between the institution that issues the debit card and the transit agency, CCTA. For Chittenden County, a possible scenario is an agreement between major employers, such as the University of Vermont or Fletcher Allen Health Care, and CCTA. The debit card issued by UVM, the CatCard, is a good candidate for this type of system. The debit card issuer will need to assure payment in the case of a lack of funds. This situation does not arise often, according to the UVM office administering the CatCard.

Such a system can be further developed to provide other transportation services, such as parking. On-street meter parking and structure parking can be paid for with the same magnetic stripe card. The City of Burlington Department of Public Works has expressed strong interest in developing this type of system in the near future.

Estimated Benefits and Costs

The benefits of fare management systems include greater convenience to riders, increased flexibility and the ability to implement more complex fare structures, and increased efficiency through the avoidance of the cost of managing cash payments. In addition, fare management systems have the capability to automate the collection of management information, such as ridership levels and transfers. This information can then be used to optimize the planning of routes, resulting in additional increased efficiency benefits. The cost of the system will largely depend upon the system's functionality required.

7.3.2 Transit Vehicle Tracking

AVL (automated vehicle location) is the technology that automatically determines and displays the position and movement of vehicles in an area. For small urban and rural areas, studies show that AVL is the second most common APTS technology in operation (after various software applications). A recent survey of 32 public transportation systems in small urban and rural areas indicated that 9 out of these systems are currently using AVL. GPS is the most commonly adopted technology for AVL applications. It is envisioned that this technology will initially be more useful for the paratransit operations of SSTA, where it can assist in dynamic scheduling. The technology can also be implemented as a demonstration program for CCTA at a relatively modest cost.

Second generation applications of this technology include algorithms that estimate vehicle travel time from stop to stop (see http://www.nextbus.com/muni/)

Equipment Needs

AVL applications typically involve the following components:

- Global Positioning System (GPS) mounted on a bus. A GPS is outfitted with a transmitter and receiver. The transmitter transmits location to a satellite system. The receiver receives a return signal from the satellite system with the coordinate information.
- Wireless connection to a computer server. This is usually a cell phone that is electronically connected to the GPS. The cell phone is programmed to contact a computer server via a modem. This phone contact is usually made every 15-60 seconds.
- Computer server. The server receives the positional information from the bus via a modem phone line.
- Software and interface. When a new position is reported, software on the server is activated to take the new information and post it on some interface. The most common interface is a web page. What the user sees is a map showing the street network. On the network are icons representing the transit vehicle. The position of the vehicle on the network is refreshed every 15-60 seconds typically, as new positional information is relayed from the bus to the server.

Estimated Costs

Table 25 shows cost estimates from four commercial AVL suppliers.

Table 25: AVL Cost Estimates*

Item	Product	Initial Training Period	Cost per Vehicle
McCain Traffic Supply	TOTE	5 days	$ 2,000
Navigation Data Systems	FLEET-TRAK	3 days	$ 1,000 – 2,000
Rockwell Int'l.	Transit Master	2-3 days	$ 3,000
Raytheon E-Systems	Fleet Service AVL	3-5 days	$ 1,000

* These costs do not include the annual communications cost

For a demonstration project, it would be reasonable to contact the USDOT Volpe Research Center in Cambridge, MA. Volpe has developed a turnkey AVL system that they will install for a cost of $2,000 - $3,000. This would include all necessary software, hardware, and space on their computer server for the web page displaying bus location. This web page could be accessed from the CCTA web site and/or the TMIC web site.

Benefits

The benefits of AVL include enabling real-time pickups, optimizing vehicle travel times, reductions in wait time, improving safety (with AVL, the location of vehicles in trouble can be immediately determined, thereby significantly reducing response time), improving performance and schedule adherence, and reductions in fleet sizes.

According to a recent study (National Urban Transportation Institute), AVL technologies need only reduce fleet sizes by 2.3% to pay for themselves. While this is the case, many agencies that have implemented AVL, have reported size reductions ranging from 4 – 9%. This suggests that AVL technologies are quite cost-effective. Agencies also report an increase of between 12% and 23% in on-time performance.

CCTA currently has a total of 38 vehicles, while SSTA has a total of 35 vehicles. Assuming a 3% reduction in fleet size and assuming a 100% market penetration, it is likely that using AVL could help both CCTA and SSTA reduce their fleet size by one vehicle each. Assuming that the initial capital cost of a transit vehicle is $225,000 and that of a paratransit vehicle is $85,000. The benefits from fleet size reduction could be estimated at

$225,000 + $85,000 = $310,000

This does not include the benefits to be expected from improved level of service and customer satisfaction, which are likely to result in an increase in ridership levels.

7.3.3 Transit Operations

ITS applications involving Transit Operations typically involve the acquisition of software that assists with dispatch and scheduling. Significant gains in operating efficiencies can be achieved through the use of Computer Aided Dispatch/Scheduling (CADS) software. CADS and related data collection systems perform automatic driver assignment and monitoring, as well as vehicle routing and scheduling for demand responsive services such as SSTA, and for fixed route services such as CCTA. Advanced CADS systems can use an AVL database as a source for current schedule performance data. In addition, CADS systems can be used to improve: vehicle coordination; schedule and transfer adherence; vehicle status monitoring for safety and maintenance; administrative reporting of passenger and vehicle information; etc.

SSTA currently use an early generation CADS software in their operations, and has expressed a desire to upgrade their software. Table 26 shows the most important CADS software features, as ranked by experienced transit operators. The functions are provided for so-called “Semi-Automated” and “Fully Automated” programs, which are on the more advanced end of CADS software options.

Table 26: Ranking of CADS Software Functions for Semi-Automated and Fully Automated Programs

Rank (Top 25)	Priority CADS Software Functions	Semi-Automated Programs	Fully Automated Programs
1	Fully computerized scheduling and dispatching		X
2	Trip eligibility check (for ADA trips)		X
3	Vehicle location on layered maps		X
4	Allows "what if" questions		X
5	Simulation training capability		X
6	Choice of performance criteria (ride/wait times, etc.)		X
7	Trips displayed on layered maps		X
8	On-line time (pickup, etc.) estimates		X
9	Redundant reservation warning	X	X
10	Problem passenger warning	X	X
11	Pop-up menus/multiple windows	X	X
12	Performance data calculations	X	X
13	Variable vehicle parameters (Number, seating, etc.)	X	X
14	Automatic rider eligibility check	X	X
15	Personalized passenger loading times		X
16	Validity checks on all inputs (completeness, legitimacy, etc.)	X	X
17	Geocoded addresses		X
18	Manual override of computer generated schedule		X
19	Computerized vehicle route selection		X
20	Flagging of costly trips	X	X
21	Import/export to spreadsheet	X	X
22	Automatic purge of inactive registrants	X	X
23	Automatic vehicle selection for passenger special needs	X	X
24	On line address verification		X
25	Frequent destination list	X	X

Benefit/Cost Information:

CADS software is the most widely implemented aspect of ITS among paratransit agencies nationwide. A survey of small urban and rural transit providers showed the following benefits:

- ▲ More efficient customer billing process
- ▲ Improved communications with customer, and between dispatch and driver
- ▲ Reduced customer complaints
- ▲ Reduced personnel costs, greater staff accountability
- ▲ Improved trip scheduling,

Table 27 lists some cost information for a sample of CADS software vendors.

Table 27: CADS Software Cost Estimates

Company	Software	Suggested # of Vehicles	# Installed	Software Costs	Initial Training Period/Costs	Annual Maintenance Fee
Trapeze Software Group	PASS	6+	130	$100,000	13-20 days	20% of Cost
Multisystems	MIDAS PT	11+	20	$50,000	10 days	$6,000
IRD Teleride	Trans View	5+	15	$35,000	5 days	$2,500
Advanced Transit Solutions	Schedule Pro	1-100	10	$9,995	2-3 days, $5,000	10% of Cost

Some studies suggest that CADS when combined with AVL could result in reducing the annual operating costs of transit and paratransit agencies by between 5% and 8%. This means that for CCTA, for example, whose annual operating costs are in the range of $3,000,000 could be expected to save 0.05 x 3,000,000 = $ 150,000 annually from these technologies.

7.4 ITS PLANNING

The purpose of this project is to define the data that should be archived as part of the ITS system. This would be a natural task to associate with the TMIC. Data for archiving comes directly from field sensors. Types of data to be collected are shown in Table 28.

Table 28: Sample of ITS Data to Archive

Primary Data Element	Units
Mainline Traffic Volume	Vehicles per Unit Time
Signalized Intersection Turning Movements	Vehicles per Unit Time
Vehicle Speed	Km/Hour
Transit Vehicle Locations and Times	Time/Location
Incident Information	Type, Time, HAZMAT category
Roadside Weather Data	Temperature, Precipitation, Surface Condition
Roadway Segment Travel Times	Seconds

Archiving standards are defined in the National ITS Architecture. The most recent source on this topic can be found at http://www.fhwa.dot.gov/ohim/its/itspage.htm.

In summary Table 29 lists the recommended short-term projects, the objectives of each, and the estimated capital and ongoing operations costs.

7.5 PROJECT DEPLOYMENT AND SEQUENCING

The sequencing of ITS deployment can occur along three tracks. The first track – public transportation – can begin immediately. Upgrade of fare management systems should be integrated with planned vehicle purchases. Acquisition of operations software (i.e. CADS) should be planned for as stand-alone investments, or as investments to be timed with other technology upgrades[1]. For the AVL project, beginning with a demonstration project, and evaluating its effectiveness before widespread adoption is recommended.

The second track involves the street surveillance and surface street control projects. Nationally, these are the most commonly deployed elements of ITS. These projects have high benefit-to-cost ratios, and have high demonstration value to the public. For this reason, this Plan recommends that traffic signal systems along the key regional arterials be updated in a systematic fashion. This type of updating can be folded into any arterial reconstruction projects, as has been accomplished with the Main Street Improvement Project and as is planned for the Shelburne Road Reconstruction Project. Further, as individual traffic signals are updated throughout the region, they should be replaced with advanced traffic signal controllers that enable interconnection, communication, and coordination.

The timing for network surveillance equipment can be pursued in a similar fashion. Namely, as key arterial intersections are reconstructed or improved, those improvements should include detection technology that is designed not only to inform operations at the intersection, but also to communicate conditions to the TMIC.

The third track involves the Transportation Management and Information Center. The TMIC can be developed as a stand-alone project, or attached to another transportation project, such as a Multi-Modal Center. However, for the TMIC to be truly useful, network surveillance equipment should be installed at key intersections and arterials throughout the region. Once there is a critical mass of real-time travel information that can be transmitted to a central location, and re-transmitted to the traveling public, a TMIC is a necessary component.

[1] For example, acquisition of new fareboxes may be the best time to upgrade operations software that can be customized to the farebox hardware/software.

Table 29: Short-Term Project Recommendations, Objectives, and Estimated Costs

Project	Objectives	Capital Costs	Ongoing Annual Costs
Automated Vehicle Location	Improve dispatch efficiency of SSTA	$5,000 per installation	$500
Transit Operations Software	Improve operating efficiencies of both CCTA and SSTA	$50,000	$1,000
Transit Fare Management	Improve financial efficiency, increase ridership	Depends upon functionality	Depends upon functionality
ITS Planning	Archive data collected through the ITS system. Make information available for improved transportation planning.	$35,000	Ongoing commitment; part of the TMIC responsibility.
Deploy Network Surveillance Equipment	Obtain real-time information on the performance of the transportation system	$5,000 per installation	$5,000 for program maintenance.
Deploy CMS and HAR	Re-transmit information about travel conditions to the traveling public.	$20,000 to establish HAR; $70,000 per CMS installation	$5,000 for program maintenance.
Advanced Traffic Signal Systems	Improve signal coordination; provide for signal pre-emption capability	$5,000 per signal controller; $40,000 for linking arterial signals	$1,000 per installation for communications costs.
TMIC—Set Up	Establish physical location for TMIC with associated communications infrastructure.	$208,000	$135,000
TMIC Incident Management System	Provide real time information on incidents, provide link with E911 for sharing information.	$30,000	nominal
Pre-Trip Traveler Information System	Provide central locus of travel/traffic information via a web site	$20,000	$2,000 - $5,000 annually.

8.0 ITS PROGRAM EVALUATION

Deploying ITS technologies is a pioneering effort for planning organizations. Given the short lifetime of the ITS field, it is still too early to tell which project initiatives will ultimately yield the greatest benefits to the transportation system and its users. For this reason, it is a requirement of the ITS planning process, that an ITS evaluation program be established wiith the adoption of each strategic plan.

It is recommended that the CCMPO establish a program to periodically review the performance of ITS investments it makes as the deployment plan unfolds. The evaluation should address the following aspects of each deployment:

- technical difficulties in developing specific applications
- the institutional relationships or agreements that needed to be established to deploy an ITS technology
- use of information provided though ITS by the traveling public
- assessment of the impact of ITS technologies on travel behavior
- effectiveness of information-dissemination methods (e.g. web page, variable message signs, print media, radio, etc.)

This information should be collected on a project-by-project level in order for the CCMPO to assess the benefits of a particular deployment. Cost information in the form of capital and maintenance/operation costs should be accurately tracked for each ITS project.

Ultimately, an evaluation program will require some active data collection. In this regard, it should be noted that the deployment of ITS in itself could very well help address this need. For example, the detection technologies deployed as a part of the ITS program could be used to record average speeds and volumes, which could be then be utilized to assess the success of the program. For the pre-trip traveler information system, recording the number of web-site hits, s a very simple procedure, could give an indication of the degree of public acceptance of the system.

However, there still may be a need for additional data collection efforts. This includes the conduct of special surveys or focus groups, or the collection of information through special before-after studies (e.g. delay studies within corridors where signal coordination has been implemented). Existing data collection programs, such as the accident database maintained by Vtrans, can also be used to shed light on the effect of ITS technologies in areas where safety is a concern.