Development of an Intelligent Transportation Systems (ITS) Strategic Plan for the State of Vermont

DRAFT FINAL REPORT

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Prepared For:

Vermont Agency of Transportation

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1.0 INTRODUCTION

Intelligent transportation systems (ITS) is the term used to refer to the application of information technologies to surface transportation needs, with the aim of improving the efficiency and safety of the transportation system in Vermont. While ITS cannot solve every surface transportation problem, ITS deployment does present the opportunity to aid in addressing the state's transportation problems, and in achieving broader social needs. This points to the need for developing a statewide ITS strategic plan for the state. This plan will help identify ITS applications that are most relevant to the unique nature of the state of Vermont, and the needs of its travelers. In addition, the plan will ensure that ITS deployment is conducted in an incremental, integrated fashion, and in conformity with the National ITS architecture. The current study is aimed at developing such a plan.

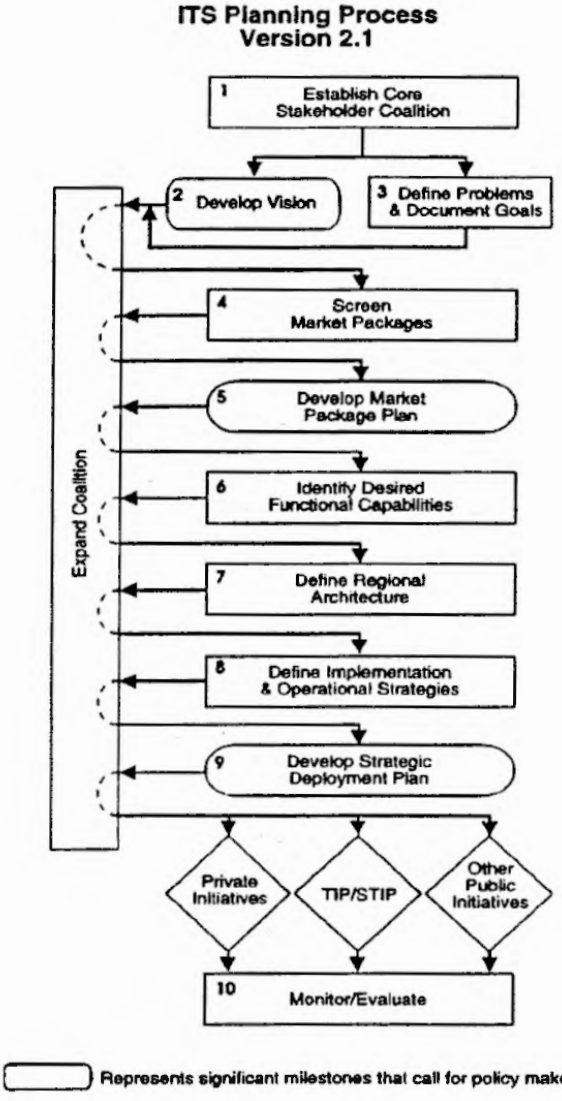
The State of Vermont presents an interesting and challenging context for developing ITS strategies because of its rather rural character, unique natural beauty, harsh winter weather and its flourishing tourism industry. Extreme congestion, which is the case in regions such as Washington, D.C. or Los Angeles, does not really exist in Vermont. While this is an advantage since it allows one to target ITS strategically, it also weakens public perception of the need for ITS deployment. Given this, the strategic ITS plan was developed around two basic principles: (1) to identify "early winners" for ITS so as to generate more public support; and (2) to deploy ITS in an incremental fashion as its benefits become more apparent to Vermonters.

1.1 Study Methodology

In developing the plan, the study followed the most recent version of the *FHWA ITS Planning Process* (Figure 1). As can be seen, the process describes a ten-task effort that starts with the establishment of the ITS stakeholder coalition, and concludes with the development of the ITS deployment plan. The process uses the concept of *ITS Market Packages* (basically, a *market package* is a collection of ITS equipment capabilities that satisfy a certain market need or help solve a particular transportation problem). The process also calls for the development of a regional ITS architecture, which has to be compatible with the National architecture, to serve as a blueprint for ITS deployment in the region.

Following the definition of a region's vision, goals and objectives, and the identification of the region's most pressing transportation problems, the process proceeds to screen the *market packages* in an effort to identify those packages that are most applicable to the region. The results of this screening step are then documented in the *Market Package Plan* (task 5). This plan, a significant milestone of the process, prioritizes the selected packages into high, medium and low priority groups, and lists the benefits to be expected from deploying each package. Task 5 marks the conclusion of the study's first phase whose focus is on general ITS concepts.

Figure 1



In the second phase of the study, which starts at task 6, the study's focus is on developing the selected market packages into a set of recommended projects. As a first step, the study defines the *functional capabilities* of the market packages (i.e. the functions needed for the package to accomplish its intended use) in task 6. In task 7, the identified functional capabilities are used to define the regional ITS architecture. A regional architecture mainly describes how individual ITS elements are linked together, and serves as a framework for the delivery of the market packages identified in the previous tasks. Without an architecture to guide the development of a new system, the system may be unable to share data, cooperate in carrying out a process, or evolve with changing practices and technology. The end product of the planning process is the strategic plan, which clearly explains how the proposed system will be implemented, operated and maintained.

Several key stakeholder groups were engaged in this planning process. At the center of these groups was the Vermont Agency of Transportation (VTrans) Executive Staff who made the core of the study's steering committee. Table 1 provides the names (in alphabetical order) and affiliations of the study's Steering Committee.

Table 1. Members of the Vermont State ITS Steering Committee

Name	Affiliation
Bruce Bender	Senior Policy Analyst, VTrans
David Dill	Director of Maintenance, VTrans
Barry Driscoll	Director of Policy and Planning, VTrans
W. Jake Elovirta	Safety Chief, Department of Motor Vehicles
Micque Glitman	Deputy Secretary of Transportation, VTrans
Samuel Lewis	Assistant Director of Project Development, VTrans
Bonnie Rutledge	Commissioner of Motor Vehicles
David Scott	Director of Project Development, VTrans
Karen Songhurst	Policy Analyst, Vtrans

The ITS Steering Committee was active over the course of the study. During this time, several meetings were held with the ITS Steering Committee, as well as with special stakeholder groups to gain input to the plan.

1.1. Organization of the Report

The current report is organized into nine sections plus three appendices. These sections are as follows.

1. *Introduction* – This introductory section briefly outlines the study's methodology in developing an ITS strategic plan for the State of Vermont, and describes the organization of the report and the content of each section.

2. *Vision, Mission, Goals and Objectives* – This section discusses the articulation of the State's vision in deploying ITS, and documents the Agency's goals and objectives that ITS could help achieve.

3. *Market Package Screening* – Section three addresses the screening of the market packages defined in the National ITS Architecture in order to identify those packages most applicable to Vermont. The section also briefly outlines the Agency's role in the deployment and operations of the selected packages.

4. *Market Package Plan* - This section documents the market package plan developed for the State, and outlines the benefits to be expected from deploying each package.

5. *Development of the Regional Architecture* - In this section, the selected market packages are used to develop the State's ITS architecture, and to identify the information flows between the different components of the state ITS system.

6. *Applicable National ITS Standards* – This section identifies those national ITS standards that are applicable to the developed statewide architecture. The section gives a brief description of each standard, followed by a list of the interfaces from the statewide architecture that the standard supports.

7. *Recommended Short-term Projects* – This section describes a list of recommended ITS projects that would help implement the state's architecture.

8. *Procurement Methods* – This section describes some of the conventional, as well as the innovative procurement methods that State DOTs around the country have experimented with in trying to procure ITS services and equipment.

9. *Recommended Actions for the Agency's ITS Program* - This final section lists some suggested actions that are intended to help implement the recommendations made by the current strategic plan.

Appendix A – This appendix contains the results of mapping the market packages against the Agency's goals and objectives.

Appendix B – This appendix lists some examples of real-world ITS projects drawn from rural states around the country.

Appendix C – This appendix includes a copy of a survey administered to the State's District Engineers. The survey solicited the engineers' opinions regarding the utility of some ITS applications and asked them to identify some candidate deployment sites for these applications.

2.0 VISION, MISSION, GOALS AND OBJECTIVES

Defining a vision for a given region ITS system is quite important since it helps identify the ITS emphasis areas that a community would like to emphasize. Given this, the purpose of this task was to arrive at an initial set of vision and goal statements for review by the project Steering Committee members. This initial set was compiled by combining insights from the following sources:

- ✓ Vermont's Long Range Transportation Plan;
- ✓ The National Advanced Rural Transportation Systems (ARTS) Program's Strategic Plan; and
- ✓ Other states' ITS strategic plans

Draft statements were developed for the vision, mission, guiding principles, goals and objectives for the state's ITS strategic plan. The statements were then presented to the steering committee members for review and approval. The adopted statements are given below.

VISION

The plan's vision for Vermont is one of:

"An improved quality of life for residents and travelers by providing more efficient and safer movement of people and goods through the judicious application of advanced ITS technologies."

MISSION

The Agency's mission is:

"To create a widespread understanding of ITS throughout Vermont so that transportation decision makers and practitioners consider and utilize ITS solutions to transportation challenges on an equal footing with other solutions, and to assure coordinated and compatible implementation of ITS projects among all partners."

GUIDING PRINCIPLES

In carrying out its mission, the Agency will be guided by the following principles, many of which are documented in the state's Long Range Transportation Plan (LRTP).

1. Make better use of the existing transportation network
2. Target investments strategically, **where they will do the most to support Vermont's quality of life and economic vitality**
3. Adopt the "Level of Improvement" (LOI) strategy. **Under this strategy, major system improvements take place in major corridors, whereas other parts of the system receive less extensive improvements depending on their significance to statewide mobility.**
4. **Deploy ITS technologies in an** incremental fashion, **as their costs and benefits are demonstrated and justified for Vermont.**
5. Provide a common framework **for the planning, deployment and integration of ITS systems through ITS architecture and standards consistency.**

GOALS AND OBJECTIVES

Safety

1. Ensure safe transportation for residents, visitors and travelers
   - Reduce weather-related traffic incidents
   - Minimize response-time for incidents and accidents
   - Reduce commercial vehicle safety violations
   - Improve emergency management communications

Mobility and Efficiency

2. Enhance Mobility
   - Enhance mobility for the transportation-disadvantaged
   - Improve access to alternative modes of transportation
   - Promote Vermont-oriented solutions to transportation problems

3. Improve efficiency of the existing transportation network
   - Improve traffic signal systems
   - Manage transportation demand
   - Enhance traffic management during road construction and special events
   - Improve intermodal connections
   - Improve efficiency of fleet operations

Economy and Environment

4. Provide a transportation system that supports economic development
   - Improve tourist access and convenience
   - Promote intermodal connectivity, coordination and choices
   - Create linkages throughout the state and globally

5. Enhance Vermont's special environment, preserve community values and reduce energy consumption
   - Reduce need to travel through telecommunication technologies
   - Reduce energy use & environmental degradation through the reduction of vehicle miles of travel
   - Improve multimodal travel
   - Enhance and support ride sharing opportunities

Coordination and Awareness

6. Create widespread understanding via awareness seminars and technical training
   - Awareness seminars throughout Vermont
   - Technical training for AOT staff and other practitioners
   - Utilize remote / distance learning tools as appropriate

7. Coordinate ITS efforts throughout the State of Vermont
   - Develop a statewide ITS steering committee
   - Assure involvement of the private and academic sectors
   - Provide an internal ITS coordination staff and budget at AOT

8. Continue regional cooperation and coordination
   - I95 Corridor Coalition participation
   - Tri-State ATIS
   - ITS America – ARTS participation, form state or regional chapter

3.0 MARKET PACKAGES SCREENING

The main purpose of this phase of the study was to screen the list of the market packages that make up the National ITS Architecture, in an effort to identify those packages that are most applicable to the State of Vermont. At the time this task was conducted, the National Architecture contained 63 market packages categorized into seven major application areas:

- ✓ Advanced Public Transportation Systems
- ✓ Advanced Traffic Management Systems
- ✓ Advanced Traveler Information Systems
- ✓ Commercial Vehicles Operation
- ✓ Advanced Vehicles Safety Systems
- ✓ Emergency Management
- ✓ ITS Planning

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, this study utilized a four-step screening process. In the first step, the market packages were mapped against the State's goals and objectives defined in a previous task of this study. In the second step, the packages were mapped against the State's identified problems. The third task then focused on studying the extent to which the different market packages enabled 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 steps were combined to select as well as to prioritize ITS market packages for the State. A brief description of each of these tasks follows.

3.1. Mapping against Goals and Objectives

In this task, each market package was matched against the goals and objectives previously defined. The idea here was to gauge the degree to which a given market package helped achieve the established goals and objectives. A ranking system of High-Medium-Low was utilized to indicate the extent to which a particular market package addressed a given objective. Ratings were based on the experience of deploying these specific market packages in other regions, modified by professional judgment. The results of this analysis can be found in Appendix A. Weights were assigned to the different goals based upon their relative importance and their relationship to one another. Specifically, the safety objectives were assigned a weight of 3.0, the mobility and efficiency a weight of 2.0, and the economy and environment objectives a weight of 1.0. 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 (a "high" was assumed to be equal to 3, a "medium" to be equal to 2, and a "low" to be equal to 1). Finally, the compliance score was scaled to a range of 0 to 10, with a 10 indicating the highest degree of compliance, and the different market packages were ranked. The final results are summarized in Table 2 below.

Table 2. Assessing Market Packages Responsiveness to Goals & Objectives

Market Package (Descending Order)	Compliance Score
Network Surveillance	10.00
Broadcast Traveler Information	9.67
Interactive Traveler Information	9.67
Incident Management	9.00
Transit Tracking	8.00
Transit Demand-Responsive Operations	7.67
Traffic Information Dissemination	7.67
Transit Fixed-Route Operations	7.00
Multi-modal Coordination	6.33
Roadway Weather Information Systems	6.33
Transit Information	5.33
Emergency Response	4.00
Emergency Routing	4.00
MayDay Support	4.00
CV Administrative Processes	3.67
Surface Street Control	3.33
Regional Traffic Control	3.33
Fleet Administration	3.33
Electronic Clearance	3.33
Weigh-In-Motion	3.33
Roadside Safety	3.33
On-board Safety Monitoring	3.33
Fleet Maintenance	3.33
HAZMAT Management	3.33
Freeway Control	3.00
Yellow Pages and Reservation	2.33
Transit Security	2.00
Transit Maintenance	2.00
Standard Railroad Crossing	2.00
International Border Crossing	2.00
Transit Passenger and Fare Management	1.33
Railroad Operations Coordination	1.00
Emissions Monitoring and Management	0.00
Freight Administration	0.00

It is noted that the Advanced Vehicle Safety Systems (AVSS) cluster was excluded from the analysis, since many of the technologies needed to implement the packages belonging to this cluster are still in the Research and Development (R&D) stage.

3.2. Mapping against Identified Problems

To ensure that ITS technologies are being deployed in response to the State's needs and problems, the study team worked with the project's steering committee to identify, in general terms, some of the most pressing transportation problems in the State. In the current task, the study focused on identifying the set of market packages that can be used to address each of the identified problems. The results of this mapping process are shown in Table 3. The last row of Table 3 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 3. Mapping Market Packages against Identified Problems

Transportation Problem	ATMS01	ATMS03	ATMS04	ATMS06	ATMS07	ATMS08	ATMS09	ATMS11	ATMS13	ATMS15	ATMS16	ATMS18	APTS1	APTS2	APTS3	APTS4	APTS5	APTS6	APTS7	APTS8
1. Need for better incident management practices	✔			✔	✔	✔						✔								
2. Need to inform drivers of expected delay & alternate routes	✔			✔																
3. Need for emergency response coordination																				
4. Need to better handle weather-related incidents				✔		✔						✔								
5. Need to make use of portable signs & VMS				✔																
6. Need to be able to communicate weather-related messages				✔								✔								
7. Need for construction zone traffic management				✔	✔	✔														
8. Need to be able to provide truckers w/ real-time information	✔			✔								✔								
9. Need to improve the safety of CVO, focusing on the driver																				
10. Need to improve CV violation enforcement																				
11. Need to provide better traveler information at exits																				
12. Need to be able to better communicate information				✔								✔								
13. Need to be able to tell people which roads are good	✔			✔								✔								
14. Need to focus on the interstate system & major roads		✔	✔																	
15. Need for better traffic management during special events	✔	✔		✔	✔															
16. Need to provide real-time info at park-and-ride facilities	✔											✔	✔							✔
17. Need for real-time transit information													✔	✔						✔
18. Need for statewide signal control		✔																		
Total Number of Problems Addressed by Market Package	**6**	**3**	**1**	**10**	**3**	**3**	**0**	**0**	**0**	**0**	**0**	**7**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**2**

Table 3. Mapping Market Packages against Identified Problems *(cont.)*

Transportation Problem	ATIS1	ATIS2	ATIS7	CVO01	CVO02	CVO03	CVO04	CVO05	CVO06	CVO07	CVO08	CVO09	CVO10	EMS1	EMS2	EMS3	ITSP
1. Need for better incident management practices														✔	✔	✔	
2. Need to inform drivers of expected delay & alternate routes	✔	✔															
3. Need for emergency response coordination														✔			
4. Need to better handle weather-related incidents	✔	✔															
5. Need to make use of portable signs & VMS																	
6. Need to be able to communicate weather-related messages	✔	✔															
7. Need for construction zone traffic management																	
8. Need to be able to provide truckers w/ real-time information	✔	✔															
9. Need to improve the safety of CVO, focusing on the driver										✔	✔	✔	✔				
10. Need to improve CV violation enforcement						✔	✔		✔								
11. Need to provide better traveler information at exits		✔	✔														
12. Need to be able to better communicate information	✔	✔	✔														
13. Need to be able to tell people which roads are good	✔	✔															
14. Need to focus on the interstate system & major roads																	
15. Need for better traffic management during special events	✔	✔															
16. Need to provide real-time info at park-and-ride facilities		✔															
17. Need for real-time transit information																	
18. Need for statewide signal control																	
Total Number of Problems Addressed by Market Package	**7**	**9**	**2**	**0**	**0**	**1**	**1**	**0**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**0**

3.3. Interrelationships among Market Packages and their Implementability

The Concept of Key Market Packages

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 the 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.

In addition to the interrelationships among ITS market packages, the deployment of these 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, the National Architecture has identified a subset of the market packages can be recognized as important early deployments or *key market packages*. In identifying these packages, each package is evaluated against the following five criteria (Table 4).

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 4. 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 4. 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			
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

Market Package	Core Function	Technology Available	Standards Not Reqd.	Institutionally Feasible	Established Benefit	Key Package
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

3.4. 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. As a first step toward this end, a combined index (CI) was developed to reflect the following two criteria:

- ✓ The degree of responsiveness of the package to the region's goals and objectiveness, as measured by the compliance score previously defined; and
- ✓ 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 (specifically, a ratio of 70/30 was adopted), since the former addresses a broader evaluation process than just the relevance to a problem. The CI ranges from a value of 10 to 0, with 10 indicating the highest level of responsiveness to goals and the greatest capacity to address problems. The following equation illustrates how CI was computed.

Composite Index (CI) = (Compliance Score X 70%) + (Number of Problems Addressed X 30%)

Table 5 shows the value of the composite Index (CI) for the different market packages. 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 5. Combined Index Market Packages Ranking

Market Packages (Descending Order)	Compliance Score	Problems Addressed	Combined Index	Key Package
Interactive Traveler Information	9.67	9	9.47	Yes
Broadcast Traveler Information	9.67	7	8.87	Yes
Network Surveillance	10.00	6	8.80	Yes
Traffic Information Dissemination	7.67	10	8.37	Yes
Incident Management	9.00	3	7.20	Yes
Roadway Weather Information Systems	6.33	7	6.53	No
Transit Tracking	8.00	2	6.20	Yes
Demand Responsive Transit Operations	7.67	0	5.37	Yes
Transit-Fixed Route Opeations	7.00	1	5.20	Yes
Multi-modal Coordination	6.33	0	4.43	No
Transit Information	5.33	2	4.33	No
Emergency Response	4.00	2	3.40	Yes
Surface Street Control	3.33	3	3.23	Yes
Regional Traffic Control	3.33	3	3.23	Yes
Emergency Routing	4.00	1	3.10	Yes
MayDay Support	4.00	1	3.10	Yes
CV Administrative Processes	3.67	1	2.87	Yes
Electronic Clearance	3.33	1	2.63	Yes
Weigh-In-Motion	3.33	1	2.63	No
Roadside CVO Safety	3.33	1	2.63	Yes
On-board CVO Safery	3.33	1	2.63	No
CVO Fleet Maintenance	3.33	1	2.63	No
HAZMAT Management	3.33	1	2.63	Yes
Freeway Control	3.00	1	2.40	Yes
Fleet Administration	3.33	0	2.33	Yes
Yellow Pages	2.33	2	2.23	No
Standard Railroad Grade Crossing	2.00	0	1.40	No
Transit Security	2.00	0	1.40	Yes
Transit Maintenance	2.00	0	1.40	Yes
International Border Crossing	2.00	0	1.40	No
Transit Passenger and Fare Management	1.33	0	0.93	Yes
Railroad Operation Coordination	1.00	0	0.70	No
Emissions Monitoring and Management	0.00	0	0.00	No
Freight Administration	0.00	0	0.00	No
ITS Planning	0.00	0	0.00	Yes

Finally, the results documented in Table 5 were used to prioritize the market packages into a proposed short-term, medium-term, and long-term implementation deployment plan, as listed below.

Short-term Packages – Initiate Deployment in 1 – 3 Years (7 packages):

ATMS Packages:

- Network Surveillance (ATMS01)
- Traffic Information Dissemination (ATMS06)
- Incident Management (ATMS08)
- Road Weather Information Systems (ATMS18)

ATIS Packages:

- Broadcast Traveler Information (ATIS1)
- Yellow Pages (ATIS7)

ITSP Packages:

- ITS Planning

Medium-term Packages – Initiate Deployment in 3 – 10 Years (11 packages):

ATMS Packages:

- Surface Street Control (ATMS3)
- Standard Railroad Grade Crossing (ATMS13)

ATIS Packages:

- Interactive Traveler Information (ATIS2)

APTS Packages:

- Transit Tracking (APTS1)
- Demand Responsive Transit Operations (APTS3)

CVO Packages:

- Electronic Clearance (CVO03)
- CV Administrative Processes (CVO04)
- Weigh-In-Motion (CVO06)
- Roadside Safety (CVO07)

EMS Packages:

- Emergency Response (EMS1)
- MayDay Systems (EMS3)

Long-term Packages – Deployment in 10+ Years (7 packages)

ATMS Packages:

- Regional Traffic Control (ATMS07)

APTS Packages:

- Transit Fixed-Route Operation (APTS2)
- Multi-modal Coordination (APTS7)
- Transit Information (APTS8)

CVO Packages:

- International Border Crossing (CVO05)
- HAZMAT Management (CVO10)

EMS Packages:

- Emergency Routing (EMS2)

3.5. The Agency's Role in the Deployment and Operation of the Market Packages

In the deployment and operation of the selected market packages listed above, VTrans will have to assume a *lead* role for some packages, and a *support* role for others. Under a *lead* role, the Agency will be responsible for providing funding, technical guidance, and project management. The Agency will also be responsible for the operation and maintenance of the system. Under the *support* role, the agency will be required to only provide financial and/or technical guidance. Support-type projects may also require the agency to develop partnerships with other public as well as private entities. Table 6 below categorizes the selected market packages based upon the Agency's role (lead vs. support) in their deployment and operation.

Table 6. Agency's Role in the Deployment and Operation of the Market Packages

Market Package	Agency's Role
SHORT-TERM PACKAGES	
ATMS Packages:	
Network Surveillance	LEAD
Traffic Information Dissemination	LEAD
Incident Management	LEAD
Road Weather Information Systems	LEAD
ATIS Packages:	
Broadcast Traveler Information	LEAD
Yellow Pages	SUPPORT
ITSP Packages:	
ITS Planning	LEAD
MEDIUM-TERM PACKAGES	
ATMS Packages:	
Surface Street Control	SUPPORT
Standard Railroad Grade Crossing	LEAD
ATIS Packages:	
Interactive Traveler Information	SUPPORT
APTS Packages:	
Transit Tracking	SUPPORT
Demand Responsive Operations	SUPPORT
CVO Packages	
Electronic Clearance	LEAD
CV Administrative Processes	LEAD
Weigh-In-Motion	LEAD
Roadside Safety	LEAD
EMS Packages:	
Emergency Response	SUPPORT
MayDay Systems	SUPPORT

LONG-TERM PACKAGES	
ATMS Packages:	
Regional Traffic Control	LEAD
APTS Packages:	
Transit Fixed-Route Operation	SUPPORT
Multi-modal Coordination	SUPPORT
Transit Information	SUPPORT
CVO Packages:	
Roadside Safety	LEAD
HAZMAT Management	SUPPORT
Electronic Clearance	SUPPORT
EMS Packages:	
Emergency Routing	SUPPORT

The next section documents the Market Package Plan (sometimes called the ITS Concepts Plan) developed for the State of Vermont. This plan briefly describes each market package, and identifies some of the likely benefits of the package. Examples of real-world ITS projects, drawn from rural states across the country, are included in Appendix B to give a feel for the design and deployment options available for the market packages.

4.0. MARKET PACKAGE PLAN

A. SHORT-TERM PACKAGES:

A.1. ATMS Packages:

A.1.1. 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 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.

ATMS1 - Network Surveillance

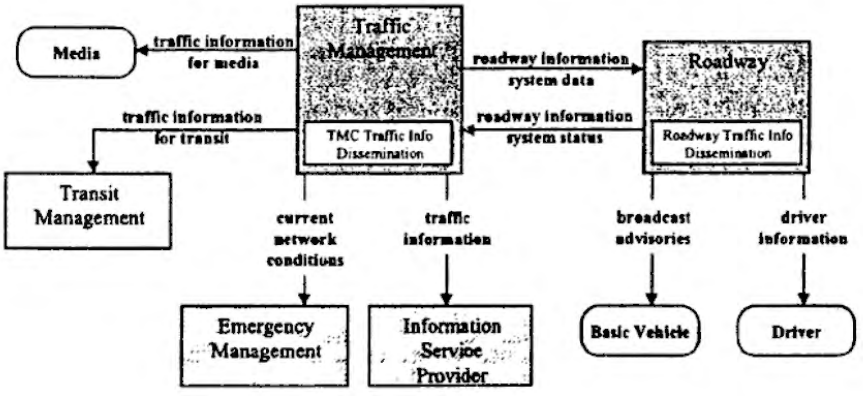
Potential Benefits:

Data support for other ATMS services.

A.1.2. 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.

ATMS6 Traffic Information Dissemination



Potential Benefits:

Reduced travel time

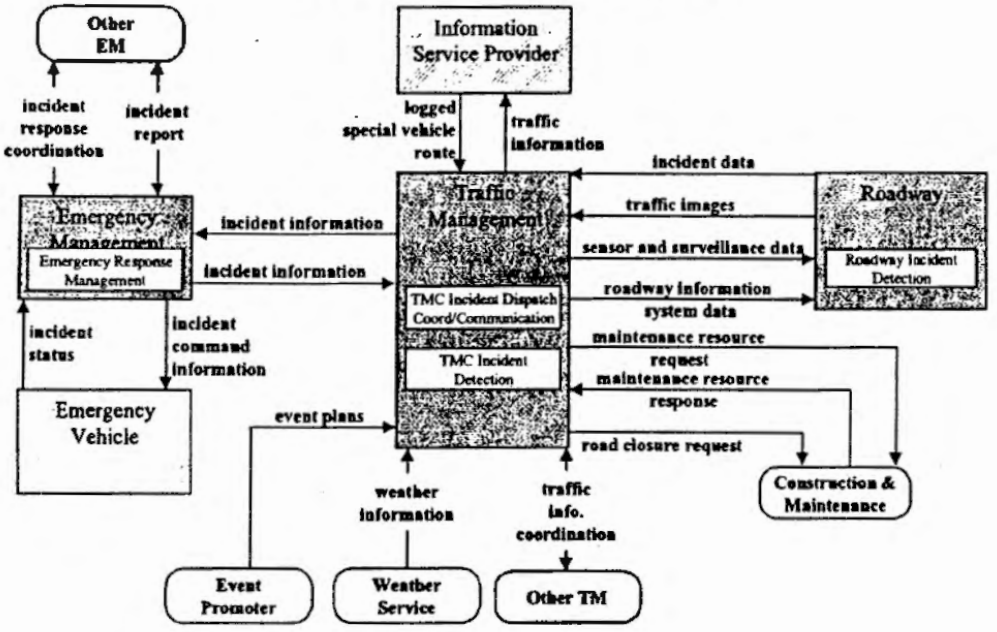
Reduced delay

Fewer secondary incidents

A.1.3. 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.

ATMS8 - Incident Management System



Potential Benefits:

Reduced delay, less secondary incidents

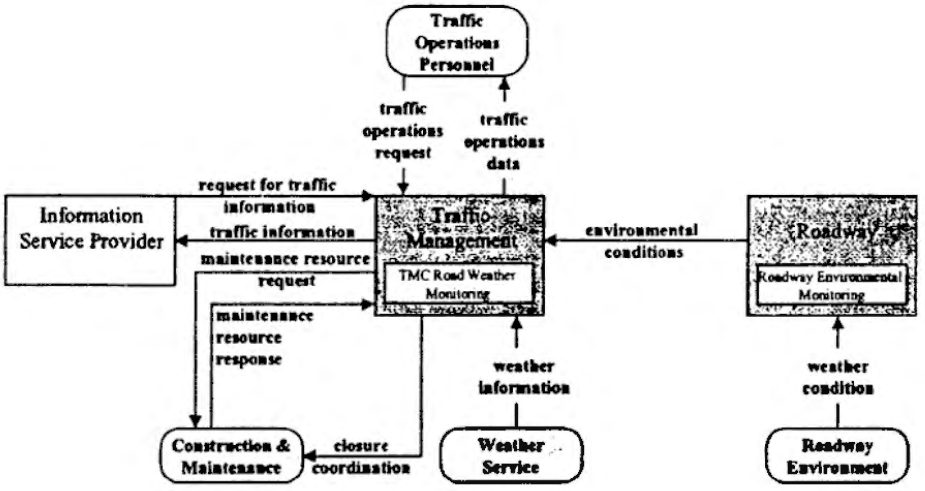
Lower response time

Improved travel time, reduced delays

A.1.4. 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.

ATMS18 - Road Weather Information System



Potential Benefits:

Improved productivity and efficiency

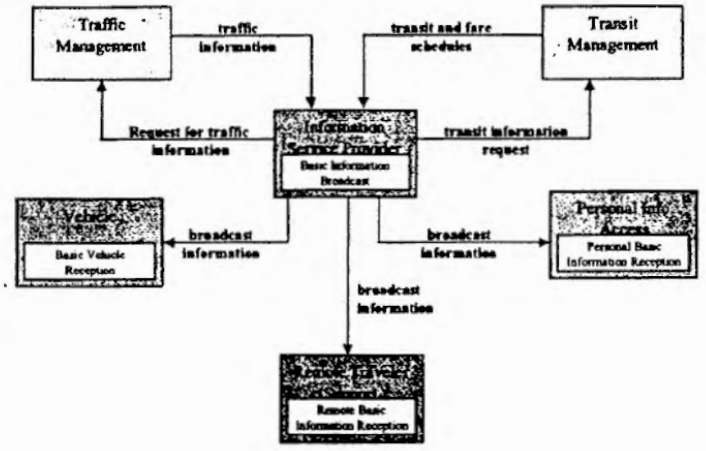
Reduction in weather-related accidents

A.2. ATIS Packages:

A.2.1. 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 VMS 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.

ATIS1 - Broadcast Traveler Information



Potential Benefits:

Reduction in travel time, with primary value for incident-related (i.e. accidents, weather, special events) traffic delays.

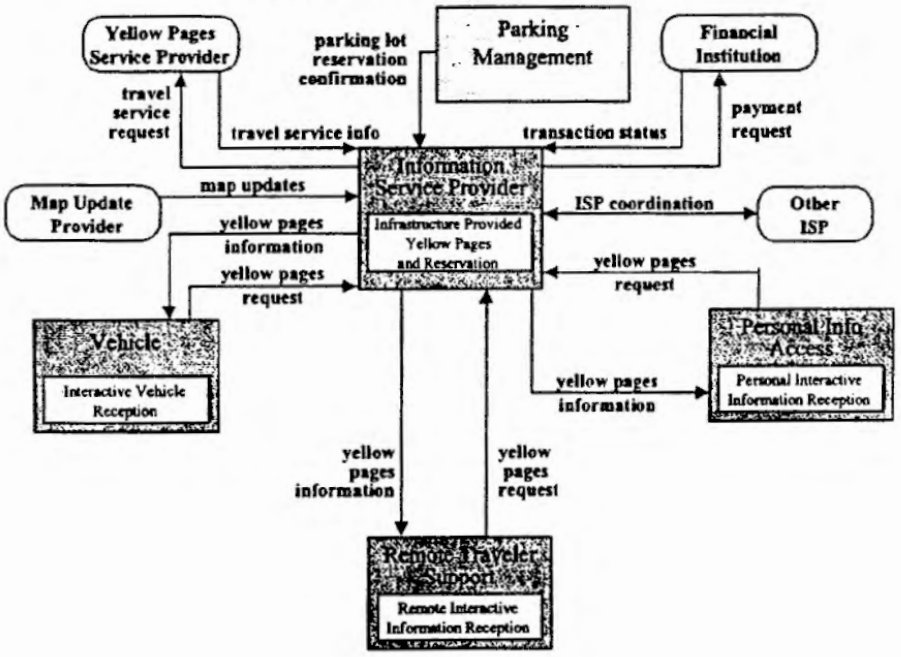
Predictable travel time

Higher benefits to travelers with long trips, multiple mode and route alternatives.

A.2.2. Yellow Pages (ATIS7)

This market package enhances the Interactive Traveler Information package by making infrastructure provided yellow pages and reservation services available to the user. The same basic user equipment is included. This market package provides multiple ways for accessing information either while en-route in a vehicle using wide-area wireless communications or pre-trip via wireline connections.

ATIS7 - Yellow Pages and Reservation



Potential Benefits:

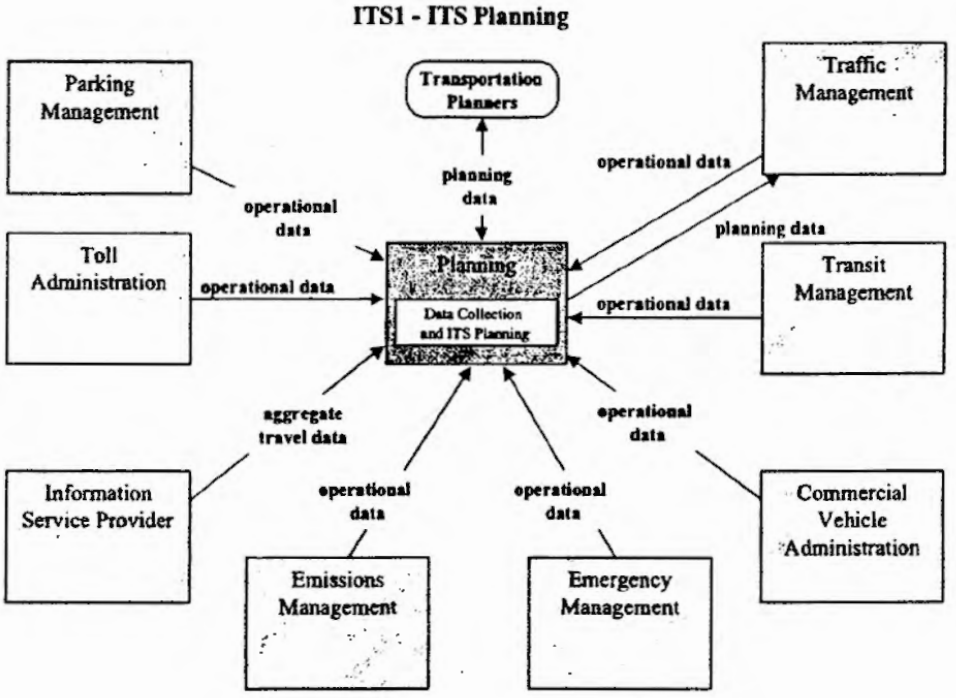
Tourism promotion

Economic Development

A.3. ITSP PACKAGES

A.3.1. ITS Planning (ITSP1)

This market package supports ITS planning functions. It accepts data from every center subsystem and uses this data to plan new deployments. This data also supports policy decision making, allocation of funding, allocation of resources and other planning activities.



Potential Benefits:

Reduction in cost of data collection

More effective transportation planning

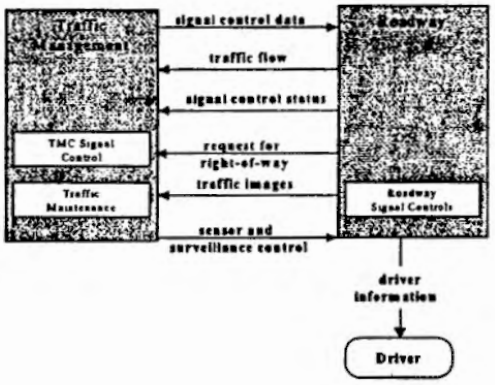
B. MEDIUM-TERM PACKAGES

B.1. ATMS Packages:

B.1.1. 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.

ATMS3 - Surface Street Control



Potential Benefits:

Reduction in travel time

Reduction in queue time

Increase in speeds

Reduction in stops

Reduction in fuel consumption

Reductions in VMT, HC and CO emissions

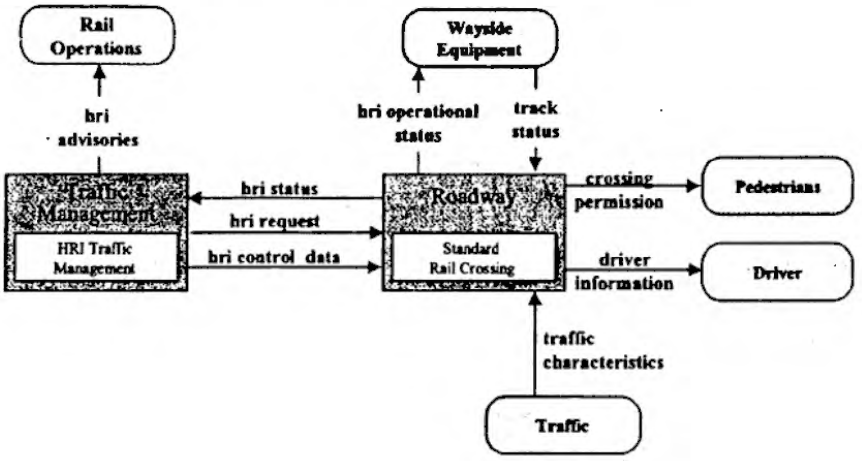
Reduction in intersection-related accident rates (especially left-turn accidents)

Significant benefit-cost ratio

B.1.2. Standard Railroad Grade Crossing (ATMS13)

This market package manages highway traffic at highway-rail intersections (HRIs) where operational requirements do not dictate more advanced features (e.g., where rail operational speeds are less than 80 miles per hour). Both passive (e.g., the crossbuck sign) and active warning systems (e.g., flashing lights and gates) are supported. (Note that passive systems exercise only the single interface between the roadway subsystem and the driver in the architecture definition.) These traditional HRI warning systems may also be augmented with other standard traffic management devices. The warning systems are activated on notification by interfaced wayside equipment of an approaching train. The equipment at the HRI may also be interconnected with adjacent signalized intersections so that local control can be adapted to highway-rail intersection activities. Health monitoring of the HRI equipment and interfaces is performed; detected abnormalities are reported to both highway and railroad officials through wayside interfaces and interfaces to the traffic management subsystem. Similar interfaces and services are provided for other types of multimodal crossings (e.g., draw bridges).

ATMS13 - Standard Railroad Grade Crossing



Potential Benefits:

Improved safety level at HRI

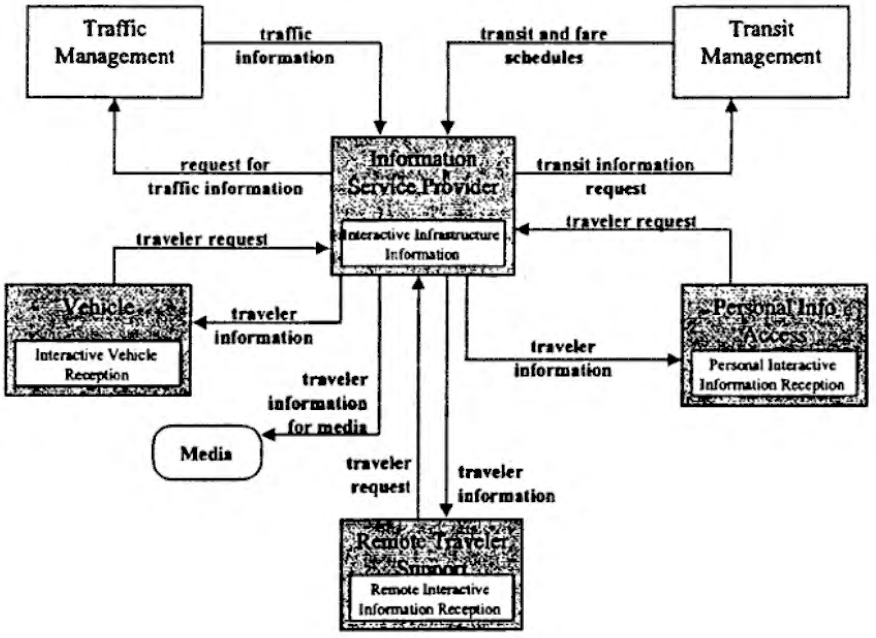
Condition of rail roadside equipment can be monitored

B.2. ATIS Packages:

B.2.1. 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.

ATIS2 - Interactive Traveler Information



Potential Benefits:

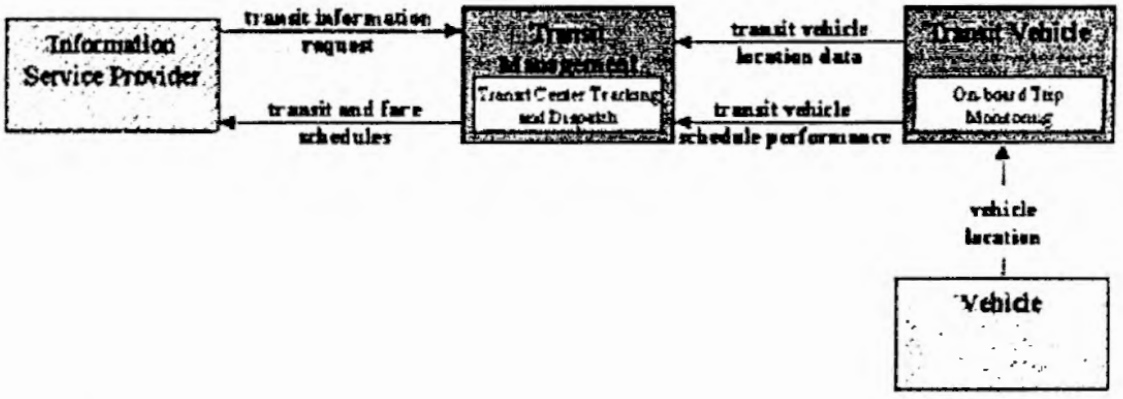
Similar to ATIS1

B.3. APTS Packages:

B.3.1. 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. .

APTS1 - Transit Vehicle Tracking



Potential Benefits:

Improvement in vehicle on-time performance

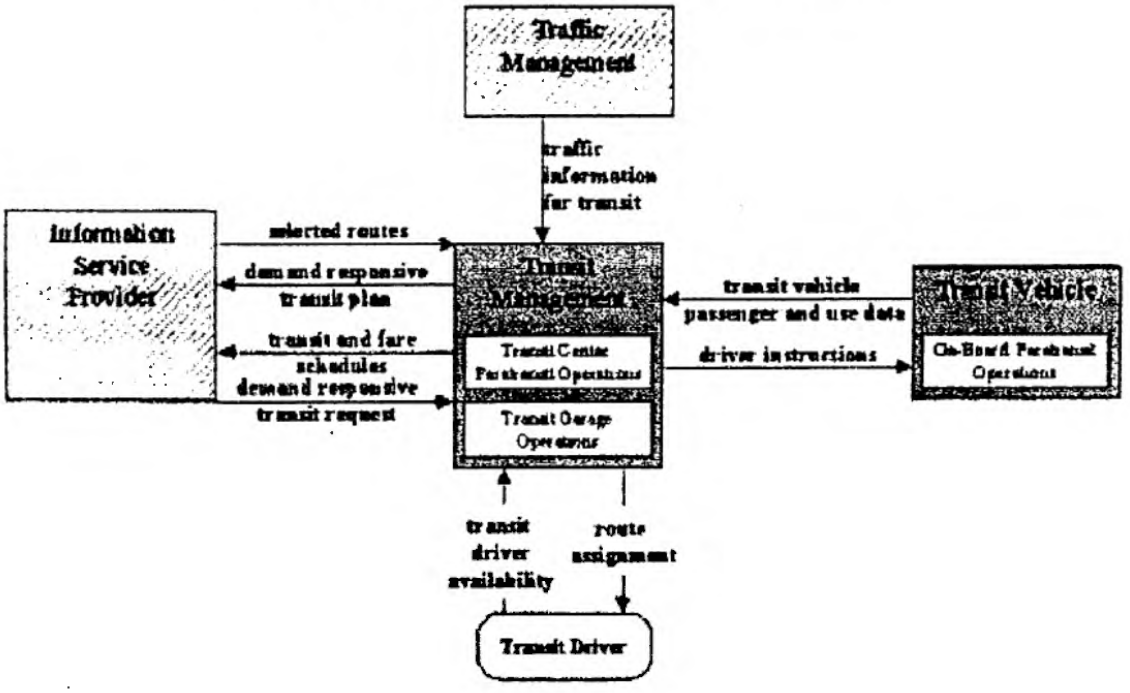
Reductions in field supervision

Higher benefits to areas with significant transit service reliability problems

B.3.2. 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.

APTS3 - Demand Response Transit Operations



Potential Benefits:

Improved productivity of vehicles and labor

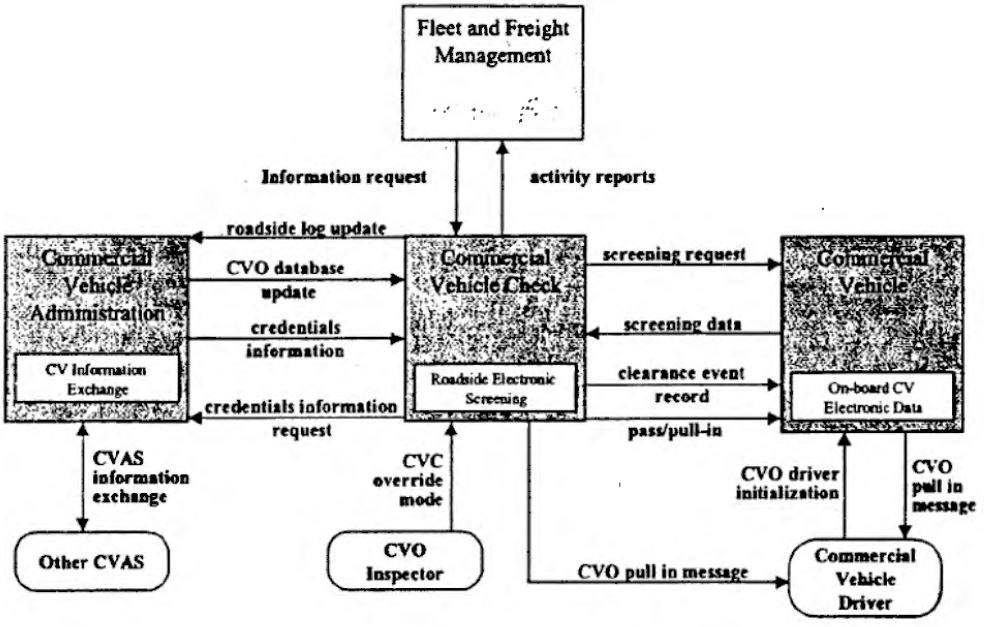
Efficiencies in routing and trip scheduling

B.4. CVO Packages:

B.4.1. Electronic Clearance (CVO03)

This market package provides for automated clearance at roadside check facilities. The roadside check facility communicates with the Commercial Vehicle Administration subsystem over wireline to retrieve infrastructure snapshots of critical carrier, vehicle, and driver data to be used to sort passing vehicles. This package allows a good driver/vehicle/carrier to pass roadside facilities at highway speeds using transponders and dedicated short range communications to the roadside. The roadside check facility may be equipped with AVI, weighing sensors, transponder read/write devices, computer workstation processing hardware, software, and databases.

CVO03 - Electronic Clearance



Potential Benefits

Reduction or elimination of border clearance time

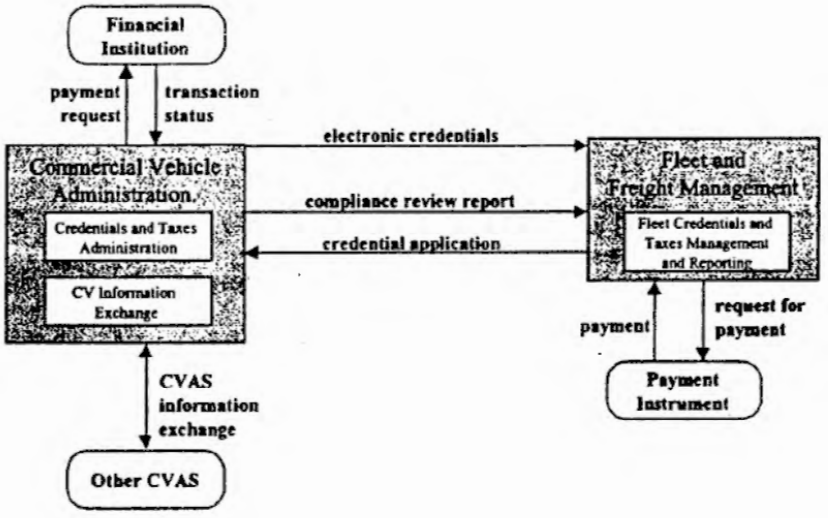
Reduction in commercial and administrative costs

Improvements in vehicle and driver productivity

B.4.2. CV Administrative Processes (CVO04)

This market package provides for electronic application, processing, fee collection, issuance, and distribution of CVO credential and tax filing. Through this process, carriers, drivers, and vehicles may be enrolled in the electronic clearance program provided by a separate market package which allows commercial vehicles to be screened at mainline speeds at commercial vehicle check points. Through this enrollment process, current profile databases are maintained in the Commercial Vehicle Administration Subsystem and snapshots of this database are made available to the commercial vehicle check facilities at the roadside to support the electronic clearance process.

CVO04 - CV Administrative Processes



Potential Benefits

Significant cost savings for commercial vehicle operators and regulatory agencies

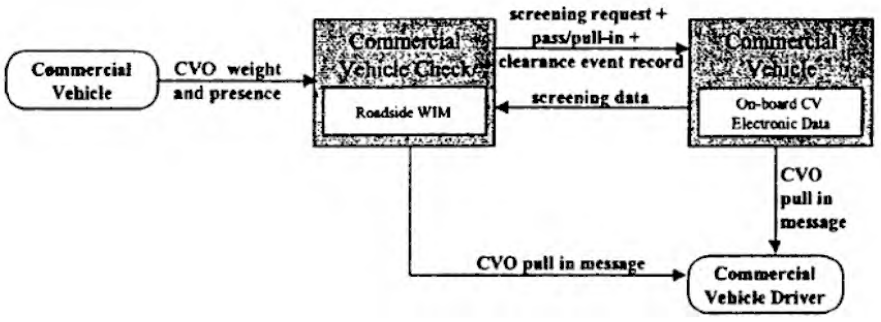
Reduced HAZMAT incidents

Reduced tax evasion

B.4.3. Weigh-In-Motion (CVO06)

This market package provides for high speed weigh-in-motion with or without AVI attachment. Primarily this market package provides the roadside with additional equipment, either fixed or removable. If the equipment is fixed, then it is thought to be an addition to the electronic clearance and would work in conjunction with the AVI and AVC equipment in place.

CVO06 - Weigh-In-Motion



Potential Benefits

Reduction in vehicle weighing times

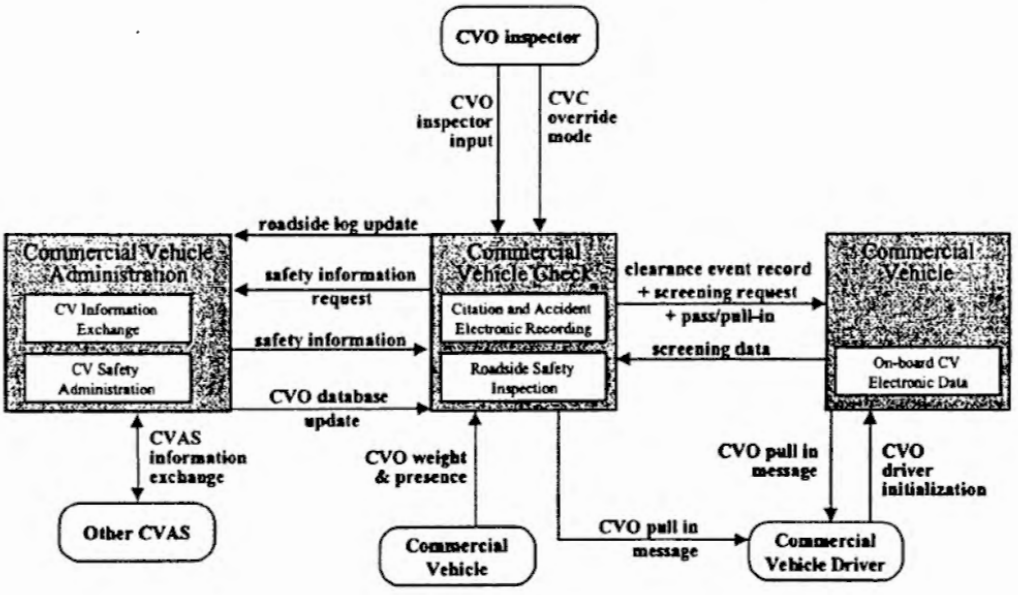
Reduction in commercial and public administrative costs

Improvements in vehicle and driver productivity

4.4. Roadside Safety (CVO07)

This market package provides for automated roadside safety monitoring and reporting. It automates commercial vehicle safety inspections at the Commercial Vehicle Check roadside element. The capabilities for performing the safety inspection are shared between this market package and the On-Board CVO Safety Market Package, which enables a variety of implementation options. The basic option, directly supported by this market package, facilitates safety inspection of vehicles that have been pulled in, perhaps as a result of the automated screening process provided by the Electronic Clearance Market Package. In this scenario, only basic identification data and status information is read from the electronic tag on the commercial vehicle. The identification data from the tag enables access to additional safety data maintained in the infrastructure which is used to support the safety inspection, and may also inform the pull-in decision if system timing requirements can be met. More advanced implementations, supported by the On-Board CVO Safety market package, utilize additional vehicle safety monitoring and reporting capabilities in the commercial vehicle to augment the roadside safety check.

CVO07 - Roadside CVO Safety



Potential Benefits

Reduction in safety inspection times

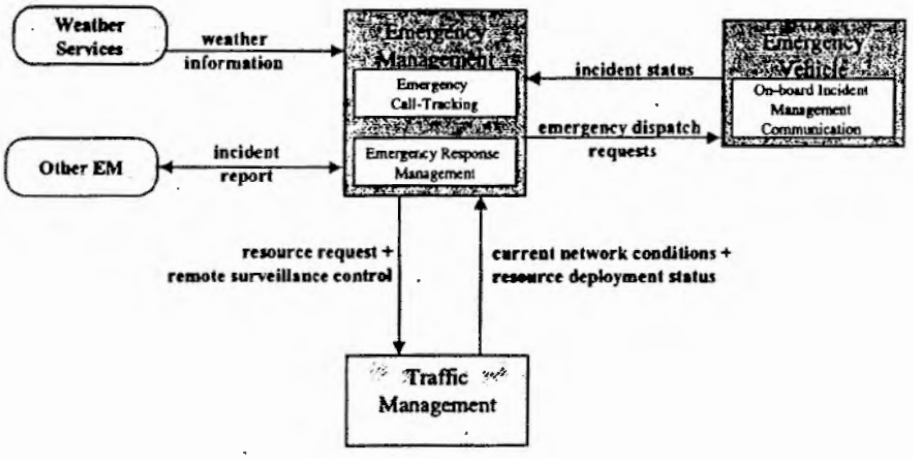
Reduction in commercial vehicles accidents

B.5. EMS Packages:

B.5.1. 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.

EM1 - Emergency Response



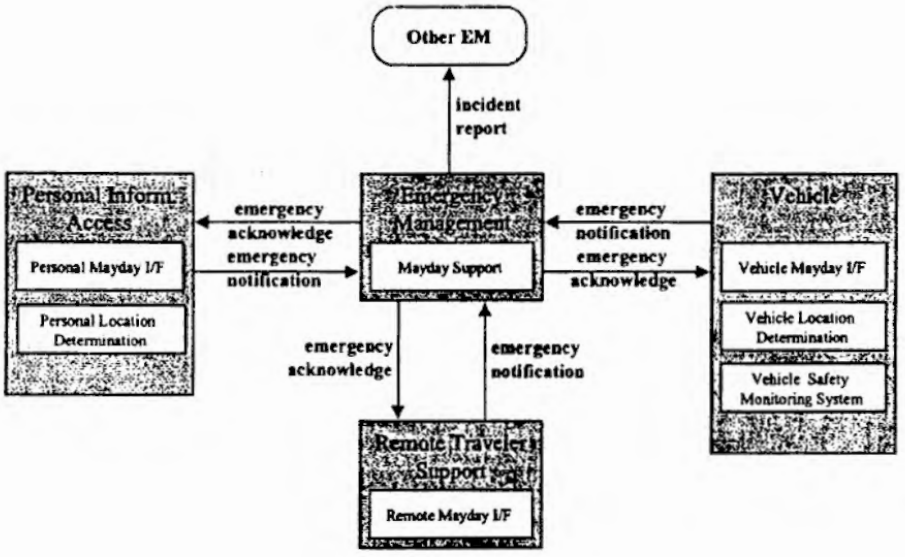
Potential Benefits

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

B.5.2. 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.

EM3 - Mayday Support



Potential Benefits:

Reduction in response time

Improved safety and security

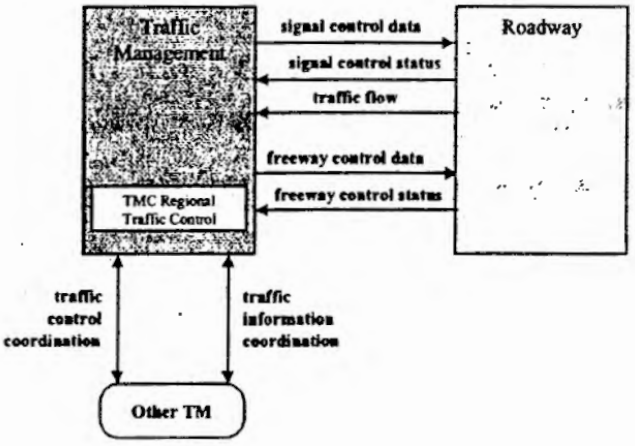
C. LONG-TERM PACKAGES

C.1. ATMS Packages:

C.1.1. 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.

ATMS7 - Regional Traffic Control



Potential Benefits:

Reduction in travel time

Reduction in queue time

Increase in speeds

Reduction in stops

Reduction in fuel consumption

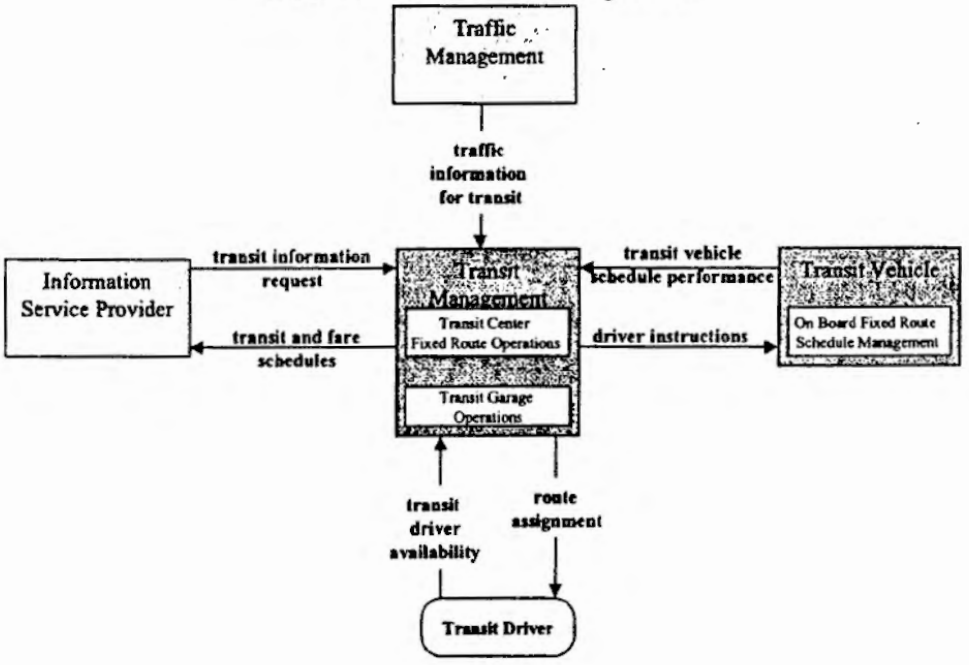
Reductions in VMT, HC and CO emissions

C.2. APTS Packages:

C.2.1. 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.

APTS2 - Transit Fixed-Route Operations



Potential Benefits:

Improved productivity of vehicles and labor.

Improved mobility of customers and employees

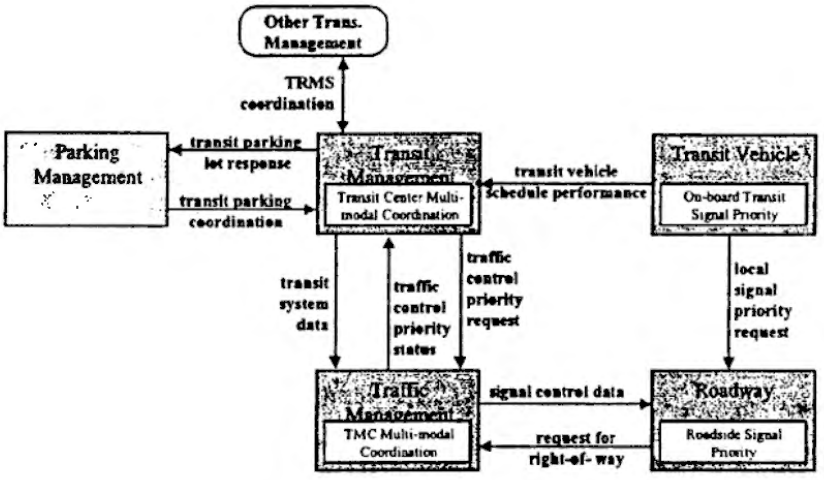
Improved travel time, reduced wait times

Improved ridership

C.2.2. 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. Local coordination between the transit vehicle and the individual intersection for signal priority is also supported by this package.

APTS7 - Multi-Modal Coordination



Potential Benefits:

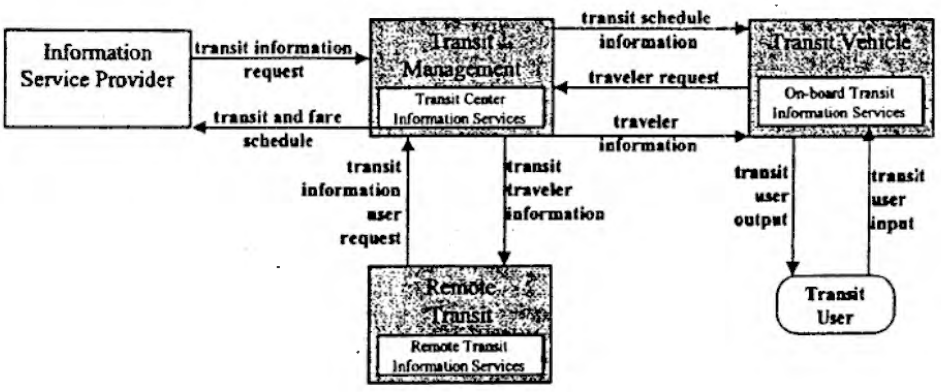
Improved on-time performance for transit

Increased ridership

C.2.3. 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.

ATPS8 - Transit Traveler Information



Potential Benefits:

Increased customer satisfaction

Increased ridership

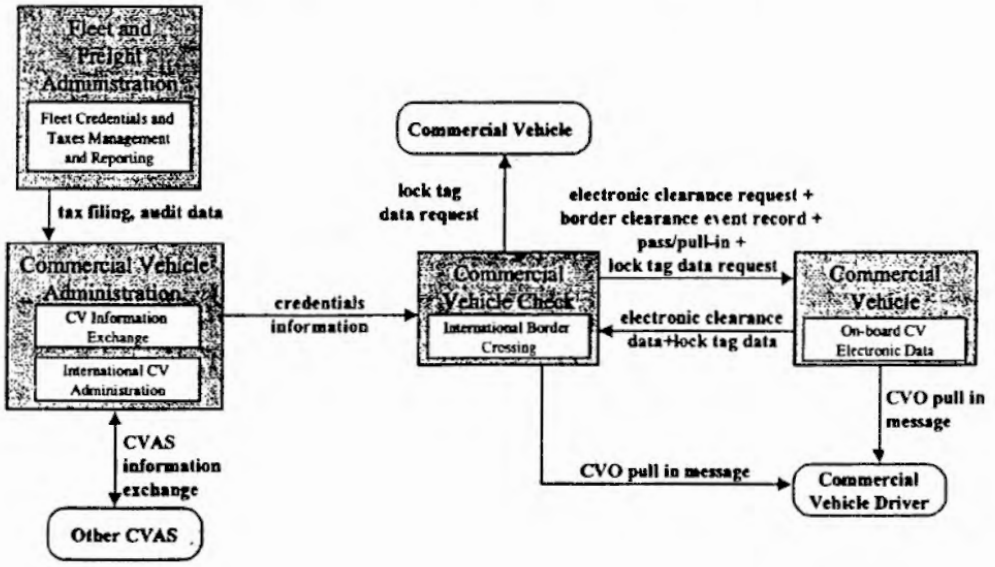
Reduced wait time

C.3. CVO Packages:

C.3.1. International Border Crossing (CVO05)

This market package provides for automated clearance specific to international border crossings. This package augments the electronic clearance package by allowing interface with customs related functions and permitting NAFTA required entry and exit from the US to Canada and Mexico.

CVO05 - International Border Electronic Clearance



Potential Benefits:

Reduction or elimination of border clearance time

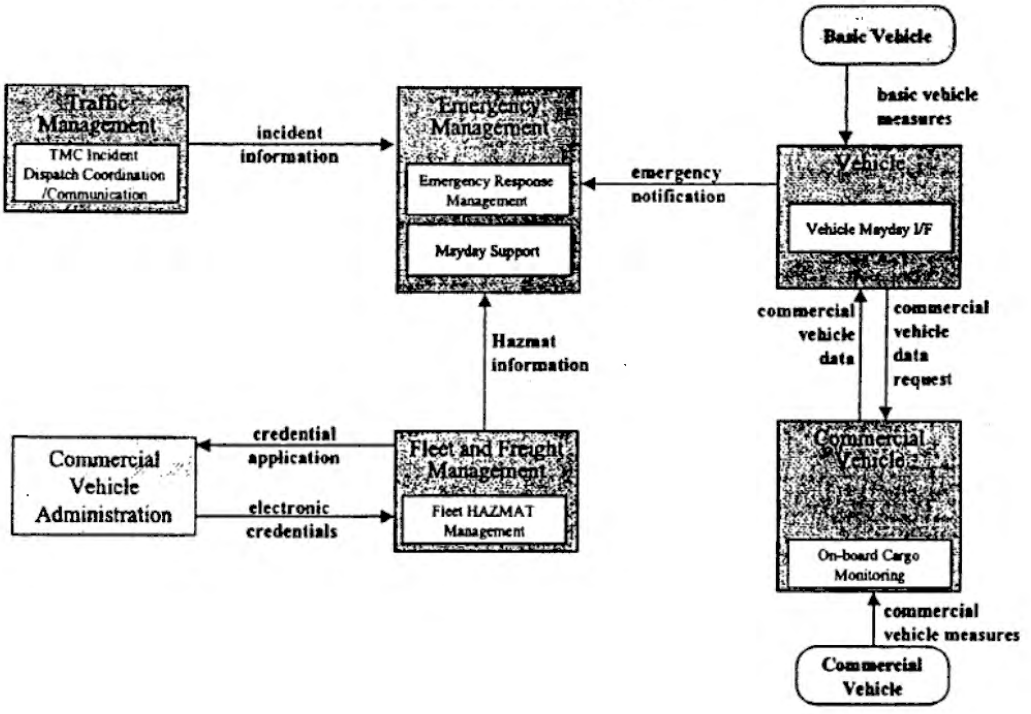
Reduction in commercial and public administrative costs

Improvements in vehicle and driver productivity

C.3.2. HAZMAT Management (CVO10)

This market package integrates incident management capabilities with commercial vehicle tracking to assure effective treatment of HAZMAT material and incidents. HAZMAT tracking is performed by the Fleet and Freight Management Subsystem. The Emergency Management subsystem is notified by the Commercial Vehicle if an incident occurs and coordinates the response. The response is tailored based on information that is provided as part of the original incident notification or derived from supplemental information provided by the Fleet and Freight Management Subsystem. The latter information can be provided prior to the beginning of the trip or gathered following the incident depending on the selected policy and implementation.

CVO10 - HAZMAT Management



Potential Benefits

Faster and more appropriate response to HAZMAT incidents

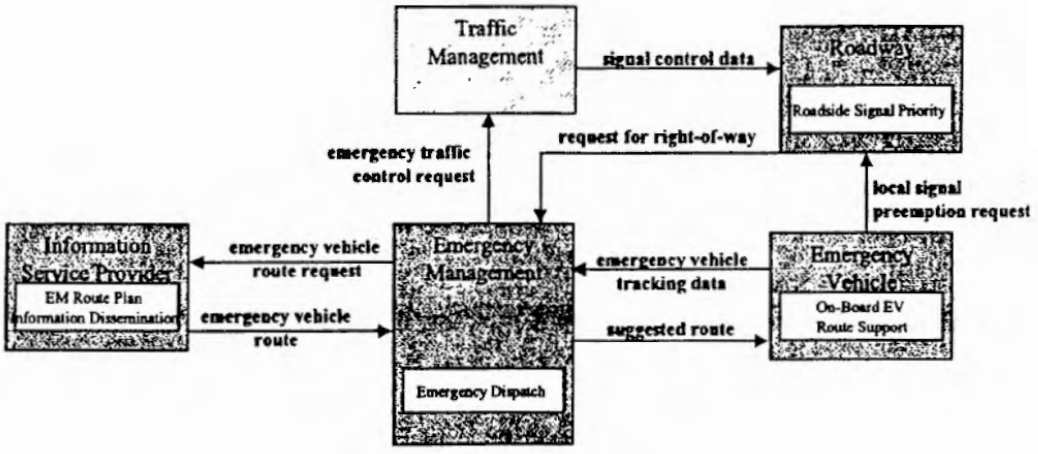
Reduction in number of accidents

C.4. EMS Packages:

C.4.1. 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.

EM2 - Emergency Routing



Potential Benefits:

Anticipated shorter response times. However, no formal evaluation of benefits is currently available.

5.0. DEVELOPMENT OF THE REGIONAL ARCHITECTURE

5.1. The District Engineers Survey

With the market package plan developed, the focus of the study shifted to developing the selected packages into actual projects, and combining the packages into a statewide architecture that defines how the different projects relate to one another. As a first step toward this goal, a short survey was administered to the State District Engineers (DTAs). The survey asked the DTAs to rate nine different ITS applications on a scale of 5 to 1 (with 5 indicating the most useful, and 1 indicating the least). The survey also asked them to identify some locations within their districts where these applications would be quite useful. Table 7 below lists the nine ITS applications considered, along with the market package code, from the National Architecture, that corresponds to each application.

Table 7. ITS Applications Rated in the Survey

ITS Application	Market Package Code
1) Real-time Surveillance of Traffic Conditions	ATMS01
2) Traffic Information Dissemination	ATMS06
3) Incident Management	ATMS08
4) Road Weather Information Systems	ATMS18
5) Advanced Traffic Signal Systems	ATMS03
6) Pre-trip Traveler Information Systems	ATIS1/ATIS2
7) Portable Event Management Systems	ATMS12
8) Fleet Management Systems	Not yet defined in N.A.
9) Standard Railroad Crossing Package	ATMS13

A copy of the administered survey can be found in Appendix C of this report.

5.1.1. Results and Uses of the Survey

A summary of the survey results are shown in Table 8 below, which gives the average score for each application (as previously mentioned, a 5 indicates that the application is most useful, and a 1 that it is least useful. As can be seen, the survey results match very closely the results from the 4-step screening process described above. This was quite reassuring since it helped increase our confidence in the soundness of the choices made in selecting the market packages. In addition, the survey helped the study identify a set of potential sites for the deployment of the market packages. This information was quite useful in defining recommended ITS projects, as will be described in more detail later in this report.

Table 8. Packages' Average Rating Score (Descending Order)

ITS Application	Average Score
Road Weather Information Systems – ATMS18	4.00
Traffic Information Dissemination – ATMS06	3.91
Network Surveillance – ATMS01	3.18
Pre-trip Traveler Information – ATIS1	3.14
Incident Management – ATMS08	2.86
Advanced Traffic Signal Systems – ATMS03	2.55
Fleet Management Systems	2.45
Portable Traffic Management – ATMS12	2.27
Standard Railroad Crossings - ATMS13	1.82

5.2. The Regional ITS Architecture

A regional ITS 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.

5.2.1. Benefits of Developing a Regional ITS Architecture

While a regional architecture does not specify the exact design approach for ITS, the development of a regional architecture is likely to yield many benefits to a region as it starts developing and acquiring systems. Some of these benefits are summarized below.

Interoperability of Systems - ITS provides transportation professionals with a wide variety of options to address their needs. Given this, a common architecture and a set of standards are desperately needed in order to ensure that the systems deployed in the different regions around the country are compatible with one another, and can communicate with one another. The importance of system "interoperability" in the context of ITS cannot be overemphasized. For ITS to succeed, a driver purchasing an in-vehicle display device in state A, for example, should be able to use his/her device to communicate with roadside equipment in state B. As can readily be seen, this is only possible if the two systems, in states A and B, are compatible with one another at the systems' interface level. To make sure this is the case, a system architecture is needed to help identify the interfaces (information flows) that need to be standardized.

System Integration – The real advantage of deploying ITS becomes more obvious when the different ITS systems are capable of sharing and exchanging information. For example, the information collected by a traffic control system can be very useful to an emergency management center in trying to determine the fastest route for an emergency vehicle to reach an accident scene. At the same time, the information collected by the emergency management center on incidents can be used by a traffic control center to adjust signal timings in response to the incident. The process of linking the different components of a system together is typically referred to as the process of "system integration", and in the recent years, has become an issue of great importance as more and more ITS components were being deployed. A regional architecture, by its very nature, is an indispensable tool for the success of this process. As previously mentioned, one of the main objectives behind developing an architecture is to describe how the different components of a system are supposed to interact with one another.

Improved Design Reliability – Developing a regional ITS architecture helps define a logical implementation path for ITS deployment. Without the architecture, there is a risk of "patch work" of unrelated systems that must be modified. The architecture, coupled with testing requirements and criteria, will ensure a successful design and implementation of the systems because flaws are identified before the full implementation is completed. This removes the possibility that a design improvement "patch" is quickly created to resolve the design issue, but instead promotes good design practices that remove error early in the development life cycle.

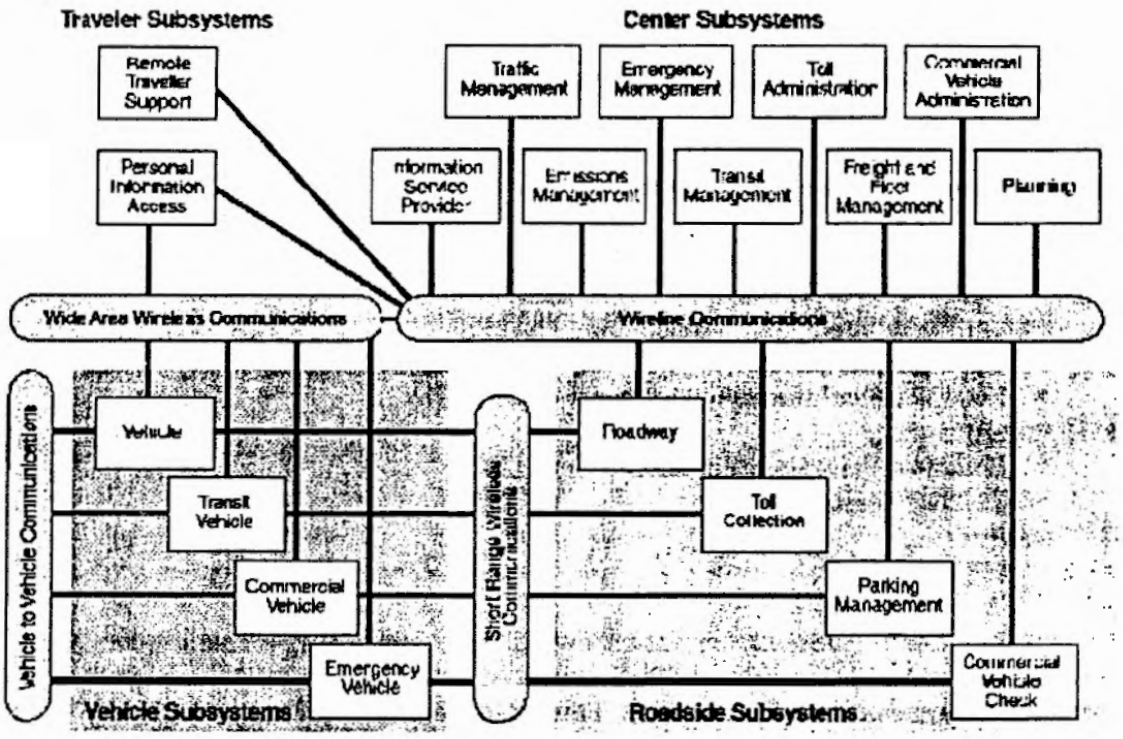
Support to Resource Sharing Initiative - The preferred approach to the resource sharing process is first to define the Region's telecommunication needs and to develop potential network architecture. This prepares the Region to negotiate with the private industry. By having the architecture before going to a resource sharing agreement with private enterprises, the stakeholders will have better understanding of needs for negotiating.

Reduced Development Cost - The regional ITS architecture provides a description of the Concept of Operations of the system, along with its Functional Requirements. This helps facilitate the later system design phase, because the higher level needs are already defined in the architecture. It also eliminates the misinterpretation of high-level system needs in design.

Greater Interaction among Regional Entities and Institutions – While each individual agency in the region will interact with the deployed systems in a unique fashion to address its individual needs, the sharing of the systems among the different business units is likely to foster a greater sense of unity. This is because access to vital information will be provided to everyone on an equal basis. The ITS architecture will also assist in identifying institutional interdependencies that exist in the region, and how agencies can benefit from each other's activities.

Figure 1 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 1. 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 1 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.

5.3. Vermont's Short-term Statewide ITS Architecture

In an earlier phase, the current study had identified a set of ITS market packages for potential short-term deployment. These packages were:

ATMS Packages:
- Network Surveillance (ATMS01)
- Traffic Information Dissemination (ATMS06)
- Incident Management (ATMS08)
- Road Weather Information Systems (ATMS18)

ATIS Packages:
- Broadcast Traveler Information (ATIS1)
- Yellow Pages (ATIS7)

ITSP Packages:
- ITS Planning

With the packages selected, the next step was to develop the regional physical architecture. As can be seen, not all of the 19 subsystems of the National Architecture are needed for Vermont's short-term regional architecture. For example, Vermont does not have any toll collection facilities, and hence the toll administration center is not required. To develop the state's architecture, this study utilized the Turbo Architecture software tool developed by ITERIS for the FHWA. Turbo Architecture is a planning and integration aid designed to facilitate usage of the National Architecture.

Three types of architecture diagrams are provided in this section for the statewide short-term architecture, namely the sausage diagram, the interconnect diagram, and the flow diagram. The sausage diagram (Figure 2) is a high-level diagram of the statewide architecture, similar to Figure 1 above of the National architecture, showing the ITS subsystems. The interconnect diagram (Figure 3) shows the different ITS elements and their interconnections. Finally, the flow diagram (Figure 4) shows the flow of information between the different elements.

Figure 2. Short-term Statewide Architecture (Sausage Diagram)

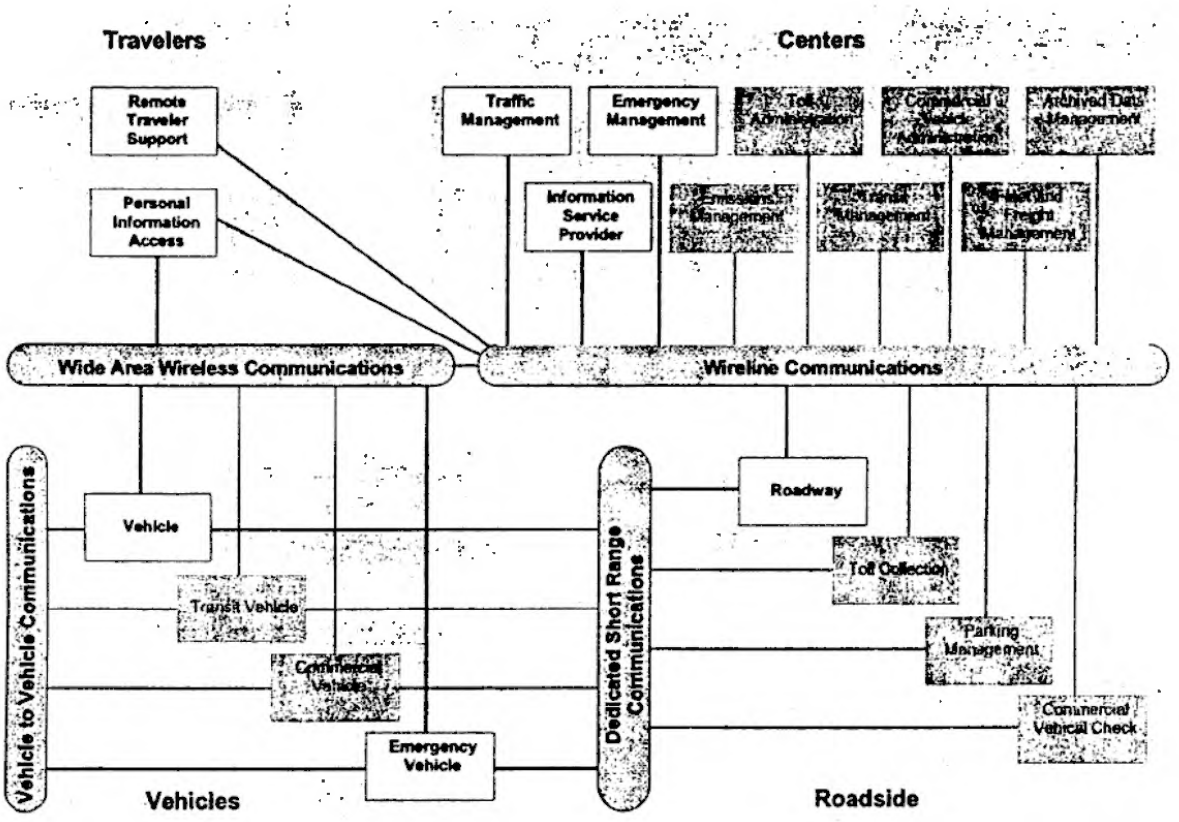


Figure 3. Short-term Statewide Architecture (Interconnect Diagram)

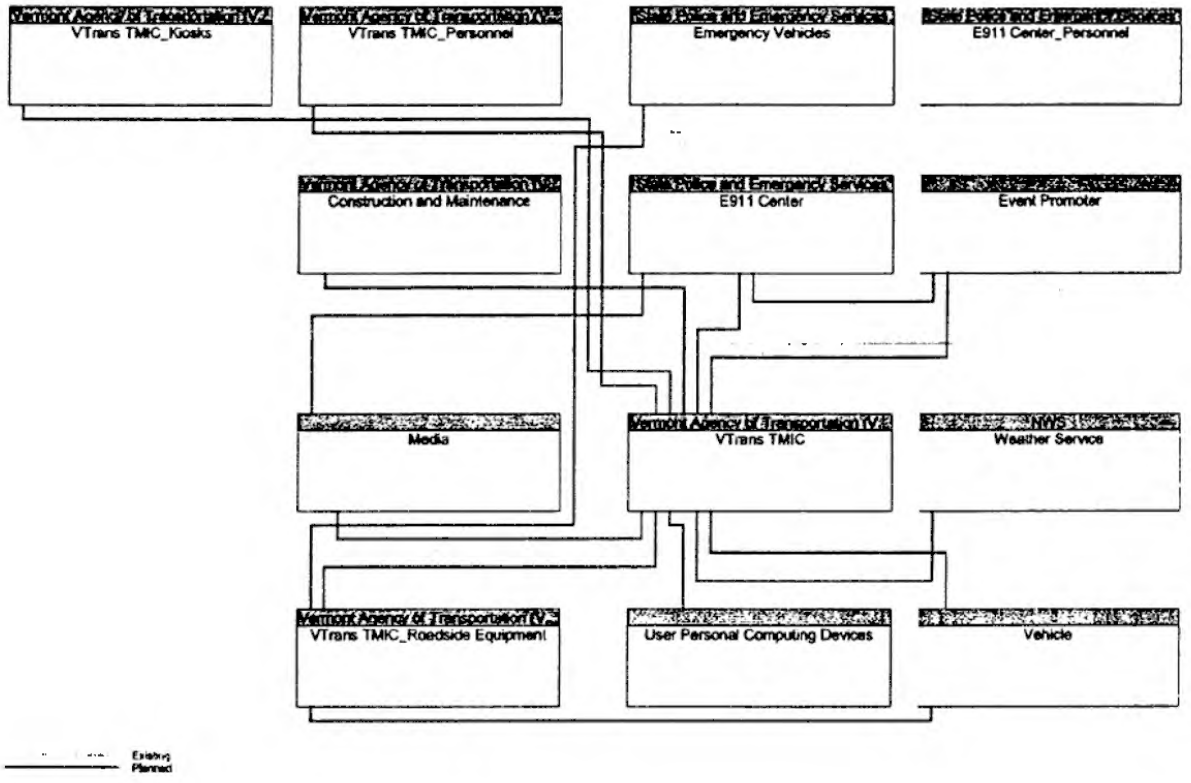
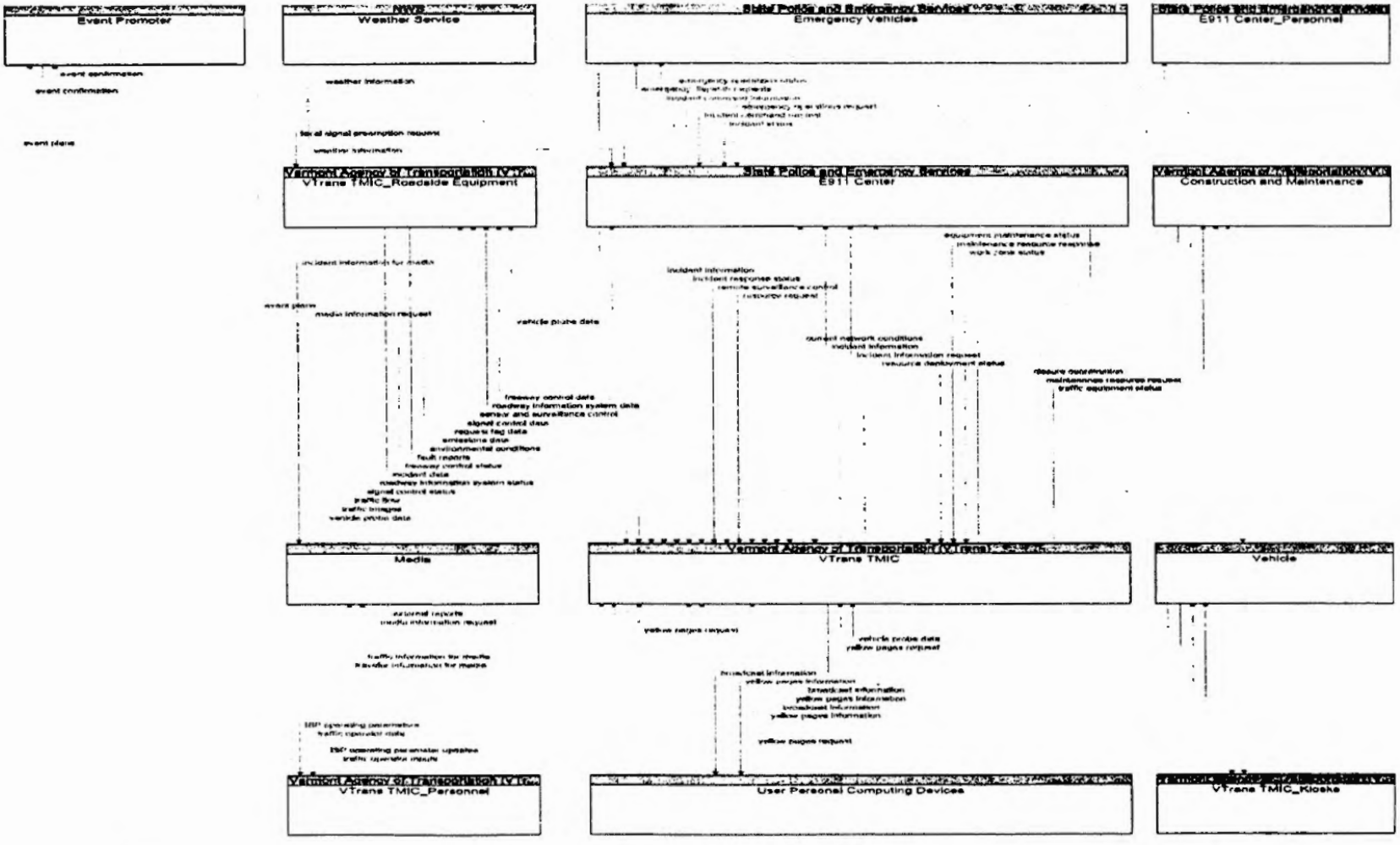


Figure 4. Short-term Statewide Architecture (Flow Diagram)



5.4. Vermont's Medium-term Statewide ITS Architecture

Eleven market packages were identified for medium-term deployment (see section 3.4). These packages were:

ATMS Packages:
- Surface Street Control (ATMS3)
- Standard Railroad Grade Crossing (ATMS13)

ATIS Packages:
- Interactive Traveler Information (ATIS2)

APTS Packages:
- Transit Tracking (APTS1)
- Demand Responsive Transit Operations (APTS3)

CVO Packages:
- Electronic Clearance (CVO03)
- CV Administrative Processes (CVO04)
- Weigh-In-Motion (CVO06)
- Electronic Clearance (CVO07)

EMS Packages:
- Emergency Response (EMS1)
- MayDay Systems (EMS3)

Figures 5 through 7 show the sausage, the inter-connect, and the flow diagrams for the medium-term statewide architecture, respectively. It should be noted, that, as previously mentioned, the agency will have to assume a lead role for some market packages and a support role for others. For example, the agency will assume only a support role for the surface street control package and the APTS packages, since these packages would typically fall under the purview of a metropolitan area such as the Burlington Metropolitan area. The medium-term statewide ITS architecture does not show those packages that fall primarily under the purview of metropolitan areas (i.e. the surface street control and the transit-related packages).

Figure 5. Medium-term Statewide Architecture (Sausage Diargram)

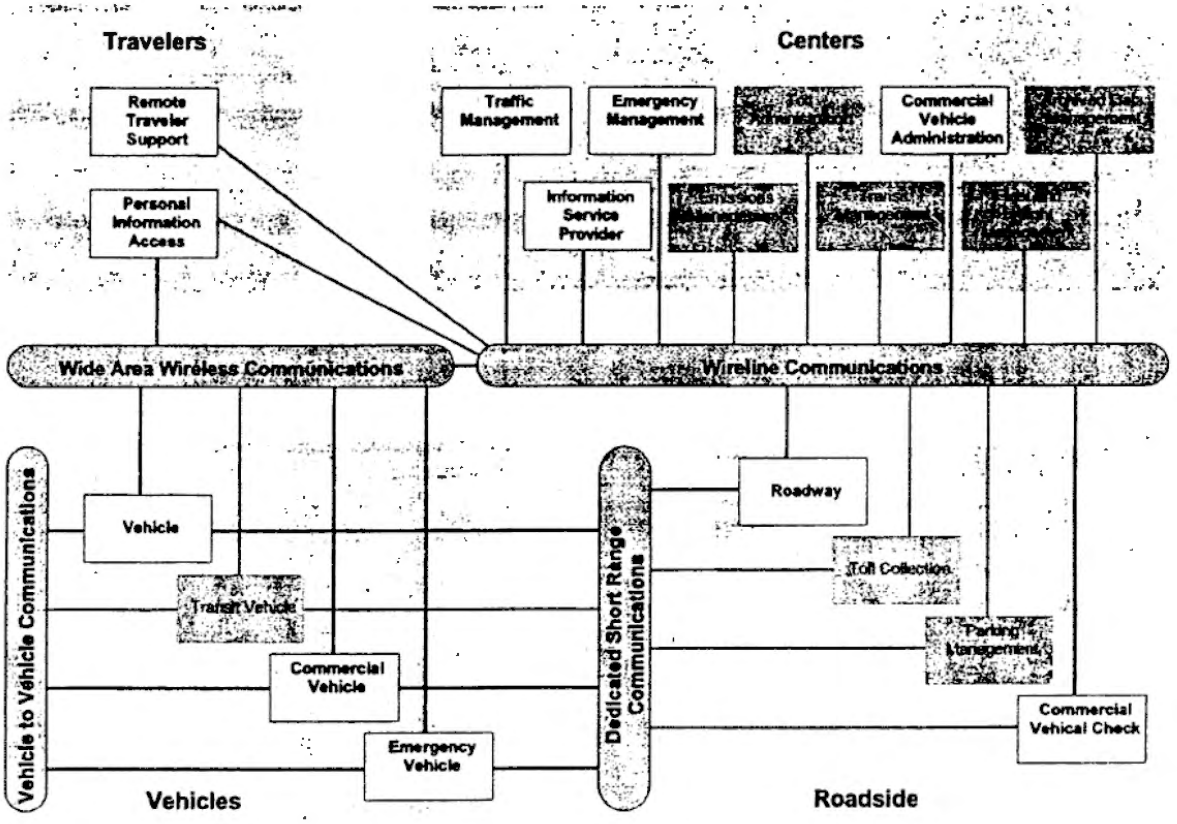


Figure 6. Medium-term Statewide Architecture (Interconnect Diagram)

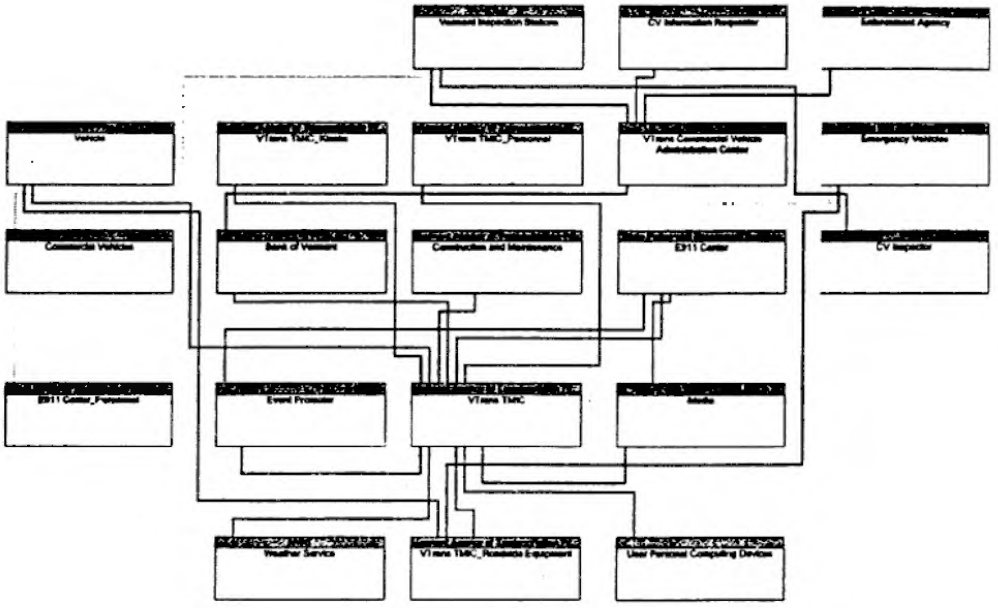
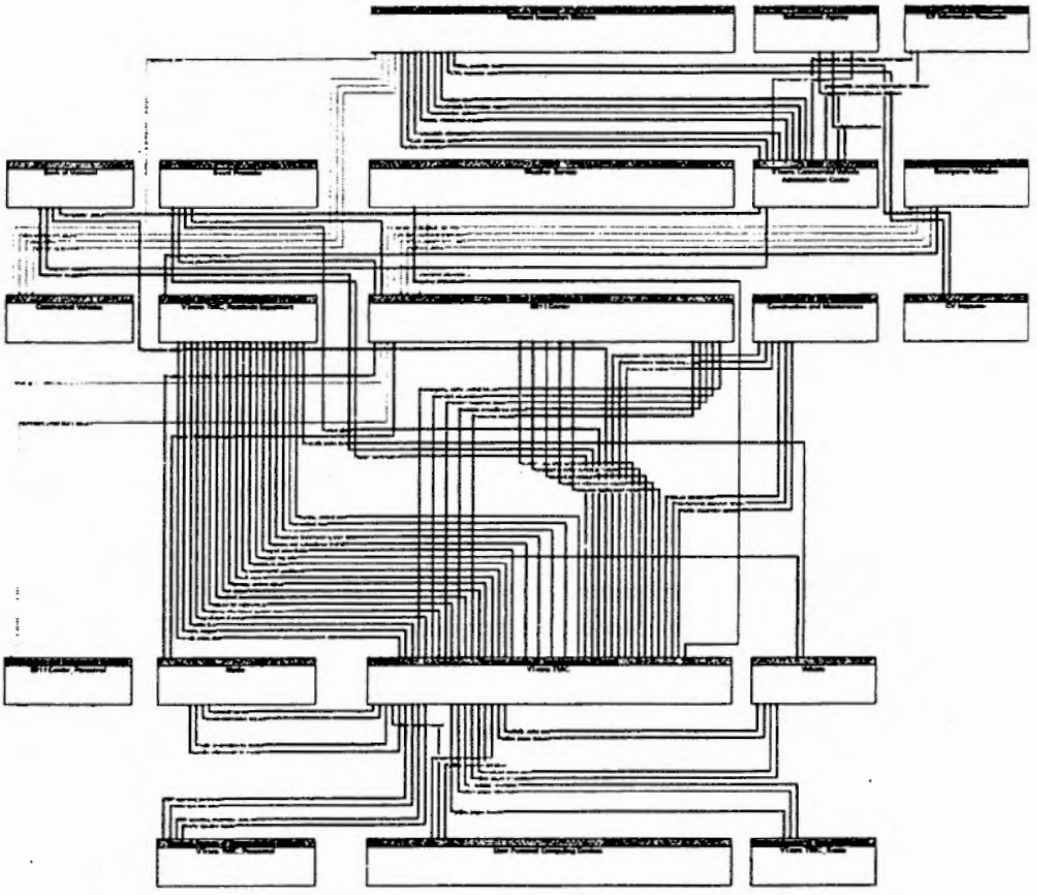


Figure 7. Medium-term Statewide Architecture (Flow Diagram)



6.0 APPLICABLE NATIONAL ITS STANDARDS

As previously mentioned, one of the primary benefits of developing a regional architecture is to help identify the system interfaces (information flows) that need to be standardized in order to ensure system "interoperability", a feature that is critical for the success of ITS. Following the development of the National ITS architecture, the U.S. DOT has embarked on a major work program aimed at the development of non-proprietary, industry-based, consensus ITS standards that would ensure "interoperability". At the present time, the U.S. DOT Standards Program is maturing from a primarily standards development. It is expected that, in the quite near future, following the approved national standards in the design and deployment of ITS projects would become a requirement for receiving federal funds.

The purpose of this section is to identify those national ITS standards that are applicable to Vermont's short-term, as well as medium-term, ITS statewide architecture. For each standard, a brief description of the standard is given first, followed by a list of the statewide ITS architecture interfaces that the standard supports. The Standard Development Organization (SDO) responsible for developing the standard, along with the standard document ID, are also provided.

6.1. Advanced Traveler Information System (ATIS) Data Dictionary Standard

Organization: **Society of Automotive Engineers (SAE)**
Document ID: **J2353**
Brief Description:
This standard, SAE J2353, Advanced Traveler Information Systems (ATIS) Data Dictionary, defines the data elements for advanced traveler information system (ATIS) messages. In addition, it may be used by other ITS systems that convey information about ATIS-related items. This standard is the repository of unambiguous definitions needed to convey information to travelers and is one of a group of basic standards that are often referred to as functional area data dictionaries.

Supports the following Interfaces from the State Architecture:

Source	Destination
User Personal Computing Devices	VTrans TMIC
Vehicle	VTrans TMIC
VTrans TMIC	Media
VTrans TMIC	User Personal Computing Devices
VTrans TMIC	Vehicle
VTrans TMIC	VTrans TMIC Kiosks
VTrans TMIC Kiosks	VTrans TMIC

6.2. Advanced Traveler Information System (ATIS) Message Set Standard

Organization: **Society of Automotive Engineers (SAE)**
Document ID: **J2354**
Brief Description:
This standard defines message sets for advanced traveler information systems (ATIS) for general use independent of medium of transmission or bandwidth. The message sets themselves are

made up of the data elements (DEs) defined in companion standard SAE J2353. This standard, SAE J2354, Advanced Traveler Information Systems (ATIS) Message Sets, provides a variety of ATIS messages, both one-way and two-way in nature, as well as various profiles for requesting such messages. In addition, it contains a diverse array of supporting messages including traffic flow, navigation, transit, weather, parking, and other commercial uses of ATIS. This standard provides a catalog of ATIS messages that can be used for many ATIS applications.

Supports the following Interfaces from the State Architecture:

Source	Destination
User Personal Computing Devices	VTrans TMIC
Vehicle	VTrans TMIC
VTrans TMIC	Media
VTrans TMIC	User Personal Computing Devices
VTrans TMIC	Vehicle
VTrans TMIC	VTrans TMIC Kiosks
VTrans TMIC Kiosks	VTrans TMIC

6.3. Commercial Vehicle Credentials Standard

Organization: **American national Standards Institute (ANSI)**
Document ID: **TS286**

Brief Description:
This standard contains the format and establishes the data contents of the **Commercial Vehicle Credentials Transaction Set (TS 286)** for use within the context of an Electronic Data Interchange (EDI) environment. This bi-directional transaction set can be used by commercial vehicle operators (e.g., carriers, owners, lessees, drivers, etc.) to apply electronically for the required credentials. Operating a commercial vehicle in the United States requires many credentials. Vehicles must be titled and registered. Carriers must have adequate liability insurance and must be authorized to carry certain types of "cargo" (e.g., hazardous materials, people, and household goods). Special permits are required to operate vehicles that are over the legal weight or size. Drivers must be licensed to drive whatever size vehicles they intend to operate, and must meet medical standards. Carriers must pay fuel taxes for operating vehicles in each jurisdiction. Some states have additional credentialing requirements. This bi-directional transaction set can also be used by authorizing jurisdictions to transmit electronically credential data to applicants and other authorized entities.

Supports the following Interfaces from the State Architecture:

Source	Destination
Vermont Inspection Stations	VTrans Commercial Vehicle Administration Center
VTrans Commercial Vehicle Administration Center	Vermont Inspection Stations

6.4. Commercial Vehicle Safety and Credentials Information Exchange Standard

Organization: American national Standards Institute (ANSI)
Document ID: TS285

Brief Description:
This standard contains the format and establishes the data contents of the **Commercial Vehicle Safety and Credentials Information Exchange Transaction Set (TS 285)** for use within the context of an Electronic Data Interchange (EDI) environment. This bi-directional standard can be used by enforcement officials, government administrators, and other authorized parties to ask electronically for information on the safety performance, regulatory compliance, and credentials status of commercial motor vehicles, carriers, and drivers. It can also be used by sources that maintain such data to respond to such requests. It can also be used to submit updates to a central repository whenever new safety or credentials information is received.

Supports the following Interfaces from the State Architecture:

Source	Destination
Vermont Inspection Stations	VTrans Commercial Vehicle Administration Center
VTrans Commercial Vehicle Administration Center	Vermont Inspection Stations

6.5. Commercial Vehicle Safety Records

Organization: American national Standards Institute (ANSI)
Document ID: TS284

Brief Description:
This standard contains the format and establishes the data contents of the **Commercial Vehicle Safety Reports Transaction Set (TS 284)** for use within the context of an electronic data interchange (EDI) environment. This bi-directional transaction set can be used by authorized parties to electronically request and send reports on information related to the safe operation of commercial road vehicles, such as inspection reports, crash data, safety and compliance review reports, and hazardous material incident reports.

Supports the following Interfaces from the State Architecture:

Source	Destination
Vermont Inspection Stations	VTrans Commercial Vehicle Administration Center

6.6 ISP-Vehicle Location Referencing Message Profiles Standard

Organization: Society of Automotive Engineers (SAE)
Document ID: J1746

Brief Description:
This standard, **SAE J1746, ISP-Vehicle Location Referencing Standard**, describes format and vocabulary for location referencing between centers, such as transportation management centers, and vehicles. A traffic management center must use this interface standard when sending or receiving locational data and vehicles must expect to send and receive references through this interface standard as well.

Supports the following Interfaces from the State Architecture

Source	Destination
Vehicle	VTrans TMIC
VTrans TMIC	User Personal Computing Devices
VTrans TMIC	Vehicle
Vtrans TMIC	VTrans TMIC Kiosks

6.7 Message Set for External TMC Communication (MS/ETMCC) Standard

Organization: **Institute of Transportation Engineers (ITE)**
Document ID: **TM 2.01**

Brief Description:
This standard, ITE-AASHTO TM2.01, Message Sets for External Traffic Management Center Communications (MS/ETMCC) includes message sets that were developed specifically for ITS traffic management systems. It consists of nineteen message sets organized into six message groups. It was developed under the oversight of a national steering committee composed of representatives of both ITE and AASHTO and is being published as a joint standard.

Supports the following Interfaces from the State Architecture

Source	Destination
Construction and Maintenance	VTrans TMIC
E911 Center	VTrans TMIC
Event Promoter	VTrans TMIC
Vtrans TMIC	Construction and Maintenance
Vtrans TMIC	E911 Center
Vtrans TMIC	Event Promoter
Vtrans TMIC	Media
Weather Service	VTrans TMIC

6.8 Message Sets for DSRC ETTM & CVO Standard

Organization: **Institute of Electrical and Electronics Engineers (IEEE)**
Document ID: **1455**

Brief Description:
This standard, in conjunction with related standards governing the data link (ASTM PS105-99) and physical (ASTM PS111-98) layers of the DSRC protocol stack, provides the basis for interoperable, non-interfering DSRC implementations using equipment from multiple vendors.

These implementations include commercial vehicle applications, toll collection, and border crossing applications.

Supports the following Interfaces from the State Architecture

Source	Destination
Commercial Vehicles	Vermont Inspection Stations
Vermont Inspection Stations	Commercial Vehicles

6.9 NTCIP – Application Profile for File Transfer Protocol (FTP) Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 2303

Supports the following Interfaces from the State Architecture

Source	Destination
Construction and Maintenance	VTrans TMIC
E911 Center	Media
E911 Center	VTrans TMIC
Event Promoter	E911 Center
Event Promoter	VTrans TMIC
Media	VTrans TMIC
VTrans TMIC	Construction and Maintenance
VTrans TMIC	E911 Center
VTrans TMIC	Media
VTrans TMIC	VTrans TMIC Roadside equipment
VTrans TMIC Roadside equipment	VTrans TMIC
Weather Service	E911 Center
Weather Service	VTrans TMIC

6.10 NTCIP – Application Profile for Simple Transportation Management Framework (STMF) Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 2301

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC	VTrans TMIC Roadside equipment
VTrans TMIC Roadside equipment	VTrans TMIC

6.11 NTCIP – Application Profile for Trivial File Transfer Protocol Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 2302

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC Roadside equipment	VTrans TMIC

6.12 NTCIP – Application Profile for Common Object Request Broker Architecture (CORBA) Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 2305

Brief Description
This standard, NTCIP 2305, Application Profile for Common Object Request Broker Architecture (CORBA), is one of two center-to-center protocols defined by the NTCIP, the other being NTCIP 2304, Data Exchange ASN.1 (DATEX-ASN). It is a general-purpose protocol for object-oriented software packages that allows systems from different manufacturers to exchange data and interoperate with each other, specifying how CORBA is to be used for center-to-center communications for transportation information within the United States.

Supports the following Interfaces from the State Architecture

Source	Destination
Construction and Maintenance	VTrans TMIC
E911 Center	Event Promoter
E911 Center	Media
E911 Center	VTrans TMIC
Event Promoter	E911 Center
Event Promoter	VTrans TMIC
Media	E911 Center
Media	VTrans TMIC
VTrans TMIC	Construction and Maintenance
VTrans TMIC	E911 Center
VTrans TMIC	Event Promoter
VTrans TMIC	Media
Weather Service	E911 Center
Weather Service	VTrans TMIC

6.13 NTCIP – Application Profile for Data Exchange ASN.1 (DATEX) Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 2304

Brief Description
This standard, NTCIP 2304, Application Profile for Data Exchange ASN.1 (DATEX-ASN), is one of two center-to-center protocols defined by the NTCIP, the other being NTCIP 2305, Common Object Request Broker Architecture (CORBA). This standard specifies how DATEX-ASN is to be used within the United States. DATEX-ASN is also an international standard (ISO 14827 Parts 1 and 2) developed by the NTCIP Center-to-Center Working Group in cooperation with the International Organization for Standardization (ISO). The main DATEX-ASN specification permits various options; this standard ensures all implementations of DATEX-ASN within the United States use the same base options and therefore can be made to interoperate. If different traffic or transit management centers were to select different options, it could lead to a failure to interoperate, even though both use DATEX-ASN.

Supports the following Interfaces from the State Architecture

Source	Destination
Construction and Maintenance	VTrans TMIC
E911 Center	Event Promoter
E911 Center	Media
E911 Center	VTrans TMIC
Event Promoter	E911 Center
Event Promoter	VTrans TMIC
Media	E911 Center
Media	VTrans TMIC
VTrans TMIC	Construction and Maintenance
VTrans TMIC	E911 Center
VTrans TMIC	Event Promoter
VTrans TMIC	Media
Weather Service	E911 Center
Weather Service	VTrans TMIC

6.14 NTCIP – Base Standard: Octet Encoding Rules (OER) Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 1102

Supports the following Interfaces from the State Architecture

Source	Destination
Construction and Maintenance	VTrans TMIC
E911 Center	Event Promoter
E911 Center	Media
E911 Center	VTrans TMIC
Event Promoter	E911 Center
Event Promoter	VTrans TMIC
Media	E911 Center
Media	VTrans TMIC
VTrans TMIC	Construction and Maintenance
VTrans TMIC	E911 Center
VTrans TMIC	Event Promoter
VTrans TMIC	Media
VTrans TMIC	VTrans TMIC Roadside Equipment
VTrans TMIC Roadside Equipment	VTrans TMIC
Weather Service	E911 Center
Weather Service	VTrans TMIC

6.15 NTCIP – Class B Profile Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 2001

Brief Description
This standard, **NTCIP 2001, NTCIP - Class B Profile**, combines the Simple Transportation Management Framework (STMF, NTCIP 1101) rules for organizing and exchanging information

between transportation centers and transportation equipment (traffic signal controllers, message signs, etc.) with other communications protocols to form a complete communications stack. Whereas STMF deals with the data processing aspects of communications, additional protocols (PMPP, RS-232, etc.) are needed to define specific data transport aspects of information exchanges. The other protocols are chosen to meet requirements for point-to-multipoint communications in a non-networked environment. This environment is typical of centralized and arterial control systems that communicate over a single, but shared, dedicated link.

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC	VTrans TMIC Roadside equipment
VTrans TMIC Roadside equipment	VTrans TMIC

6.16 NTCIP – Data Collection & Monitoring Devices Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 1206

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC	VTrans TMIC Roadside equipment
VTrans TMIC Roadside equipment	VTrans TMIC

6.17 NTCIP – Data Dictionary for Closed Circuit Television (CCTV) Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 1205

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC	VTrans TMIC Roadside equipment
VTrans TMIC Roadside equipment	VTrans TMIC

6.18 NTCIP – Global Object Definitions Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 1301

Brief Description
This standard, **NTCIP 1201, NTCIP - Global Object Definitions**, provides the vocabulary—commands, responses and information—necessary for general device management, including those objects required for device identification, time-based schedule configuration, and event log configuration. As a minimum, all roadside devices that are required to communicate with a central system should support the device identification objects.

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC	VTrans TMIC Roadside equipment
VTrans TMIC Roadside equipment	VTrans TMIC

6.19 NTCIP – Internet (TCP/IP and UDP/IP) Transport Profile Standard

Organization: **NTCIP Joint Committee (AASHTO, ITE and NEMA)**
Document ID: **2202**

Supports the following Interfaces from the State Architecture

Source	Destination
Construction and Maintenance	VTrans TMIC
E911 Center	Event Promoter
E911 Center	Media
E911 Center	VTrans TMIC
Event Promoter	E911 Center
Event Promoter	VTrans TMIC
Media	E911 Center
Media	VTrans TMIC
VTrans TMIC	Construction and Maintenance
VTrans TMIC	E911 Center
VTrans TMIC	Event Promoter
VTrans TMIC	Media
VTrans TMIC	VTrans TMIC Roadside Equipment
VTrans TMIC Roadside Equipment	VTrans TMIC
Weather Service	E911 Center
Weather Service	VTrans TMIC

6.20 NTCIP – Object Definitions for Dynamic Message Signs Standard

Organization: **NTCIP Joint Committee (AASHTO, ITE and NEMA)**
Document ID: **1203**

Brief Description
This standard, NTCIP 1203, NTCIP - Object Definitions for Dynamic Message Signs, provides the vocabulary— commands, responses, and information—necessary for traffic management and

operations personnel to advise and inform the vehicle operators of current highway conditions by using dynamic message signs. Since dynamic message signs require multiple objects to operate (information object, paging object, flashing object, etc.), this standard also includes a message syntax, called MULTI (Mark-Up Language for Transportation Information), which allows objects to be grouped into a message object. The message object is analogous to a sentence in that both the message object and a sentence require a syntax, or ordering of the information objects (words), to be understood.

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC	VTrans TMIC Roadside equipment
VTrans TMIC Roadside equipment	VTrans TMIC

6.21 NTCIP – Object Definitions for Environmental Sensor Stations and Roadside Weather Information Systems Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 1204

Brief Description
This standard, NTCIP 1204, NTCIP - Object Definitions for Environmental Sensor Stations, provides the vocabulary— commands, responses and information—necessary for the management of environmental sensor stations, including road weather information systems (RWIS) and air quality monitoring systems.

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC Roadside equipment	VTrans TMIC

6.22 NTCIP – Object Definitions for Video Switches Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 1208

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC	VTrans TMIC Roadside equipment
VTrans TMIC Roadside equipment	VTrans TMIC

6.23 NTCIP – Point to Multi-Point Protocol Using RS-232 Subnetwork Profile Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 2101

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC	VTrans TMIC Roadside equipment
VTrans TMIC Roadside equipment	VTrans TMIC

6.24 NTCIP – Simple Transportation Management Framework (STMF) Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 1101

Brief Description
This standard, NTCIP 1101, NTCIP - Simple Transportation Management Framework (STMF) plus its Amendment from 1998 (Amendment 1), specifies a set of rules for processing, organizing and exchanging information between transportation centers (management applications) and transportation equipment (traffic signal controllers, message signs, etc.) so they can communicate with each other. The STMF integrates the Internet-standard Simple Network Management Protocol (SNMP) and its derivative Simple Transportation Management Protocol (STMP), which has been designed to be compatible with SNMP. STMP is a newly developed base standard designed to address limited bandwidth communications links that requires SNMP for its configuration. In the annexes of this standard, there are sets of definitions that specify the setup of the data as well as the parameters needed to enable the bandwidth-saving STMP.

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC	VTrans TMIC Roadside equipment
VTrans TMIC Roadside equipment	VTrans TMIC

6.25 NTCIP – Simple Transportation Management Protocol (STMP) Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 1103

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC	VTrans TMIC Roadside equipment
VTrans TMIC Roadside equipment	VTrans TMIC

6.26 NTCIP – Subnetwork Profile for Ethernet

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 2104

Supports the following Interfaces from the State Architecture

Source	Destination
Construction and Maintenance	VTrans TMIC
E911 Center	Event Promoter
E911 Center	Media
E911 Center	VTrans TMIC
Event Promoter	E911 Center
Event Promoter	VTrans TMIC
Media	E911 Center
Media	VTrans TMIC
VTrans TMIC	Construction and Maintenance
VTrans TMIC	E911 Center
VTrans TMIC	Event Promoter
VTrans TMIC	Media
VTrans TMIC	VTrans TMIC Roadside Equipment
VTrans TMIC Roadside Equipment	VTrans TMIC
Weather Service	E911 Center
Weather Service	VTrans TMIC

6.27 NTCIP – Subnetwork Profile for Point-to-Point Protocol Using RS-232 Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 2103

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC	VTrans TMIC Roadside equipment
VTrans TMIC Roadside equipment	VTrans TMIC

6.28 NTCIP – Transportation System Sensor Objects Standard

Organization: NTCIP Joint Committee (AASHTO, ITE and NEMA)
Document ID: 1209

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC	VTrans TMIC Roadside equipment
VTrans TMIC Roadside equipment	VTrans TMIC

6.29 Standard for ATIS Message Sets Delivered Over Bandwidth Restricted Media

Organization: Society of Automotive Engineers (SAE)
Document ID: J2369

Brief Description
This standard, SAE J2369, Standard for ATIS Message Sets Delivered Over Bandwidth Restricted Media, is intended primarily for systems designers who are building ATIS systems

which require standardized message sets for interoperation with other message standards (such as SAE J2354, TMD External Message Set). Additionally, those who need to support multiple end use devices with a common message set over a bandwidth-limited channel will also find this standard useful.

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC	User Personal Computing Devices
VTrans TMIC	Vehicles
VTrans TMIC	VTrans TMIC Kiosks

6.30 Standard for Common Incident Management Sets (IMMS) for use by EMCs

Organization: **Institute of Electrical and Electronics Engineers (IEEE)**
Document ID: **P1512**

Brief Description
This standard (which includes the base standard and its companion volumes) provides a framework for the exchange of messages among emergency management centers. It does not limit the data contained in the messages; rather, it allows the transmission of any mutually agreed-upon messages among centers, as well as messages composed of standard ITS data elements. It remains the responsibility of the participating local jurisdictions to determine the level of interoperation that meets their needs.

Supports the following Interfaces from the State Architecture

Source	Destination
E911 Center	Event Promoter
E911 Center	Media
E911 Center	VTrans TMIC
Event Promoter	E911 Center
Media	E911 Center
VTrans TMIC	E911 Center

6.31 Standard for Functional Level Traffic Management Data Dictionary

Organization: **Institute of Transportation Engineers (ITE)**
Document ID: **TM 1.03**

Brief Description
This standard provides formal message sets for six message groups necessary to convey key data within and between traffic management centers and other ITS centers. As a message set standard, it provides a list of specific data elements for each message plus other format information such as message name, message number, and certain other mandatory and optional message attributes. The MS/ETMCC is designed to be independent of any specific communications protocol. The

MS/ETMCC, as a national ITS standard, provides a set of messages intended to be the core of individual messages implemented at specific sites.

Supports the following Interfaces from the State Architecture

Source	Destination
Construction and Maintenance	VTrans TMIC
E911 Center	VTrans TMIC
Event Promoter	VTrans TMIC
VTrans TMIC	Construction and Maintenance
VTrans TMIC	E911 Center
VTrans TMIC	Event Promoter
VTrans TMIC	Media
Weather Service	Vtrans TMIC

6.32 Standard Specification for DSRC – Data Link Layer

Organization: **American Society of Testing and Materials (ASTM)**
Document ID: **PS105 - 99**

Brief Description
This standard, ASTM PS 105-99, Specification for Dedicated Short Range Communication (DSRC) – Data Link Layer, defines the requirements for the open systems interconnection (OSI) reference model, layer two (data link layer), i.e., methods for ensuring data integrity. This standard provides information for on-board equipment based on both active and backscatter technologies and allows for interoperability between systems based on either one of these technologies. The standard allows for mixed time, frequency, and space division multiple access approaches, all similar to cellular telephone techniques that allow multiple users on a limited number of frequencies.

Supports the following Interfaces from the State Architecture

Source	Destination
Commercial Vehicles	Vermont Inspection Stations
Emergency Vehicles	VTrans TMIC Roadside Equipment
Vehicle	VTrans TMIC Roadside Equipment
Vermont Inspection Station	Commercial Vehicles
VTrans TMIC Roadside Equipment	Vehicle

6.33 Standard Specification for DSRC – Data Link Layer

Organization: **American Society of Testing and Materials (ASTM)**
Document ID: **PS111 - 98**

Brief Description
This standard, ASTM PS 111-98, Specification for Dedicated Short Range Communication (DSRC) - Physical Layer, is comprised of the requirements for the physical, i.e., electrical and mechanical, interfaces and the transmission medium, i.e., air, in the 902 to 928 MHz location and

monitoring service (LMS) band. This standard provides information for onboard equipment based on both active and backscatter technologies and allows for interoperability between systems based on either of these technologies. The standard allows for mixed time, frequency, and space division multiple access approaches, all similar to cellular telephone techniques allowing multiple users on a limited number of frequencies.

6.34 Subcarrier Traffic Information Channel (STIC) System

Organization: **Consumer Electronics Association**
Document ID: **EIA - 795**

Brief Description
The STIC system is intended for one-way transmission of ITS and other related information to mobile and fixed users using subcarriers on broadcast FM signals. It is designed to be flexible, allow for trade-offs among data rate, robustness, receiver battery life and transmission delay. The waveform explicitly supports:

- ATIS message sets defined by SAE J2369;
- Differential global positioning system (DGPS) message sets defined by the Radio Technical Commission for Maritime
- Services (RTCM), Special Committee No. 104;
- Emergency alert system messages defined by the Code of Federal Regulations (CFR) Title 47, Part 11; and
- Retransmission of radio broadcast data system (RBDS) data.

The standardized STIC system supports the original mobile high rate STIC encoding methods as tested by the National Radio Systems Committee (NRSC) High Speed Subcarrier (HSSC) Subcommittee.

Supports the following Interfaces from the State Architecture

Source	Destination
VTrans TMIC	User Personal Computing Devices
VTrans TMIC	Vehicles
VTrans TMIC	VTrans TMIC Kiosks

7.0 RECOMMENDED SHORT-TERM PROJECTS

This section presents an initial project list for the deployment of recommended ITS technologies in the State. These projects would help implement the state architecture outlined in the previous section. The recommended projects are grouped under the following three project areas:

1. Advanced Traffic Management Systems (ATMS)
2. Advanced Traveler Information Systems (ATIS); and
3. Safety-related Projects

1) Advanced Traffic Management Systems

Project 1.1: Establish a Statewide TMIC to Monitor, Collect, Analyze & Disseminate information

This project will involve the establishment of a statewide Transportation Management and Information Center (TMIC). The TMIC will act as the primary point of coordination for managing transportation resources. The center will be responsible for the collection, fusion, analysis and dissemination of information on the status of the transportation system, focusing first on the interstate and major arterials network (i.e. the National Highway System). The center will receive its information from a number of sources, including roadside traffic detection devices, roadway weather information systems (RWIS), links to emergency management centers, and motorists' reporting of unusual events (e.g. accidents). The center will also receive information on any scheduled road construction work from the appropriate departments. In the TMIC, all this information will be fused and analyzed, and will then be disseminated to the public and other appropriate agencies through a number of en-route, as well as pre-trip, information dissemination devices. This project should be regarded as an encompassing project that includes the following elements.

Project 1.1A: Setting up the TMIC Facility
Project 1.1B: Deploying Network Surveillance
Project 1.1C: Deploying VMS and HAR
Project 1.1D: Improving the Incident Management Process
Project 1.1E: Deploying Road Weather Information Systems (RWIS)

Project 1.1A: Setting up the TMIC Facility

A physical location will be needed for the TMIC. The space needs will depend upon the geographic area served (i.e. the number of centerline miles monitored), as well as the functions performed by the TMIC. Typically, TMIC facilities are housed by either a state's department of transportation (DOT) or by the state police. In some cases, TMICs are joint ventures between the DOT and the State Police.

Existing TMICs are designed with the intent of establishing a facility that collocates all participants in the traffic management process to coordinate their activities. However, in recent years, there have been some voices within the ITS community that have questioned this philosophy of large expensive, centralized statewide centers. These voices have argued for a decentralized approach, whereby the large center would be replaced by a number of workstations, which can communicate with one other, provided to all participants in the traffic management process. Regardless of which approach is followed, TMICs should be located close to the areas they are managing.

Given the nature of the state of Vermont and the nature of travel in the State, it appears that TMICs are needed the most for:

(1) Managing some of the most heavily congested corridors in Chittenden County (the most populous county in the State). These corridors include the I-89 segment between exits 12 and 17, Route 7, Route 15, Route 2 and Route 2A.

(2) Managing travel to the ski resort areas in the State and its seasonal peak characteristics – example I-91, Route 4 and Route 7

It should be noted that the vision for Vermont TMIC is to start with a small center to be staffed with at most 2 people. Provision should, however, be provided for potential expansion in the future.

Equipment Needs

The TMIC will require computer hardware (i.e. workstations) and software for the processing of the traffic data collected. Communication links will have to be established between the TMIC and the roadside equipment, as well as between the TMIC and other centers in the region (e.g. emergency management center). Originally, leased communications lines could be used. However, consideration should be given to establishing a dedicated communication network as need arises, perhaps through resource-sharing agreements with the telecommunications industry.

Staffing Needs

One of the most difficult components of TMIC is staffing. A recent survey of TMIC around the country conducted by the Virginia Transportation Research Council (VTRC) indicates that the current average staffing level is 1 operator for each 40 centerline miles of roadway monitored. It is envisioned that one or two operators would be required to staff Vermont's TMIC. Supplementing full-time operators with part-time employees and College students is an option (e.g. the MONITOR TMIC in Milwaukee, Wisconsin).

Project 1.1B: Deploying Network Surveillance

This project will deploy the network surveillance equipment needed to monitor the status of the transportation system. There are several options available for traffic condition monitoring, including:

Inductive Loop Detectors (ILD): The inductive loop is the most widely used device for vehicle detection. Their main use is at intersections in conjunction with advanced signal traffic control systems (they could also be used on freeways for incident detection purposes). In Vermont, the following locations were identified as either already equipped with or candidate for ILDs deployment:

- VT RT 15 between Exit 15 and Five Corners in Essex Junction
- US 7 Shelburne Road – I189 South to Shelburne (signal coordination)
- Route 2 and 2A
- US 302 Barre-Montpelier Road
- Memorial Drive in Monteplier
- Jct. VT62, VT14 and US302 in Barre City
- Jct. VT14 and US2 in East Montpelier
- Jct. US2 and US302 in Montpelier

Non-intrusive Detection Technologies: These relatively new detection technologies are capable of measuring a wide variety of traffic parameters, including traffic volume, density, and speed. Moreover, they can be installed and maintained without disrupting traffic flow. Several types of non-intrusive vehicle detection technologies are available including microwave radar detectors, infrared detectors, ultrasonic detectors, and acoustic detectors. Recent studies conducted to evaluate the different technologies do not favor one technology over another, but typically point to the advantages and disadvantages of each type. Non-intrusive detection devices could be used at intersections, as well as at mid-block to report traffic speeds for use within traveler information systems.

Closed Circuit Television (CCTV) Cameras and Video Image Processing (VIP): CCTV cameras are primarily used for incident detection and verification. The real advantage of video surveillance over other detection technologies lies in its ability to provide traffic operators with visual data, thereby allowing for the confirmation and interpretation of accident information to determine the correct response. CCTV could be deployed along freeways, at critical intersections and for the remote monitoring of weather conditions as a part of a road weather information system (RWIS). Among the candidate deployment locations identified are:

- I89 - between Exits 12 and 17
- Critical intersections with congestion problems or high accident frequencies (e.g. Five Corners in Essex Junction)
- Route 9 Mountain, and Route 11/30 Mountain (to remotely view winter roads)
- Top of Mendon Mountain on US Route 4 and of Brandon Mountain on Route 73 (to remotely view winter roads)

Police and Citizens Reporting: In many cases, reports of incidents from citizens and the police can provide significant system monitoring condition, and at a very low cost compared to other surveillance technologies. Police and citizen reports do not provide a continuous stream of condition data as other surveillance technologies, but rather they provide event information at unpredictable intervals that could be very useful for traffic management purposes. Given this, it

is recommended that a program to encourage citizens' reporting of incidents be initiated, which could involve road signs for a cellular incident reporting hotline.

Cell Phone Tracking: Current methods of monitoring and estimating traffic conditions rely on the use of point detectors (such as loops embedded in the pavement.) These traffic sensors are typically somewhat costly to install and maintain. Recently, there has been an interest among the ITS community in investigating the feasibility of a more dynamic means of traffic monitoring and prediction through the use of data generated from anonymous cell phone tracking. If successful, this approach could provide Vermont with a relatively low cost system for monitoring traffic conditions. US Wireless is currently working with the State DOTs and the Universities of Virginia and Maryland to evaluate this approach in the Capital Beltway area. It is recommended that Agency monitor the progress of this effort and explore its applicability to Vermont.

Project 1.1C: Deploying VMS and HAR

This project will deploy the equipment needed to disseminate real-time information to travelers, while en-route. Two types of equipment are recommended: Variable Message Signs (VMS) and Highway Advisory Radio (HAR). VMS are a primary means of disseminating information to travelers. They can be used to display messages regarding current traffic conditions, congestion, accidents, as well as suggested alternate routes. They can also be used to display weather advisory messages regarding icy or low visibility conditions, for example.

VMS are available in a number of technologies including reflective disk, bulb matrix, light emitting diode (LED), fiber-optic shuttered (FOS), and fiber-optic hybrid. They may be permanently mounted, or may be of the mobile type. The permanent VMS have to be strategically located ahead of possible diversion points, and ahead of problematic areas (e.g. areas that are susceptible to icy or recurrent congestion problems). The mobile VMS, on the other hand, can be easily moved from one place to another, and are particularly useful around work zone areas. In Vermont, the following potential applications for VMS were identified:

- *VMS along Interstates I-89 and I-91:* These signs will be used to post messages regarding the occurrence of incidents and diversion opportunities. The messages can also be used to warn drivers of icy road conditions. VMS are especially needed along the stretch of I-89 between exits 12 and 17 as indicated by the recent rash of accidents.

- *VMS at Entry points to the State (e.g. at the MA state line):* These will be used to inform drivers of travel and weather-related conditions, especially during the ski season.

- *VMS along Route 9 and Route 11/30 Mountains:* These messages will primarily be intended for posting weather advisory related messages. Examples of these messages would include:
    - *"Trucks Must Put Chains"*
    - *"Road Closed Due to Winter Conditions"*
    - *"Road Blocked by Trucks"*

- *VMS at Construction Sites:* VMS are currently being used at most construction sites around the State. This use should be encouraged and expanded.

- *VMS along Major Arterials:* Among the major arterial corridors identified for deploying VMS are:
    - Route 7, particularly in Chittenden County; and
    - Routes US2 and US302 in District 6.

The key consideration when using a VMS is to recognize that VMS can only display a limited amount of information. For this reason, the use of VMS should be supported by the use of HAR to provide more detailed information.

Project 1.1D: Improving the Incident Management Process:

The primary goal of this project is to improve over the current incident management practices in the State. Incidents are of two types: planned and unplanned. Planned incidents involve special events such as state fairs or road maintenance activities. Unplanned incidents, on the other hand, typically involve events such as vehicle breakdowns, spilled loads, or vehicle accidents. The impact of incidents on traffic operations efficiency and safety is so significant that even a small improvement in managing and responding to incidents could be quite beneficial to the State.

The establishment of the proposed TMIC, with its monitoring and information dissemination capabilities, will provide the state and local agencies with an unprecedented opportunity to better manage and respond to incidents. However, for the TMIC to be truly effective, a carefully structured protocol for coordination among the different agencies involved in the incident management process is required. Given this, this project will start first by establishing an Incident Management Steering Committee be established that would include members from the different stakeholders that play a role in managing and responding to incidents. This committee will be responsible for clearly defining and coordinating the roles of the different stakeholders, and for developing multi-jurisdictional incident management and diversion plans. This project will also involve establishing a link to the existing E911 system, and developing a protocol for disseminating incident information. The parties to the protocol could include regional TMIC operators, the E911 board and the State Police.

Project 1.1E: Deploying Road Weather Information Systems (RWIS):

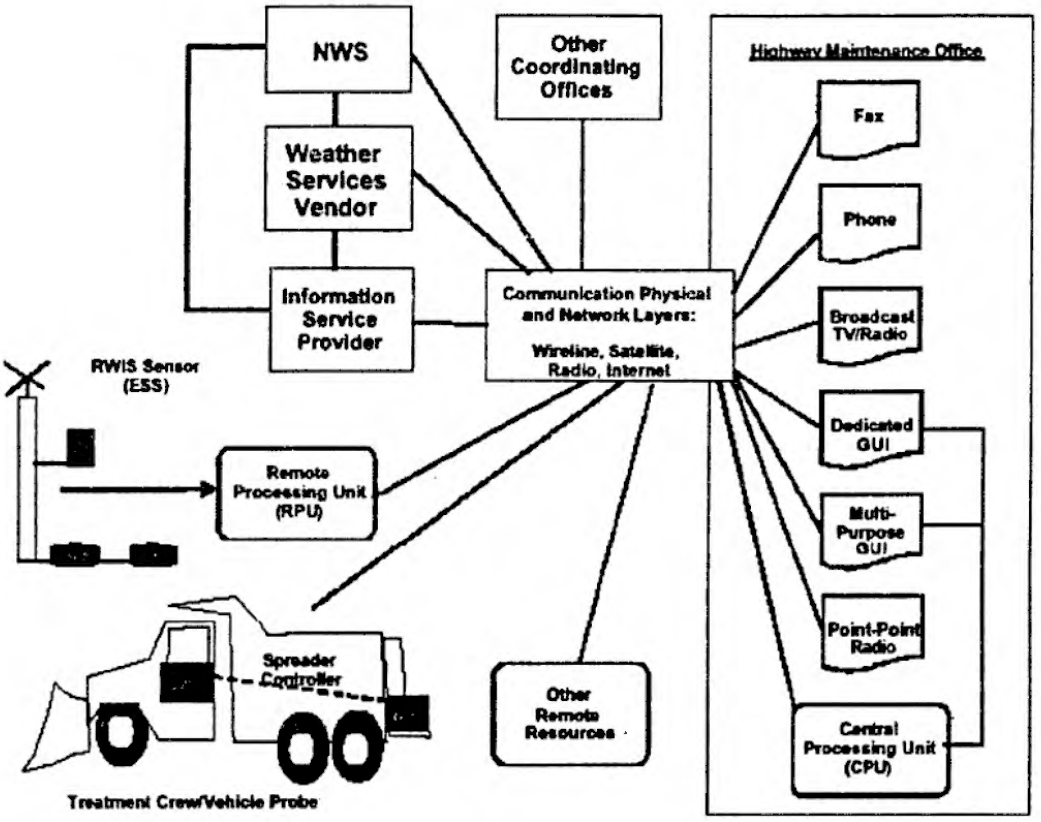
This project will deploy Road Weather Information Systems (RWIS) at strategic locations around the State. The term "RWIS" refers to the set of road condition sensors and weather information services used to support decisions regarding winter highway maintenance and other highway decisions. RWIS include four kinds of services:

1. The Environmental Sensor Stations (ESS) for direct road condition observation (often called RWIS by themselves);
2. Further processing of sensor data for road condition prediction;

3. Supply of general atmospheric condition forecasts and advisories by Value Added Metrological Services (VAMS) (sometimes considered outside of RWIS); and
4. Dissemination of various weather information products by Information Service Providers (ISPs).

A high-level structure of a RWIS is shown in Figure 8 below.

Figure 8. Road Weather Information Systems (RWIS)



The RWIS view is focused on the highway maintenance office, which will typically have a variety of non-integrated communication termini such as a telephone, point-to-point radio to crews, broadcast radio/TV, fax machines, and a graphical user interface (GUI) which would typically be used for Internet communications, local applications, and RWIS sensor displays. The entities external to the maintenance office are shown as the National Weather Service (NWS), private Value Added Metrological Services (VAMS), and Information Service Providers (ISPs), coordinating offices, ESS sites, maintenance crews and other remote resources. The ESS sensor connectivity is generally through a set of remote processing units (RPUs) to one or more central processing units (CPUs) housed at the maintenance office and other receiving sites. The

RPUs home one or more sensor units. The CPUs poll or otherwise collect the sensor data, redistribute it (e.g., to the VAMS), process it for display and provide for archiving.

The VAMS can provide any of the types of products provided by the NWS. These include textual messages, static graphics (e.g., via fax), and graphical products through the GUIs. Flash flood and avalanche warnings are two specialized products. The main responsibility of VAMS, however, is high-resolution forecasting of precipitation amount and form, possibly with local climatological expertise to improve skill, and road condition measurement and forecasting. Road condition information may rely either on ESS measurements or on atmospheric information, or fuse both. For road temperature and freezing prediction, an ESS measures the sensor points directly. Time series extrapolation gives point predictions. The point measurement or prediction can further be extended over a route segment by the climatological technique of thermal mapping. This uses samples of point measurements (usually by vehicle probe) and regression to the ESS point measurement. Other attributes (wind, precipitation, chemical concentration) can be derived similarly, although the method is usually to assume similarity of nearby areas.

As previously mentioned, this project will deploy RWIS at strategic locations around the state. The information collected will be used:

(1) To support decision-making by maintenance personnel;
(2) To post weather advisory messages on VMS; and
(3) To feed traveler information systems.

The following locations were identified as candidate locations for deployment:

- *I-89 - between exits 11 and 12 (top of French Hill)*
- *I-91 – between the MA line and exit 30 N, and on Sheffield Heights in District 9*
- *Routes 100, 9, 11/30, and US7 for trucker information of winter conditions of mountain routes, and also for skiers on road condition and delays*
- *Route 4 – Mendon Mountain, and between Rutland and NY line*
- *US2 in Cabot*
- *VT 15 – high water spot*
- *VT 17 - in Buel's Gore*
- *VT 105 – Richford Mountain*
- *VT 108 - in Stowe*
- *VT 125 – near Middlebury snow bowl*
- *US2 in Cabot*

2) Advanced Traveler Information Systems:

Project 2.1: Developing a Statewide Advanced Rural Traveler Information System (ARTIS):

Advanced traveler information systems (ATIS) are integral components of an ITS system. An ATIS for an area is never conceived as a standalone system, but rather as a part of a larger system that interacts with other ITS systems to collect and disseminate information. The current project aims at developing a statewide ARTIS for Vermont for disseminating the

information being collected by the TMIC, as well as other information collected from other sources. The central piece of this project will be developing a web site to post the traffic information collected by the TMIC. The web site will include a color-coded map of the major highways in the region depicting the average speeds (see http://www.smarttrek.org/), the locations of any incidents, and the scheduled work zones. Links could also be provided to other useful travel-related information such as transit schedules, ridesharing information, as well as places of attraction. The table below shows an extensive list of data of potential interest to the traveler. As can be seen, information is being classified as either static or real-time information.

Table 4. Potential Contents of the Statewide ARTIS:

Static information – known in advance, changes infrequently	Planned construction and maintenance activities
	Special events, such as state fairs and sporting evenets
	Transit fares, schedules, and routes
	Intermodal connections (e.g. ferry schedules along Lake Champlain)
	Commercial vehicle regulations (such as HAZMAT and height & weight restrictions
	Parking locations and costs
	Business listings, such as hotels and gas stations
	Tourist destinations
	Navigational instructions
Real-time information Changes frequently	Roadway conditions, including congestion and incident information
	Alternate routes
	Road weather conditions, such as snow and fog
	Transit schedule adherence
	Travel time

The site should be accessible through web browsers on a personal computer and through kiosks. The kiosks could be located at rest areas, at tourist attractions, and at major transportation centers. If desired, the web page could be augmented with a phone service, providing both long-term and short-term travel-related information.

3) Safety-related Projects

Under this area, five projects are identified. These projects can be regarded as stand-alone projects that are geared more toward the rural environment.

Project 3.1: Advanced Curve Speed Warning Advisory:

This project implements interactive curve warning signs, which combine speed-measuring radar with variable message signs (VMS). An example of this project may be found on a section of I-5, approximately 200 miles north of Sacramento, California.

Project 3.2: Downhill Truck Speed Warning Systems:
The dynamic truck speed warning system is designed to improve driver safety by warning the truck driver of potential collisions and rollovers. The speed warning system uses a combination

of radar gun technology and weigh-in motion technology to determine the safe descent speed for trucks for a designated curve and downgrade. The safe speed is posted to trucks using a VMS. An example of such a system can be found on I-70 in Glenwood Canyon, Colorado. The cost of the system is estimated at $25,000 and $30,000.

Project 3.3: Dynamic Speed Limits On Mountain Passes:

The purpose of this ITS application is to improve safety and reduce the number of accidents that occur on Mountain Passes. The idea is to set dynamic speed limits based upon information from a number of sources. An example of this application could be found in Washington State along Snoqualmie Pass, a 40-mile stretch of I-90 east of Seattle. The WSDOT's project uses wide aperture radar to track vehicle speeds, along with six weather stations to monitor temperature, humidity, precipitation, wind and specific road surface conditions. This information is gathered and transmitted by packet radio and microwave transmission to a control center on the top of the mountain, where the safe speed is calculated and transmitted to travelers via nine VMS.

Project 3.4: Portable Traffic Management Systems (PTMS):

PTMS represents an integration of existing, off-the-shelf, and emerging traffic management technologies into a complete portable traffic control system for use in managing traffic during major events (e.g. sporting events) and around work zones. The system is portable, wireless and able to withstand the elements within the work zone. It provides traffic engineers with data such as speeds, volumes and incident detection so that decisions can be made and communicated to the traveling public. The system consists of four basic subsystems:

- Vehicle Detection/Surveillance
- Traffic Control Center
- Driver Information
- Communications

A good example of these systems is the one developed for the Minnesota Department of Transportation. The system consists of portable skids that are placed at strategic locations in the work zone area, and linked together by spread spectrum radio. The skids can include both vehicle detection devices (i.e. CCTV and VIP), and driver information systems (i.e. HAR). The data from the vehicle detection/surveillance subsystem is transmitted to the Traffic Control Center at Mn/DOT Traffic Management Center. The data is reviewed by system operators, and decisions are made regarding traffic control changes.

Project 3.5: Portable Speed Warning Systems:

These systems which are currently being used throughout the US and Vermont are intended to deter speeders on various roads. They use a two-digit variable message sign, radar gun, a computer, and a generator to run the system. Portable speed warning speeds could be used for speed awareness purposes, for speed monitoring as well as for enforcement. The cost is typically in the range of $20,000 per trailer.

8.0 PROCUREMENT METHODS

The successful deployment, operation and maintenance of ITS projects require effective procurement methods to acquire the hardware, software, and the services required for the projects. Unfortunately, however, many of the conventional procurement practices do not lend themselves well to ITS projects. This section describes some of the conventional, as well as the innovative procurement methods that State DOTs around the country have experimented with in trying to procure ITS services and equipment. The advantages and disadvantages of the different methods will be discussed. The material in this section is largely based on an issue paper developed as a part of a study to develop an ITS strategic plan for the State of Florida.

Several contracting methods for the procurement of ITS exist. Among these are (1) the Engineer/Contractor or Low Bid method; (2) the Design/Build method; (3) the System Manager method; (4) the System Integrator method; (5) the Commercial-off-the-Shelf (COTS) software acquisition; (6) the Build-to-Budget method; and (7) the shared resources method. A brief description of each of these methods follows.

8.1 The Engineer/Contractor Method

This is the conventional contracting vehicle that has been used for years within State DOTs. Under this method, the project is designed by either a public agency or a consultant (the "Engineer"). A bid solicitation is then issued, which would typically include the design specifications prepared by the "Engineer", and a "Contractor" is selected on the basis of the lowest bid received. As experience has shown this method is, unfortunately, not suitable for the development of ITS projects with their information technology and communications components, because of the "artificial" dividing line between design and construction. In addition, software projects are often very hard to specify. In summary, the Engineer/Contractor method is appropriate for construction projects, but not for project involving a lot of software development such as ITS.

8.2 Design/Build Method

In this method (sometimes referred to as "turnkey"), the design and the construction functions are combined into a single contracting vehicle, with the agency assuming responsibility for inspections and approvals. Experience shows that Design/Build contracts are most successful when built around a preliminary design that is complete only to a level of 20 to 60 percent. Since design and construction are done within the same entity, this method avoids many of the traditional problems that characterize the Engineer/Contractor method. The method also allows for the speedy completion of projects. This method has been successfully used for traffic signal installations, as well as for conventional, but complex, highway and bridge projects.

8.3 System Manager

In this method, a system manager is selected using conventional consultant procurement processes. Once selected, the system manager assumes responsibility for the design (i.e.

producing plans and specifications), software development, hardware procurement, integration, training and quality control. Low bid is then used for equipment and electrical contracting services. The main advantage of this method is that it allows for the overall system design, software development, and testing to be performed and controlled by a single entity. However, the method is heavily dependent upon the successful performance of the system manager, and therefore, careful inspection of the firms qualifications is needed before selection. Large traffic control and management centers have typically been procured using this method.

8.4 System Integrator

This method is very similar to the system manager method. The only difference is that the system integrator is allowed to bid on equipment and electrical services as well.

8.5 Commercial-Off-the-Shelf Software Acquisition

While this method is somewhat new to ITS, it is widely used for the majority of software acquisition in the public and private sectors. Under this method, the agency prepares a "functional requirements" or "needs" statement, along with a well-documented evaluation procedure. The agency then evaluates commercially available software against the specified functional requirements, and selects the one that best meets its needs. This method increases the chance of receiving a mature, bug-free system. It also typically results in reduced deployment costs, and encourages the use of standards. The drawback, however, is a loss of the ability to tailor software to the needs.

8.6 Build to Budget

This method uses functional requirements instead of a detailed design. Bidders then develop designs based on their best solutions to meeting the functional requirements identified. This method allows proposers to use their most cost-effective designs. However, there is a somewhat increased risk because of a lack of detailed designs.

8.7 The Shared Resources Method

A shared resources project refers to an agreement between a public-sector entity(ies) and a private-sector entity(ies) with the objective of providing services using the combined resources of both entities. One of the most common examples of shared resources projects in the ITS context is the granting of highway rights of way to a private telecommunications company in exchange for telecommunications capacity and expertise. Examples of shared resources projects of that kind abound all over the country.

Given the availability of different and innovative contracting methods for ITS procurement, it is highly recommended that the Agency seriously consider some of the most successful of these methods in procuring ITS. This will require a study of Vermont statues and laws to identify barriers and opportunities for the use of alternative procurement methods for ITS projects.

9.0 RECOMMENDED ACTIONS FOR THE AGENCY'S ITS PROGRAM

In order to support the Agency's emerging ITS program, several actions need to be undertaken. This final section of the current report lists some suggested actions that are intended to help implement the recommendations made by the current strategic plan with regard to implementing the statewide architecture and the recommended list of projects. These actions are briefly discussed below.

9.1 Develop a Statewide ITS Steering Committee

As previously mentioned in this report, for ITS to succeed, it has to be deployed in an integrated and logical fashion. The current strategic plan, with its preliminary statewide architecture and recommended list of ITS projects, is intended to provide direction to the Agency in deploying ITS throughout Vermont. To help implement the ITS strategic plan, however, it is recommended that an ITS statewide steering committee be established to oversee and manage the emerging ITS activities occurring throughout the state. The responsibilities of this steering committee would include the following activities:

Policy, Program Development and Budget Responsibilities

- To develop ITS policies and procedures
- To determine ITS staffing and resources needs
- To identify and seek ITS funding sources
- To set priorities for the state ITS research program
- To develop a statewide ITS training, education and public awareness program

ITS Architecture and Standards Responsibilities

- To maintain the statewide architecture, and to support the development of other regional architectures that are consistent with the National Architecture
- To monitor the status of the National ITS architectures, and to ensure that ITS projects throughout the state are deployed in a standards-consistent fashion
- To ensure statewide consistency in incident management practices

Co-ordination with Public and Private Entities

- To co-ordinate with other state-level partners (such as the state police, the E911 board, travel and tourism, ... etc.) in the deployment and operation of ITS projects
- To seek opportunities for partnership with the private-sector
- To ensure co-ordination with public transportation organizations including transit and railroad agencies, as well as airport authorities

The next paragraphs will discuss some of these responsibilities in some detail. It should be noted, however, that the ITS steering committee should work toward eventually establishing a state ITS program, with a statewide ITS manager position. The ITS manager would then assume the responsibilities originally assumed by the ITS steering committee members.

9.2 Conduct a comprehensive communications study

Telecommunications infrastructure is critical to the operations of an ITS system, since it ties together the different components of the system, and allows for transferring data between the major elements such as the roadside equipment, the control centers, and the travelers. The cost of the operations and maintenance of Telecommunications infrastructure could also be quite significant. Given this, it is highly recommended that the Agency undertake a comprehensive communications study aimed at arriving at the "optimal" communications solution for satisfying the agency's needs.

The first step in this study would be to conduct a "needs assessment" analysis in order to accurately define the communications requirements of the state's ITS system. In this regard, the developed statewide ITS architecture can be a tool of great asset. By identifying types, volumes, sources, and users of transportation information, the regional ITS architecture will help in understanding connectivity and bandwidth requirements, as well as the nature (periodic, continuous, random) of the required communication flow. The study should also look at the available telecommunications resources within the State, as well as the rapid advancements in both the wireline as well as the wireless telecommunications industry.

9.3 Seek opportunities for partnership with telecommunications companies

Given the critical need for high-capacity, high-speed telecommunications infrastructure for many ITS applications, it is strongly recommended that the Agency seek opportunities for public/private partnerships with telecommunications companies. Under these partnerships, a state DOT would grant a telecommunications company the right to install communications infrastructure (e.g. fiber-optic cable) within the state's highway right of way, and in return the DOT would receive access to the telecommunications infrastructure at no cost. Partnerships of that kind have been tried in many states around the country, and have proven to be quite beneficial to both parties.

9.4 Maintain the statewide and regional architecture

The preliminary statewide ITS architecture developed as a part of this study should always be regarded as a living document, as well as a guide. As more ITS activities start taking place around the State, and as the deployment of ITS projects is initiated, the statewide ITS architecture should be revised in order to reflect and show these actual implementations. In addition, other regions around the state should be encouraged to develop their own architectures in a manner that is consistent with the national and statewide architecture.

9.5 Keep monitoring the status of National Standards

As previously mentioned in this report, the U.S. DOT has embarked on an aggressive ITS standards national program in an effort to ensure system "interoperability". A number of standards that are currently in a draft format are expected to be approved in the near future. In addition, more new standards are likely to emerge in the coming years. Given this, it is

recommended that the Agency keep monitoring the status of the National standards. The agency should also establish policies to ensure that these standards are considered in project design and implementation.

9.6 Develop guidance for ITS Procurement

As previously mentioned, ITS procurement does not lend itself to traditional low bid contracts. A number of more appropriate procurement methods have been discussed in this report. A study of Vermont statues and laws is needed to identify barriers and opportunities for the use of alternative procurement methods for ITS projects.

9.7 Develop guidance for ITS Projects Design, Operations and Maintenance

The ITS steering committee should start working toward developing guidance for the design, operations, and maintenance of ITS projects. In the project design phase, each ITS project should include preliminary design studies and tradeoff analyses to determine the most cost-effective design from a life cycle cost standpoint. This is especially important with the major subsystems such as communications, control centers, changeable message sign, and detector stations. ITS design guidelines are needed for ITS projects in the areas of component details and placement, and their density along the roadway. These guidelines will be helpful for streamlining the planning and design process for new deployments.

In order to develop guidance on ITS operations and maintenance, it is recommended that the Agency start documenting ITS deployment, operations and maintenace costs once ITS projects are initiated. Developing guidance on ITS operations should also include a determination of the appropriate staffing requirements for ITS operations. The Agency may also wish to consider the feasibility of using outsourcing for ITS operations and maintenance especially during the early stages of ITS deployment. Determining the best course of action (i.e. in terms of whether outsourcing should be used or not) should involve a sound estimate of the Agency's strengths and weaknesses, as well as a consideration of the liabilities and risks of each approach.

9.8 Develop a Statewide ITS/CVO Element

The State should establish a statewide CVO element to be responsible for coordinating ITS/CVO activities around the state. The recommended deployment strategy for ITS/CVO projects that the State should follow consists of three key steps: planning, design and implementation. These steps are described below.

Planning - The key idea here is for the state to develop an ITS/CVO business plan. Developing ITS/CVO plans has always been a key element of the FHWA mainstreaming program. To date, forty states have either completed or are currently working on their plans. The main objectives of state business plans are to:

- Establish an ongoing CVO planning process;
- Promote public/private partnerships;

- Provide justification for ITS/CVO funding; and
- Guide the integration of new ITS/CVO technologies

The plan is recommended to include the following:

- Goals and objectives of the state in deploying ITS/CVO technologies;
- ITS/CVO recommended projects;
- Technical approach;
- Organizations and management;
- Schedules and milestones;
- Funding

Experience has shown that the process of ITS/CVO plan development helps promote ITS/CVO awareness in the state, and is very effective in building coalition among the agencies involved and the industry. The plan lays the framework for CVO projects over a period between 3 and 5 years, and defines the major projects to be undertaken. These may include projects to change policies or improve business processes.

Design - The purpose of this second step is to permit the state to establish its Commercial Vehicle Information Systems and Networks (CVISN) project team. CVISN is a national program expected to result in enhanced safety for drivers and trucks and improved operating efficiencies for government agencies and motor carriers. The project team should include at a minimum a CVISN project manager and a system architect. Workshops are available to help states develop their CVISN project plan and the Top-Level Design of the system. These workshops focus on learning from the experience of the CVISN Prototype (Virginia and Maryland) and Pilot States (a group of 10 states) where CVISN is being implemented. As opposed to the business plan, which has a strategic focus, the CVISN project plan has a technical focus, and defines the state information system design.

Deployment - Deploying CVISN is a major undertaking that typically takes several years. In order to reduce risk, deployment should be undertaken in an incremental fashion. It is actually recommended to break this large project into a series of 3 - 6 month phases with specific results or products identified for each phase. Incremental deployment and measurable milestones ensure stakeholder participation and real visibility into project progress.

9.9 Initiate Steps to incorporate ITS into the MPO planning process

The ITS steering committee should start exploring methods aimed at incorporating ITS into the Metropolitan Planning Process. Institutional and inter-jurisdictional relationships must be put in place to enable ITS to be mainstreamed into the planning and programming of transportation improvements. For the rather urban areas of Vermont (such as Chittenden County), the MPO should assume the responsibility for inter-jurisdictional and intergovernmental coordination within the urban area, whereas for the rural areas, the State should assume this role and responsibility. A framework also needs to be established that integrates operational and managerial strategies with multi-jurisdictional, multi-stakeholder scope. Planning for operations, with ITS as an operational tool, will be a critical new element in the MPO planning process.

APPENDIX A:– Results of Mapping Market Packages Against Goals and Objectives

Market Package: APTS1 - Transit Tracking

Goals and Objectives	Responsiveness to Objective
GOAL 1 – Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Medium
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	High
2.2. Improve access to alternative modes of transportation	High
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	High
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	High
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	High
5.3. Improve multimodal travel	High
5.4. Enhance and support ridesharing opportunities	Medium

Market Package: APTS2 - Transit Fixed-Route Operations

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	High
2.2. Improve access to alternative modes of transportation	High
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	High
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	High
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	High
5.3. Improve multimodal travel	High
5.4. Enhance and support ridesharing opportunities	Medium

Market Package: APTS3 - Demand Response Transit Operations

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Medium
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	High
2.2. Improve access to alternative modes of transportation	High
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Medium
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	High
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	High
5.3. Improve multimodal travel	High
5.4. Enhance and support ridesharing opportunities	High

Market Package: APTS4 - Transit Passenger and Fare Management

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	Medium
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Medium
5.3. Improve multimodal travel	Medium
5.4. Enhance and support ridesharing opportunities	Low

Market Package: APTS5 - Transit Security

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Medium
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Medium
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	Low
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: APTS6 - Transit Maintenance

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	High
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Medium
5.3. Improve multimodal travel	Medium
5.4. Enhance and support ridesharing opportunities	Low

Market Package: APTS7 - Multi-modal Coordination

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	High
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Medium
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Medium
2.2. Improve access to alternative modes of transportation	Medium
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Medium
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	Medium
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Medium
5.3. Improve multimodal travel	Medium
5.4. Enhance and support ridesharing opportunities	Low

Market Package: APTS8 - Transit Information

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	High
2.2. Improve access to alternative modes of transportation	High
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	High
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	Low
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	High
5.3. Improve multimodal travel	High
5.4. Enhance and support ridesharing opportunities	Low

Market Package: ATMS01 - Network Surveillance

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	High
1.2. Minimize response-time for incidents and accidents	High
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	High
3.2. Manage transportation demand	Medium
3.3. Enhance traffic management during road construction & special events	High
3.4. Improve efficiency of fleet operations	High
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	High
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	High
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

ATMS02 - Probe Surveillance, represents an alternative approach for network surveillance, and hence has the same degree of responsiveness to objectives as the previous package.

Market Package: ATMS03 - Surface Street Control

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	High
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	High
3.4. Improve efficiency of fleet operations	Low
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	High
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: ATMS04 - Freeway Control

This package has definite advantages with respect to increasing the transportation efficiency in heavily congested areas with a significant freeway network. Examples of this package have been deployed in large metropolitan areas all over the country including Northern Virginia, Maryland, Texas, and California. However, the rural nature of the state of Vermont has to be kept in mind when considering this package.

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Medium
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Medium
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Medium
3.4. Improve efficiency of fleet operations	Low
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Medium
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: ATMS05 - HOV Lane Management

This market package is designed to manage HOV lanes by coordinating freeway ramp meters and connector signals with HOV lane usage. Given this, and given the fact that Vermont does not have HOV lanes at the current moment, this package is not applicable.

Market Package: ATMS06 - Traffic Information Dissemination

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	High
1.2. Minimize response-time for incidents and accidents	Medium
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	High
3.3. Enhance traffic management during road construction & special events	High
3.4. Improve efficiency of fleet operations	Medium
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	High
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	High
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: ATMS07 - Regional Traffic Control

This market package advances the Surface Street Control and Freeway Control Market Packages by adding the communications links and integrated control strategies that enable integrated interjurisdictional traffic control. Given this, the package will have the same degree of responsiveness to objectives as the Street Surface Control package or the Freeway Control package, depending upon the context of its application.

Market Package: ATMS08 - Incident Management Systems

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Medium
1.2. Minimize response-time for incidents and accidents	High
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	High
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	High
3.3. Enhance traffic management during road construction & special events	High
3.4. Improve efficiency of fleet operations	Medium
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	High
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: ATMS09 - Traffic Prediction and Demand Management
This package requires somewhat extensive surveillance, and thus appears to be more of a long-term package.

Market Package: ATMS10 - Electronic Toll Collection
This package is not applicable to Vermont, since we do not have toll roads at the present time.

Market Package: ATMS11 - Emissions Monitoring and Management

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	Low
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: ATMS12 - Virtual TMC and Smart Probe Data

This market package presents an alternative approach to the development of central TMCs that meets the special requirements of rural road systems. According to this package, traffic management is distributed over a very wide area (e.g., a whole state or collection of states), and each locality has the capability of accessing available information for assessment of road conditions. The package uses vehicles as smart probes that are capable of measuring road conditions and providing this information to the roadway for relay to the Traffic Management Subsystem and potentially direct relay to following vehicles. In-vehicle signing is used to inform drivers of detected road conditions.

Although this package sounds promising, especially given the nature of the State of Vermont, the technologies needed for the implementation of this package have not completely matured yet. The package thus appears to be more of a long-term package.

Market Package: ATMS13 - Standard Railroad Grade Crossing

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	High
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	Low
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: APTS14 - Advanced Railroad Grade Crossing

This package is similar to ATMS13, but is designed for the needs of highway-rail intersections (HRIs) where rail operational speeds are greater than 80 miles per hour. Given this, the package is not applicable to Vermont at the present time.

Market Package: ATMS15 - Railroad Operations Coordination

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	Medium
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Medium
5.4. Enhance and support ridesharing opportunities	Low

Market Package: ATMS16 - Parking Facility Management
Although parking problems do exist in downtown Burlington, my assumption was that the magnitude of the problem is not that great.

Market Package: ATMS17 - Reversible Lane Management
This market package provides for the management of reversible lane facilities, a facility that does not exist in Chittenden County. Given this, the package is not currently applicable.

Market Package: ATMS18 - Roadway Weather Information Systems

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	High
1.2. Minimize response-time for incidents and accidents	Medium
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	High
3.4. Improve efficiency of fleet operations	High
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	High
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: ATIS1 - Broadcast Traveler Information

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	High
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Medium
2.2. Improve access to alternative modes of transportation	High
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Medium
3.3. Enhance traffic management during road construction & special events	High
3.4. Improve efficiency of fleet operations	High
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	High
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	High
5.3. Improve multimodal travel	High
5.4. Enhance and support ridesharing opportunities	Medium

Market Package: ATIS2 - Interactive Traveler Information

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	High
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Medium
2.2. Improve access to alternative modes of transportation	High
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Medium
3.3. Enhance traffic management during road construction & special events	High
3.4. Improve efficiency of fleet operations	High
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	High
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	High
5.3. Improve multimodal travel	High
5.4. Enhance and support ridesharing opportunities	Medium

Market Package: ATIS3 - Autonomous Route Guidance
This package is mainly a private sector (specifically, the auto industry) initiative that relies on in-vehicle devices to enable route planning and detailed route guidance based on static, stored information. No communication with the infrastructure is assumed or required. Given this, it was felt that this package is not relevant to the purposes of the current study.

Market Package: ATIS4 - Dynamic Route Guidance
This package combines the autonomous route guidance user equipment (ATIS3) with the capability to receive real-time traffic, transit and road condition information. Given this, the package seems to be more of a long-term deployment. In any case, the package has the same degree of responsiveness to objectives as the ATIS1 or the ATIS2 packages.

Market Package: ATIS5 - ISP Based Route Guidance
This market package offers the same functionality as the Dynamic Route Guidance package (ATIS4), but it moves the route planning function from the vehicle to the information service provider. The package includes both turn-by-turn route guidance, as might be used in a vehicle, as well as pre-trip routes. The package includes two way data communications and optionally also equips the vehicle with the databases, location determination capability, and display technology to support turn by turn route guidance. The package has the same degree of responsiveness to objectives as the ATIS1 or the ATIS2 packages, but once again, appears to be a long-term deployment.

Market Package: ATIS6 - Integrated Transportation Management/Route Guidance
This mark ackage allows a traffic management center to continuously optimize the traffic control strategy based on near-real time information on *intended* routes for a proportion of the vehicles within their network, while offering the user advanced route planning and guidance which is responsive to current conditions. Current congestion in Vermont does not appear to warrant such a level of sophistication in the development of routing strategies. Nevertheless, the package might be considered as a long-term package to be deployed after more basic services are in place.

Market Package: ATIS7 - Yellow Page and Reservation
This market package enhances the Interactive Traveler Information package by making infrastructure provided yellow pages and reservation services available to the user. The package appears to be a useful addition to the ATIS packages, especially given the nature of the tourism industry in Vermont.

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Medium
3.3. Enhance traffic management during road construction & special events	Medium
3.4. Improve efficiency of fleet operations	Low
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	High
4.2. Create linkages throughout the state and globally	Medium
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: ATIS8 - Dynamic Ride Sharing
This market package enhances the Interactive Traveler Information package by adding an infrastructure provided dynamic ridesharing/ride matching capability. There does not seem to be a real need for this package at the current time. However, the package may be considered as a long-term deployment.

Market Package: ATIS9 - In-vehicle Signing
This market package supports distribution of traffic and travel advisory information to drivers through in-vehicle devices. It includes short-range communications between roadside equipment, the vehicle and wireline connections to the Traffic Management Subsystem for coordination and control. The package appears to be a long-term deployment that would require cooperation with the private sector.

Market Package: EMS1 - Emergency Response

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	High
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	High
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	Low
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: EMS2 - Emergency Routing

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	High
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	High
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	Low
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: EMS3 - MayDay Support

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	High
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	High
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	Low
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: CVO1 – Fleet Administration (mainly a freight industry initiative)

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	High
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	High
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: CVO2– Freight Administration (mainly a freight industry initiative)

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	Low
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: CVO3– Electronic Clearance

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	High
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	High
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: CVO4– CV Administrative Processes

Goals and Objectives	Responsiveness to Objective
GOAL 1 – Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	High
1.4. Improve emergency management communications	Low
GOAL 2 – Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 – Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	High
GOAL 4 – Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Medium
GOAL 5 – Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: CVO5 – International Border Electronic Clearance

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	Low
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	High
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	High
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: CVO6 – Weigh-In-Motion

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	High
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	High
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: CVO7 – Roadside Safety

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	High
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	High
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: CVO8 – On-board CVO Safety

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	High
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	High
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: CVO9 – CVO Fleet Maintenance

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	Low
1.3. Reduce commercial vehicle safety violations	High
1.4. Improve emergency management communications	Low
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	High
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

Market Package: CVO10 – HAZMAT Management

Goals and Objectives	Responsiveness to Objective
GOAL 1 - Ensure Safe Transportation for residents, visitors & travelers	
1.1. Reduce weather-related traffic incidents	Low
1.2. Minimize response-time for incidents and accidents	High
1.3. Reduce commercial vehicle safety violations	High
1.4. Improve emergency management communications	High
GOAL 2 - Enhance Mobility	
2.1. Enhance mobility for the transportation-disadvantaged	Low
2.2. Improve access to alternative modes of transportation	Low
GOAL 3 - Improve Efficiency	
3.1. Improve traffic signal systems	Low
3.2. Manage transportation demand	Low
3.3. Enhance traffic management during road construction & special events	Low
3.4. Improve efficiency of fleet operations	Low
GOAL 4 - Support Economic Development	
4.1. Improve tourist access and convenience	Low
4.2. Create linkages throughout the state and globally	Low
GOAL 5 - Preserve the Environment, Community Values and Energy	
5.1. Reduce need to travel through telecommunications	Low
5.2. Reduce energy use	Low
5.3. Improve multimodal travel	Low
5.4. Enhance and support ridesharing opportunities	Low

APPENDIX B:- Real-World Examples of Rural ITS Deployments

For deployment purposes, the National Advanced Rural Transportation Systems (ARTS) program defines the following seven deployment tracks:

1. Rural Crash Prevention
2. Emergency Management
3. Traveler Information Infrastructure
4. Rural ITS mobility systems (mainly rural transit and paratransit systems)
5. Rural Traffic Management
6. Highway Operations and Maintenance
7. Surface Transportation Weather and Winter Mobility

This section describes some real-world examples of systems belonging to these deployment tracks, drawn from rural states across the country.

Advanced Rural Traveler Information Systems (ARTIS)

ARTIS are traveler information systems developed specifically to meet the needs of rural travel (deployment track #3). The services that these systems provide include electronic yellow pages for points of attractions in the region, route advisory information, weather and road conditions information, etc. A good example of these systems is the Branson Travel and Recreational Information program developed by Missouri DOT and FHWA (in partnership with some private companies). This system was developed as a comprehensive travel guide for the Branson area. The system uses traffic detector and traffic cameras to constantly monitor traffic conditions on the most significant routes in the area. The collected information is made available to travelers through a variety of devices including the Internet, kiosks, radio, telephone and variable message signs. More information on this project can be found at: http://branson.tripusa.com/

Another good example of ARTIS is the system developed by Arizona DOT for the Flagstaff area. This system provides the traveler with a wealth of information on travel and weather conditions, lodging and dining, attractions and activities and other general information. More information on this system can be found at http://arizona.tripusa.com/

Advanced Rural Transportation Information and Co-ordination (ARTIC)

The ARTIC is an ITS field operational test that spans across deployment track #2, #4 and #6. ARTIC combines the communications dispatch operations of four public service agencies into a single communications center that serves a remote area in the Arrowhead region in northeastern Minnesota. The main goal of the project is to coordinate and pool resources to reduce duplication (as we have discussed before, this is quite important for remote, rural areas where resources are quite limited). The project also aims at improving the transportation system efficiency and enhancing user and driver safety.

The test operation started in October 1997 with the following partners: Arrowhead Regional Development Commission, Arrowhead Transit, FHWA, MnDOT, and Minnesota State Police. A consolidated center was established to host the emergency response functions and communications equipment for both the State Patrol and MnDOT. The center also included the fleet management operations for a dial-a-ride company and a transit company. Automatic Vehicle Location (AVL) devices and Mobile Data Terminal (MDT) equipment were installed in 4 State Patrol cruisers, 15 MnDOT snow plow trucks, 12 transit buses and 3 dial-a-ride vehicles. These equipment provided operational personnel with: (1) up-to-the-minute information on vehicle locations and availability; and (2) improved communications capabilities during emergencies. In addition to the above equipment, the project implemented a computer-assisted transit scheduling system and a computer-aided dispatch (CAD) system to automate the Patrol call taking, communications and records management functions.

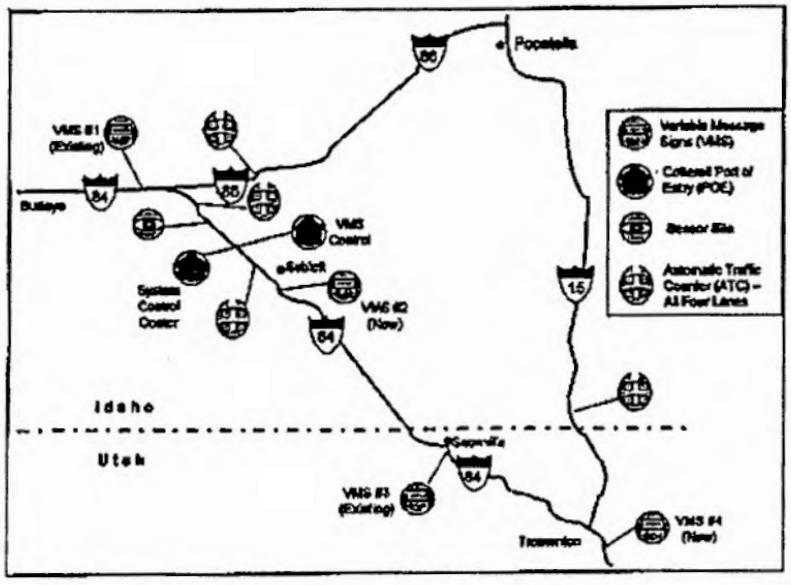
Evaluation results from that test demonstrate that the system has resulted in much faster response than what was possible before. In one case, a MnDOT snowplow, being the closest vehicle, responded to a vehicle accident location in a fraction of the time that it would have taken for the law enforcement assets to respond. The snowplow operator was able to rely very useful information that helped resolve the accident situation.

The FORTELL Initiative

FORETELL is a regional initiative to bring together public and private sector partners from the fields of transportation and meteorology to integrate advanced weather systems and ITS (deployment track #7). The basis of FORETELL's system design is to bring together all available weather data sources including satellites, radars, wind profilers, the National Weather Service sites, the Department of Defense, aviation and conventional Road Weather Information Systems (RWIS). State-of-the-art atmospheric prediction models will be used and combined with site-specific pavement condition forecasting models (these models which are currently used in Europe uses energy balance principles to predict pavement condition) to support fine resolution forecasts. ITS Service Centers will provide the focus for data fusion, road condition forecasting and information dissemination activities. Planned dissemination media include radio, TV, conventional and cellular phone, pagers and the Internet, as well as roadside devices such as VMS and HAR.

Idaho Storm Warning System

Idaho Storm Warning System is an example of a system that falls under the first deployment track dealing with rural crash prevention. The system was designed to warn motorists about adverse weather conditions, with the goal of reducing the frequency and severity of visibility-related accidents along a section of I-84 in Idaho and Northern Utah (see figure).



Source: Field Operational Tests Compendium

This section was subject to low visibility conditions caused by blowing snow during the winter and sand during the spring. Partners for the development of the system included FHWA, Idaho DOT, National Weather Service, Handar Incorporated, Santa Fe Technologies and Surface Street Incorporated.

The system consists of a group of sensor systems that provide visibility and other weather-related data, and a set of Variable Message Signs (VMSs) located along the highway. During the project, three different types of visibility sensing systems were tested:

- SCAN, which incorporates 2 different types of visibility sensors, one using visible light, and the other using infrared light. The system also includes weather measurement sensors for wind speed and direction, temperature, relative humidity and types and amount of precipitation;
- HANDAR, which has weather sensors and a point detection visibility sensor similar to the visible light sensor of SCAN; and
- LINDAR, which is a single visibility sensor using advanced laser technology. LIDAR operates similar to radar systems and can provide visibility measurements over a larger area than the other 2 technologies.

Information from all the three systems is transmitted to a central computer. The computer analyses sensor reading every 5 minutes and alerts operators if the visibility falls below a certain threshold. The operator then has the choice to activate the VMSs to advise motorists. Initial evaluation results demonstrate that the system has the potential to provide useful information regarding low visibility. However, there is a need to combine information from all three sensors (data fusion) to ensure the right message is displayed on the VMSs.

The "Simple Solutions" ToolBox

In a rural outreach effort, FHWA recently funded a project entitled "Simple Solutions". The goal of this project was to identify simple, proven solutions for transportation-related problems in rural areas. Although these simple solutions may not be considered an ITS as such, they do represent technology-based, practical solutions that could serve as precursors to future applications of more advanced systems. 56 solutions were identified and researched during the first phase of the project. 14 solutions out of these 56 were then selected for more detailed investigation. Some examples of these solutions are:

1. Pager systems for activating crossing warning signs from a remote location;
2. An internet Web site used by a county as a center piece to disseminating information within its jurisdiction;
3. A speed warning system that utilizes radar and VMS to warn truck drivers if they are approaching a dangerous curve or slope too fast;
4. A snow route design optimization software that develops efficient snow-plow routes;
5. Infra-red sensors mounted on snow plows to help determine which areas of the roadway need to be treated with de-icing or anti-icing agents;
6. A work-zone signage and traffic monitoring system that responds to traffic levels and provides tailored warnings to drivers to merge in time
7. A siren-activated signal pre-emption system which requires no additional equipment to be fitted to the priority vehicle
8. Road and weather information distributed to multiple user agencies via a broadcast fax machine.

APPENDIX C: DISTRICT ENGINEERS SURVEY

Districts Intelligent Transportation Systems (ITS) Survey
October 18, 2000

District Number _____

The purpose of this survey:

The Agency has recently launched a study for Intelligent Transportation Systems (ITS) strategic planning for the state (ITS is the term for the application of advanced technologies to increase the efficiency and safety of the transportation system). The main purpose of the current survey is to get your expert opinion on which ITS applications you feel are most appropriate for Vermont. Below, you will find a list of some of the some widely used ITS applications (packages), along with a brief description of each application. You are kindly asked to rate each technology on a scale of 5 to 1 (with 5 indicating the most useful, and 1 indicating the least). You are also asked to kindly identify some locations within your district where these technologies would be quite useful.

1) Real-time Surveillance of Traffic Conditions:

This application involves the use of traffic detectors (such as loops, non-intrusive detection technologies, and video cameras) to monitor the status of traffic flow. 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 video camera sends data back to a Traffic Management Center). The package enables traffic managers to monitor traffic and road conditions, identify and verify incidents, detect faults in traffic equipment, and collect census traffic data for long-range planning.

ITS Package Rating (please circle one):

5 (most useful) 4 3 2 1 (least useful)

Candidate Deployment Locations within your District:

2) Traffic Information Dissemination:

This market package allows traffic information to be disseminated to drivers and vehicles using roadway equipment such as variable 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 drivers can tailor their routes to account for the new information.

ITS Package Rating (please circle one):

5 (most useful) 4 3 2 1 (least useful)

Strategic Deployment Locations within your District:

3) Incident Management:

This package manages both predicted (i.e. construction work) and unpredicted incidents so that the impact to the transportation network and traveler safety is minimized. Required 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 used to detect and verify incidents and implement an appropriate response. The response may include traffic control strategy modifications and presentation of information to affected travelers using variable message signs and highway advisory radio.

ITS Package Rating (please circle one):

5 (most useful) 4 3 2 1 (least useful)

Candidate Roadways within your District for Deployment:

Districts Intelligent Transportation Systems (ITS) Survey
October 18, 2000

District Number _____

The purpose of this survey:

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ITS Package Rating (please circle one):

5 (most useful) 4 3 2 1 (least useful)

Candidate Deployment Locations within your District:

6) Pre-trip Traveler Information Systems

This package involves the collection of traffic conditions, advisories, general public transportation and parking information and the dissemination of this information to travelers befor. 'hey start their trip. One deployment scenario would involve the development of a webp. to post traffic information collected from the traffic and weather surveillance equipment. The web site would include a color-coded map of the major highways in the region depicting the average speeds, icy conditions (if any), 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. 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. incidents) information.

ITS Package Rating (please circle one):

5 (most useful) 4 3 2 1 (least useful)

7) Portable Event Management Systems

These systems are designed to efficiently handle major event logistics. They include traffic management capabilities through the use of portable variable message signs. They also provide information on hotel and service availability, as well as directions on how to reach the services when available.

ITS Package Rating (please circle one):

5 (most useful) 4 3 2 1 (least useful)

Identify some scenarios where this package would be useful

8) Fleet Management Systems

This application involves the use of Automatic Vehicle Location (AVL) technologies (e.g. GPS receivers on snowplows) to optimize the dispatch and routing of snowplows. The goal is to improve the coordination and routing of the fleet and increase the efficiency of fleet operations.

ITS Package Rating (please circle one):

5 (most useful) 4 3 2 1 (least useful)

9) Standard Railroad Crossing Package

This market package manages highway traffic at highway-rail intersections (HRIs). Both passive (e.g., the crossbuck sign) and active warning systems (e.g., flashing lights and gates) are supported. These traditional HRI warning systems may also be augmented with other standard traffic management devices. The warning systems are activated on notification by interfaced wayside equipment of an approaching train. The equipment at the HRI may also be interconnected with adjacent signalized intersections so that local control can be adapted to highway-rail intersection activities. Monitoring of the HRI equipment and interfaces is performed, and detected problems are reported to both highway and railroad officials.

ITS Package Rating (please circle one):

5 (most useful) 4 3 2 1 (least useful)

Candidate Deployment Locations within your District:

Additional Questions

What do you think are the most pressing transportation problems that your agency is facing (e.g. congested highway sections, lack of signal co-ordination, slow response to incidents)?

For the nine ITS applications that you have rated above, namely:

1) **Real-time traffic surveillance**
2) **Traffic Information Dissemination**
3) **Incident management**
4) **Roadway weather information systems**
5) **Advanced Traffic Signal Systems**
6) **Pre-trip Traveler Information**
7) **Portable Event Management Systems**
8) **Fleet Management Systems**
9) **Standard Railroad Crossing Package**

Are there any of such systems already in use in your district? If so, please list those systems.