Chittenden County ITS Plan

Final Report

prepared for

Chittenden County RPC

prepared by

Cambridge Systematics, Inc.
Acknowledgements

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Approval Resolution

RESOLUTION OF THE
CHITTENDEN COUNTY REGIONAL PLANNING COMMISSION APPROVING THE 2016
CHITTENDEN COUNTY INTELLIGENT TRANSPORTATION SYSTEM (ITS) PLAN

WHEREAS, the Chittenden County Regional Planning Commission (CCRPC), is one of 11 regional planning
commissions in Vermont, and also serves the region as the sole Metropolitan Planning Organization (MPO)
operating within Vermont, acts as the principal forum for planning, policy and community development and is
responsible for managing the continuous, cooperative and comprehensive Transportation Planning process in
Chittenden County; and

WHEREAS, the Federal Highway Administration (FHWA) issued a Final Rule 940 and the Federal Transit
Administration (FTA) issued a similar policy on National ITS Architecture on January 8, 2001 to implement
§5206(e) of the Transportation Equity Act for the 21st Century; and

WHEREAS, the Rule/Policy requires that any region currently implementing ITS projects shall have a regional ITS
architecture in place by April 8, 2005 and that ITS projects funded by the Highway Trust Fund and the Mass
Transit Account must conform to the regional ITS architecture; and

WHEREAS, the CCRPC published the Regional Intelligent Transportation Systems (ITS) Architecture for Chittenden
County (April, 2005), a "living-document" prepared to guide the planning and implementation of ITS in
Chittenden County; and

WHEREAS, the 2025 Metropolitan Transportation Plan (MTP), as amended in January 2010, recommends ITS
projects to improve travel efficiency and manage traffic flows with technology-based tools; and

WHEREAS, in 2014, the CCRPC hired Cambridge Systematics, Inc. to assist with the update of the 2005 Regional ITS
Architecture and development of a 2016 Chittenden County ITS Plan; and

WHEREAS, A Steering Committee was formed to provide general oversight and guidance during the development
of the ITS Plan with representation from the Cities of Burlington and South Burlington, the CCRPC, Vermont
Agency of Transportation (VTrans), Chittenden County Transportation Authority (CCTA), and Local Motion.
Input for the ITS Plan was also gathered from the following organizations: Vermont Department of Motor
Vehicles, Vermont State Police, Burlington Airport, University of Vermont (UV), Greater Burlington Industrial
Corporation (GBIC), National Weather Service and the University of Vermont Medical Center; and

WHEREAS, the Chittenden County Technical Advisory Committee and the Executive Committee recommended
approval of the Chittenden County ITS Plan at their January 5, and January 6, 2016 meetings, respectively; and

NOW, THEREFORE, BE IT RESOLVED THAT:

The Chittenden County Regional Planning Commission hereby approves the Chittenden County ITS Plan, dated
January 2016, as the regional vision and policy plan regarding the use of specific ITS applications to address
regional transportation needs.

Dated this 20th day of January 2016 in Winooski, Vermont.

CHITTENDEN COUNTY REGIONAL PLANNING COMMISSION

Andrew H. Montroll, Chair
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## Abbreviations

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<th>Full Form</th>
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<tbody>
<tr>
<td>511</td>
<td>US Traveler Information Telephone Number</td>
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<tr>
<td>AASHTO</td>
<td>American Association of State Highway and Transportation Officials</td>
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<tr>
<td>AD</td>
<td>Archive data</td>
</tr>
<tr>
<td>APC</td>
<td>Automatic Passenger Counter</td>
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<tr>
<td>APTS</td>
<td>Advanced Public Transportation System</td>
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<tr>
<td>ATIS</td>
<td>Advanced Traveler Information System</td>
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<tr>
<td>ATMS</td>
<td>Advanced Transportation Management System</td>
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<tr>
<td>AVL</td>
<td>Automatic Vehicle Location</td>
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<td>AVSS</td>
<td>Advanced Vehicle Safety System</td>
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<tr>
<td>BRT</td>
<td>Bus Rapid Transit</td>
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<tr>
<td>CAD</td>
<td>Computer Aided Dispatch</td>
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<td>CCRPC</td>
<td>Chittenden County Regional Planning Commission</td>
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<td>CCMPO</td>
<td>Chittenden County Metropolitan Planning Organization</td>
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<td>CCTA</td>
<td>Chittenden County Transportation Authority</td>
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<tr>
<td>CCTV</td>
<td>Closed-Circuit Television</td>
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<td>CVISN</td>
<td>Commercial Vehicle Information Systems and Networks</td>
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<td>CVO</td>
<td>Commercial Vehicle Operations</td>
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<td>FHWA</td>
<td>Federal Highway Administration</td>
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<tr>
<td>ISP</td>
<td>Information Service Provider</td>
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<td>ITS</td>
<td>Intelligent Transportation System</td>
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<tr>
<td>LSC</td>
<td>Lyndon State College Meteorological Department</td>
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<tr>
<td>MC</td>
<td>Maintenance and Construction</td>
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<tr>
<td>MDC</td>
<td>Mobile Data Computers</td>
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<td>MPO</td>
<td>Metropolitan Planning Organization</td>
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<td>MTP</td>
<td>Metropolitan Transportation Plan</td>
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<tr>
<td>NWS</td>
<td>National Weather Service</td>
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<tr>
<td>PCMS</td>
<td>Portable Changeable Message Signs</td>
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<tr>
<td>PRND</td>
<td>Preventive Radiological/Nuclear Detection</td>
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<tr>
<td>RRFB</td>
<td>Rectangular Rapid Flash Beacon</td>
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<tr>
<td>RWIS</td>
<td>Road Weather Information Station</td>
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<tr>
<td>SEOC</td>
<td>Vermont State Emergency Operation Center</td>
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<td>TOC</td>
<td>Transportation Operations Center</td>
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<td>TMC</td>
<td>Transportation Management Center</td>
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<td>TSP</td>
<td>Transit Signal Priority</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>DOT</td>
<td>Department of Transportation</td>
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<tr>
<td>DMS</td>
<td>Dynamic Message Sign</td>
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<tr>
<td>DMV</td>
<td>Department of Motor Vehicles</td>
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<td>DPW</td>
<td>Department of Public Works</td>
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<tr>
<td>DSRC</td>
<td>Dedicated Short Range Communication</td>
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<tr>
<td>EM</td>
<td>Emergency Management</td>
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<tr>
<td>ESS</td>
<td>Environmental Sensor Station</td>
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1.0 Introduction

The following report corresponds to the study *Chittenden County ITS Architecture Update*, prepared for Chittenden County Regional Planning Commission (CCRPC). This report documents the process of updating the ITS Architecture of the Chittenden County region for the 2015 – 2025 term.

1.1 WHAT IS ITS?

ITS stands for Intelligent Transportation System. Intelligent Transportation Systems are defined by the U.S. Department of Transportation as “the integration of advanced communication technologies into the transportation technologies and vehicles. Intelligent transportation systems (ITS) encompass a broad range of wireless and wire line communications-based information and electronics technologies.”

ITS is the planning, design, and implementation of technology on transportation infrastructure and services to provide better services to users and reduce negative externalities on the environment. ITS technologies encompass all transportation modes, from pedestrian activities to freight movement. By implementing technologies over a region, the mobility and accessibility of the region can be enhanced, helping users go to where they want to go, when they want to, in an easier and cleaner manner.

1.2 WHAT IS AN ITS ARCHITECTURE?

An ITS Architecture is a structured guideline to plan, define, and integrate ITS technology in a region. There are Architectures defined for different regions, considering a range of stakeholders from Federal agencies to State and regional agencies, local municipalities and advocacy groups. The structured framework of ITS Architecture allows communication across regions and allows a smoother ITS deployment.

1.3 ITS ARCHITECTURE UPDATE OBJECTIVES

The objective of this report is to update the Chittenden County Regional ITS Architecture. After 10 years, the Chittenden County ITS Architecture needs to be

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1 Definition obtained from the US DOT Intelligent Transportation Systems Joint Program Office. http://www.its.dot.gov/faqs.htm
updated to take in consideration new projects and technologies that respond to the region’s needs and tackle current transportation issues.

1.4 DOCUMENT OVERVIEW

The following report consists of 6 sections:

1. Section 1 – Introduction: A brief explanation of the project’s objective and regional background is presented.

2. Section 2 – Status of the System: A description of current and short-term planned ITS inventory is presented. The stakeholders involved in ITS are introduced.

3. Section 3 – Background: A brief description of the former ITS Architecture is presented.

4. Section 4 – Gap/Need Assessment: Results from the Gap/Need assessment are presented and future ITS projects are described and summarized for their inclusion in the ITS Architecture Update.

5. Section 5 – Operational Concept: Having identified projects, their operations are described and stakeholders are defined according to their responsibilities. Flow diagrams are created to represent the communication and flows of different services and data, according to the Architecture services considered.

6. Section 6 – ITS Strategic Deployment Plan. This final section classifies the projects described, assigning them an approximate cost estimate, to structure an implementation plan for the future.

1.5 ITS ARCHITECTURE COMPLIANCE

The following report follows the USDOT National ITS Architecture conformity rule (23 CFR Part 940, and the FTA National Architecture Policy on Transit Projects). This rule requires that ITS Architectures be completed for regionally significant ITS projects, if the projects are to be eligible for Federal transportation funding. Today, developing, documenting and using the ITS Architecture is considered a best practice in the transportation/ITS industry.

1.6 THE CHITTENDEN REGION

Chittenden County is one of 14 counties in Vermont with a population of 156,545 in 2010. It contains approximately 25% of the total population in the State of Vermont (625,741 in 2010). The population is concentrated in and around Burlington City (42,417) including the nearby cities and towns of South Burlington (17,904), Winooski (7,267), Essex (19,587), Essex Junction (9,271), Colchester (17,067), Williston (8,698), and Shelburne (7,144).
The County of Chittenden shares boundaries with the counties of Grand Isle, Franklin, Lamoille, Washington, and Addison. In addition, it shares a border with Lake Champlain. The County contains 19 municipalities (as observed in Figure 1.1):

- Burlington
- South Burlington
- Winooski
- Williston
- Essex
- Essex Junction
- Colchester
- Milton
- Westford
- Underhill
- Jericho
- Richmond
- Bolton
- Shelburne
- St. George
- Charlotte
- Hinesburg
- Huntington
- Buels Gore
Figure 1.1 Chittenden County Region Extent and Boundaries

Source: Vermont Center of Geographic Information
2.0 Status of the System

The first task of this study was to identify the state of the Chittenden Region ITS system. For this purpose, the first task is to identify the key stakeholders and understand their involvement in the ITS Architecture. The second task consists of describing the current ITS inventory. Once the state of the system is described, future projects and plans can be designed to meet the region’s needs and incorporate them in the ITS Architecture Update, and include them in the Vermont Statewide ITS Architecture.

2.1 STAKEHOLDERS

The following stakeholders were identified as key players in the region’s ITS system:

Chittenden County Regional Planning Commission (CCRPC)

CCRPC is the regional Metropolitan Planning Organization (MPO) for the 18 municipalities in the region. It is the main forum for planning, policy, and community development in the region. It is responsible for developing the Metropolitan Transportation Plan (MTP), the Transportation Improvement Program (TIP), and the Unified Planning Work Program (UPWP).

Vermont Agency of Transportation (VTrans)

VTrans is the State of Vermont agency that is responsible for managing, operating, and/or maintaining state-owned transportation infrastructure (roads, transit, airports, railways), including the Interstate system and many of the major arterials that connect the CCRPC region to other areas. VTrans owns the following State airports: Franklin County, Middlebury, Rutland, Bennington, Springfield and Newport. VTrans is also responsible for the Vermont Statewide ITS Architecture of which the CCRPC ITS Architecture is a component.

Chittenden County Transportation Authority (CCTA)

CCTA is the public transportation agency that provides fixed route, deviated fixed route, demand response, commuter shuttle, Medicaid and complementary paratransit transit services, either directly or through service contracting. CCTA operates primarily in the urban portion of the Burlington region (including Burlington, Essex, Essex Junction, Shelburne, South Burlington, Williston, Winooski and a portion of Colchester).
City of Burlington
Burlington is the core urban municipality of Chittenden County, with an approximate population of 42,000. It is the owner and operator of traffic signals in their geographic jurisdiction. The City of Burlington also maintains the City of Burlington International Airport.

City of South Burlington
The second largest city in the region, with an approximate population of 18,000, located south from Burlington. It is owner and responsible for traffic signals in their jurisdiction.

City of Winooski
The third largest city in the region, with an approximate population of 7,500, located east from Burlington.

Town of Essex
The Town of Essex has a population of 19,587, according to the 2010 census. Although the population in Essex is the second largest in the State of Vermont, and large enough to be considered a city, it is not incorporated as such. However, Essex is an important town due to its size and geographic proximity to Burlington.

Village of Essex Junction
The Village of Essex Junction was formed in 1892 as a way to provide necessary services at the time. The political and geographic boundaries remain, although it is within the Town of Essex. An important landmark in the Village of Essex Junction is the 5 Corners intersection. This is an intersection where important highways – such as VT-15, VT-2A, and VT-117 - and rail services by Amtrak interact, as well as the New England Central Railroad with a branch to Burlington to connect with Vermont Rail Systems.

Town of Colchester
The Town of Colchester is located next to Lake Champlain, north of Burlington. With a population of 17,067, the Town of Colchester is the second most populated town and fourth largest municipality in the State.

Town of Williston
The Town of Williston is located east of South Burlington, acting as an important commercial center of the Burlington Metropolitan Area. With a population of 8,698 (approximately 1000 more than in the previous census), the Town of Williston is one the fastest growing towns in the State.
Town of Shelburne

The Town of Shelburne is located south of Burlington, next to Lake Champlain. Shelburne is a major suburb of the Burlington Metropolitan Area and is served by Route 7 the major north-south highway in western Vermont.

Other Municipalities

There are 11 other municipalities in the region which are primarily rural and lightly populated. There are traffic signals scattered across these jurisdictions at some major intersections.

Departments of Public Safety

The main stakeholder involved in this group is the State of Vermont Public safety Department, which is responsible for public safety and managing emergency operations. The Vermont State Police, Vermont Emergency Management, and Vermont Fire Safety are part of this agency. There are also municipal public safety departments included in this group. This group represents municipalities’ police and fire departments, as well as private entity's police, fire, and/or other public safety agencies, including Sheriff’s Departments.

Departments of Motor Vehicles

This group refers mainly to Vermont’s DMV, but it also includes municipalities’ DMV’s, and the Commercial Vehicle Information System Network (CVISN) program.

Transportation Advocacy Groups

Local transportation Advocacy Groups, in particular ‘Local Motion’, which is non-profit organization focused on bicycle and pedestrian transportation and recreation in Chittenden County and throughout Vermont.

Other Transportation Service Providers

Other transportation services in the region include the Burlington International Airport, commercial vehicles, taxi services, private tows and plow services, the Lake Champlain Transportation Company which runs several ferry routes, as well as other transit services.

Other Service Providers

There are important services that are involved with ITS services in the region, including the University of Vermont Medical Center, Fire and Police Departments in different municipalities and other urban public services, such as entities that operate electric and gas services, as well as social services for the elderly, disabled, and low-income communities.
2.2 **CURRENT INVENTORY**

Before the ITS Architecture Update is considered, it is important to acknowledge the current state of transportation infrastructure and services in the regional ITS. The first task was to determine current ITS inventory and short term ITS projects to consider in the Architecture Update. For this purpose, the maps in this section were developed, showing the current ITS system inventory in the region.

**Traffic signals**

There are 116 traffic signals owned by municipalities (Burlington and South Burlington mainly), and 69 traffic signals owned by VTrans. Inside the core urban area, there are 77 pedestrian traffic signal intersections.

There is coordination among 28 of the municipal signals, along important corridors such as Main St. and Dorset St. VTrans has a larger number of coordinated intersections, with 51 coordinated signals across important corridors such as VT-15 and US-7. Furthermore, there are 5 planned traffic signals in the region. The location of all these signals can be observed in Figures 2.1 and 2.2.

**Beacons**

There are numerous beacons located in the region, these are classified as:

- Rectangular Rapid Flashing Beacon (RRFB)
- School Zone Flasher
- 4-Way Red Flasher
- Flashing Beacons (all types)

The location of these beacons can be observed in Figure 2.3 and 2.4.

**Cameras**

Cameras are located at signalized intersections and used for vehicle detection. Figures 2.5 and 2.6 show the locations of these features.

**Transit Routes**

There are 20 fixed transit routes and 673 located bus stops in the Chittenden Region. These routes are operated by CCTA. Other services in the region, such as CCTA’s paratransit services, operate on demand rather than fixed route. Figures 2.7 and 2.8 show the location of CCTA routes and bus stops.

**Transit Features and Improvements**

There are number of planned transit features and improvements in the short-term pipeline. CCTA is considering the implementation of a new Bus Rapid Transit (BRT) line in the region, as well as Transit Signal Priority (TSP) along two
important corridors in the area. In addition, there are plans to install four bus arrival signs and one information screen in the area. Currently, there are four park-and-ride facilities in the area. Figures 2.9 and 2.10 show the locations of these features and improvements, as well as the location of the Automatic Vehicle Location (AVL) Equipment dispatch and the TSP Center.

**ITS Planned Components**

In summary, there are a number of ITS features currently considered for implementation, including cameras and transit features. Figures 2.11 and 2.12 show the location of these components.
Figure 2.1 Signalized Intersections – CCRPC Region

Legend
- Pedestrian Signals
- Coordinated VTrans
- VTran Signals
- Coordinated Municipal
- Municipal Signals
- Planned Signals

Source: Vermont Center of Geographic Information, Chittenden County Regional Planning Commission
Figure 2.2  Signalized Intersections – Burlington Urban Area

Source: Vermont Center of Geographic Information, Chittenden County Regional Planning Commission
Figure 2.3 Beacons – CCRPC Region

Source: Vermont Center of Geographic Information, Chittenden County Regional Planning Commission
Figure 2.4  Beacons – Burlington Urban Area

Source: Vermont Center of Geographic Information, Chittenden County Regional Planning Commission
Figure 2.5 Cameras – CCRPC Region

Legend

Vehicle Detection Cameras
- Municipal Vehicle Detection Cameras
- VTrans Vehicle Detection Cameras

Source: Vermont Center of Geographic Information, Chittenden County Regional Planning Commission²

² Note: VTrans Vehicle Detection Cameras are from the Detection Technology Master List, and include all detection technologies except for loop detectors.
Figure 2.6  Cameras - Burlington Urban Area

Source: Vermont Center of Geographic Information, Chittenden County Regional Planning Commission

Note: VTrans Vehicle Detection Cameras are from the Detection Technology Master List, and include all detection technologies except for loop detectors.
Figure 2.7  Transit Routes – CCRPC Region

Source: Vermont Center of Geographic Information, Chittenden County Regional Planning Commission
Figure 2.8  Transit Routes – Burlington Urban Area

Source: Vermont Center of Geographic Information, Chittenden County Regional Planning Commission
Figure 2.9  Transit Features and Improvements – CCRPC Region

Legend
Type
- AVL Equipment and Automated Dispatch
- Bus Arrival Sign (Planned)
- Bus Information Screen (Planned)
- Park and Ride
- TSP
- Transit Signal Priority (Planned)
- Bus Rapid Transit (Planned)
- CCTA Transit Routes

Source: Vermont Center of Geographic Information, Chittenden County Regional Planning Commission
Figure 2.10  Transit Features and Improvements – Burlington Urban Area

Legend

Type
- AVL Equipment and Automated Dispatch
- Bus Arrival Sign (Planned)
- Bus Information Screen (Planned)
- Park and Ride
- TSP
- Transit Signal Priority
- Bus Rapid Transit
- CCTA Transit Routes

Source: Vermont Center of Geographic Information, Chittenden County Regional Planning Commission
Figure 2.11  Road Weather Information System – CCRPC Region

Source: Vermont Center of Geographic Information, Chittenden County Regional Planning Commission

4 Note: An extra WIM station is located in Bolton.
Figure 2.12  ITS Planned Components – CCRPC Region

Source: Vermont Center of Geographic Information, Chittenden County Regional Planning Commission
Figure 2.13  ITS Planned Components – Burlington Urban Area

Source: Vermont Center of Geographic Information, Chittenden County Regional Planning Commission
3.0 Background

3.1 PREVIOUS ITS ARCHITECTURE

In 2004, the Chittenden County Metropolitan Planning Organization (CCMPO), in cooperation with different stakeholders, developed the Chittenden County Regional ITS Architecture to guide ITS deployment within the region. CCMPO, with the help of the firm IBI Group, partnering with Resource System Group, TranSystems, and ConSysTec, developed the ITS Architecture, currently available online:

http://www.consystec.com/ccmpo/web/_regionhome.htm

This study presents the steps followed to update the current ITS Architecture and include future projects, considering the current region’s transportation needs.

3.2 ITS TURBO ARCHITECTURE

The previous ITS Architecture links stakeholders and their inventory in a framework that follows the National ITS Architecture format. In addition, the Architecture was developed in the Turbo Architecture format. The ITS Turbo Architecture is a tool designed by Iteris to manage and update ITS Architecture in an easier and faster manner. The Architecture includes a list of defined stakeholders in the region, a list of inventory available, and a list of Operational Concepts.

This study’s objective is to update the information included in the previous ITS Architecture, and include ITS projects relevant to the region’s needs and objectives.

Updating the Stakeholder List

The Chittenden County ITS System Architecture was revised to determine the stakeholders currently incorporated in the Architecture. There are 91 stakeholders registered in the Architecture, with 8 groups, representing the police and fire departments of Burlington, South Burlington, Winooski, Municipal Departments, Colchester, Essex, Milton, and Shelburne. The full list of current stakeholders can be seen in this document’s 1st Appendix. In addition to this list, the following stakeholders were identified and added:

- Burlington International Airport – Manager of the operation of the Burlington International Airport.
• Local Motion - A non-profit organization focused on bicycle and pedestrian transportation and recreation in Chittenden County and throughout Vermont.

• Lyndon State College Meteorological Department – Academic Institution in charge of monitoring and forecasting weather in the area.

• Vermont State Emergency Operations Center (SEOC) -

Additional stakeholders that could be added in this update are advocacy groups, like bicycle and pedestrian groups, as well as new technology solution providers, such as probe vehicle data providers. The list will be updated upon feedback received during the project inventory phase.

**Updating the ITS Inventory List**

The inventory inside the current ITS Architecture consists of 185 elements, including 127 existing elements and 58 planned elements. Each element consists of a name, a stakeholder, a status (whether it is an existing element or planned), and a brief description. The different stakeholders were consulted to determine if the inventory list had changed since the last ITS Architecture report was developed. The following elements were added to the list:

- CCTA – CCTA On-board WiFi, CCTA On-board Vehicle Cameras
- VTrans – VTrans Commercial Vehicle Check, VTrans Commercial Vehicle Administration, VTrans Roadway Equipment
- Travelers – Connected Vehicle
4.0 **Gap/Need Assessment**

### 4.1 **STAKEHOLDER INVOLVEMENT**

One of the most important steps in the development of the ITS Architecture Update was obtaining inputs from the different stakeholders involved. The kickoff meeting took place in May 2014. During this meeting the project was introduced and initial regional needs were discussed.

To further understand the regional technology gaps and transportation needs, workshops and focus groups were conducted with the participation of different stakeholders in the region on November 2014. These workshops started with an introductory presentation of the project, that led to a group discussion where participants talked about and defined the gaps and needs of ITS in the region. These activities were also helpful to identify ongoing and planned ITS deployment projects. The input obtained from these activities was key to develop this ITS Architecture Update report.

One of the main objectives of this study was to come up with projects that address the region’s ITS gaps and needs. To develop this project list, previous studies and reports were consulted (in particular the ITS Strategic Deployment Plan from 2005). In addition, a number of proposed projects are presented, that were based on input from the November focus groups and workshops. During these meetings, current needs and gaps were identified by the participants, and projects were proposed in response to them. The list of projects to be included in the ITS Architecture is listed by mode in the subsequent sections.

### 4.2 **HIGHWAY/ARTERIAL PROJECTS**

1. **VTrans Advanced Transportation Management System (ATMS) Adoption**
   - VTrans has recently implemented an Advanced Traffic Management System (ATMS) project to manage the State’s freeway and signal systems. However, the structure of the ATMS allows the inclusion of local signal programs. Incorporating local signal programs to the State’s ATMS would allow for better coordination among the region’s corridors and improve mobility and safety in the system, for all its users, including bicycles and pedestrians. This project also has the potential to address active transportation modes, like pedestrian crossings and bicycles. In order for this to happen, local and regional authorities need to define and agree on roles and responsibilities to properly manage the signal control systems in the region. The implementing agency for this project would be VTrans through the ATMS, by petition of CCRPC and municipalities involved.

2. **Adaptive Signal Control (ASC) on Selected Corridors**
   - This project aims to improve mobility conditions in corridors with recurrent congestion. By
implementing ASC technology, corridors would be better coordinated and delays would reduce. In addition, these corridors could be integrated into the State’s ATMS system for a better operations strategy. Currently, the on/off ramp intersections of Route 289 and 2A comprise the sole location where ASC has been implemented in the state. Several signalized intersections along Route 15 and 2A in Essex and Williston respectively are being evaluated for ASC. Other corridors considered in a short-term scenario would be Route 7 and Route 2. As these are all State routes, VTrans would be responsible for their implementation.

3. **Updating Signal Timing** – VTrans updates signal timing on a four-year cycle, or sooner if problems exist. The objective of this project is to mimic the State’s performance by developing a regional program that parallels VTrans program. Updated signal timings should address current traffic conditions, and all other modes of transportation involved, such as pedestrian activity and bicycles. This way, signals would operate better and maintenance costs would be reduced. The implementing agency would be CCRPC, in coordination with different municipalities.

4. **Advanced Traffic Monitoring System using Bluetooth Technology** – Currently, there is a plan to implement corridor level advanced traffic monitoring of travel times and vehicle speeds by anonymously tracking Bluetooth devices on up to 5 different corridors in the region:
   - Corridor 1: Interstate 89, from Exit 14 to US 2. This corridor includes the intersections on Williston Rd/Main St – from Industrial Ave to University Heights
   - Corridor 3: Exit 12/VT-2/VT-2A. These corridors include Essex Rd, from (and including) Essex Junction to (and including) Interstate 89. The study area also includes Williston Rd, from Industrial Ave to Essex Rd.
   - Corridor 4: Interstate 89, Exit 17. This corridor considers the three intersections present on US-2 – from Roosevelt Hwy to US-7.
   - Corridor 5: Interstate 89, Exit 16. This corridor considers US-2, from Severance Rd to the Winooski River.

To date, there are no advanced traffic monitoring installations in Vermont. This project is “designed to advance traffic monitoring in high volume roadway corridors where safety, commuter congestion, and construction activity are paramount issues”5. Given that this technology can provide high quality speed data, it should be considered to collect a bicycle speed dataset on the corridors considered. As an addition to the project, authorities could

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5 Project description obtained from the “Technology and Innovation Deployment Program (TIDP) Accelerated Innovation Deployment (AID) Demonstration Project.”
look to purchase private probe vehicle data. Real-time information is currently being collected by private and public entities that allow planning entities to have better information at the time it is needed. Entities such as NPRMDS (Here), Inrix, TomTom, among others provide these services and could be considered as a data source to complement the data collected via Bluetooth. This is currently an on-going project. The implementing agency would be CCRPC with assistance from VTrans.

5. **5 Corners Intersection Signal Timing** - The 5-Corners intersection has one of the worst levels of service in the area, partly due to the interaction with the railway system. Furthermore, this intersection is important due to the interaction with children crossings, due to the high school activity in the area. This project aims to develop an improved signal program for the intersection performance and incorporate it into the ATMS system.

6. **CCTV Implementation** - CCTV would allow better monitoring and surveillance of the transportation infrastructure, particularly on busier portions of I-89. However there are concerns about privacy and monitoring that will need to be addressed. Potential corridors should be evaluated and included in a CCTV deployment plan if deployment is feasible. The implementing agency would be VTrans.

7. **Permanent Variable Message Signs (VMS)** - This project seeks to implement permanent VMS to replace portable ones. Five new permanent VMS are being deployed on I-89 to service upcoming construction near Waterbury. Two are just south of CCRPC region, two are in Williston, and one in Colchester within CCRPC region. New permanent VMS could be considered to provide information to users in a more efficient and cost-effective manner. The implementing agency would be VTrans.

8. **Parking Management System** - Managing parking can be one of the most efficient ways to reduce congestion. The City of Burlington is currently implementing a new parking management scheme seeking to create a more efficient use of parking spaces. The program would use electronic “trailblazer” signs to guide motorists to parking garages which have available spaces. This would help reduce the number of vehicles circulating for spaces, particularly during special events or times of heavy traffic. The study is being conducted by CCRPC and the City of Burlington; the implementing agency would be the City of Burlington.

### 4.3 TRANSIT PROJECTS

9. **Transit Signal Priority (TSP) Implementation** - This project consists of implementing TSP on key routes. Currently, CCTA envisions implementing this feature along the planned BRT lines on US 2 and VT 15, as well as fixed routes on Route 6 (Shelburne/Rt. 7), US 2/Williston Rd, and VT 15. For this purpose, coordination between the CCTA, municipalities, and VTrans’ ATMS
is required. The implementing agency would be CCTA, in coordination with VTrans ATMS.

10. **TSP Implementation in Tertiary Corridors** – To provide better service and reduce delays for transit users, TSP is envisioned to be implemented across feeder routes as well as on main transit corridors. This would require coordination between CCTA, municipalities, and VTrans’ ATMS. The implementing agency would be CCTA, in coordination with VTrans ATMS.

11. **Automatic Vehicle Location (AVL) on Transit Vehicles** – For a better operation of transit services, AVL technology is planned on CCTA buses. The objective is to increase the coverage of AVL technology to have real-time information and improve the transit service in general. The implementing agency would be CCTA.

12. **Transit Computer-Aided Dispatch (CAD)** – To further improve the transit service, and taking advantage of AVL implementation, CAD can be deployed. This action would allow the transit authority to have better control over the service, improving its reliability, and making the service more attractive. The implementing agency would be CCTA.

13. **Fixed Information Signs for Transit Users** – To provide a better service to its users, CCTA is planning to install fixed information screen in a strategic location in Burlington, allowing users to view dispatch and arrival schedules. Along with transit information, these features consider those with sight, hearing, and other disabilities. This feature is currently planned, further strategic locations are being evaluated to expand the scope of the project. The implementing agency would be CCTA.

14. **Smart Cards** – A more flexible payment method would help transit services be more competitive with other modes of transportation, taking advantage of potential integration with other transit services and transportation modes. This project could lead to evaluate new fare payment options, like mobile phone technology applications, along with future developments in this area. Smart cards or mobile ticketing could enhance the service and improve the service accountability. The implementing agency would be CCTA, in coordination with private institutions.

15. **Automatic Passenger Counters (APC)** – To have better boarding and alighting information, the installment of APC is considered. The APC deployment can be integrated along with the AVL system. The implementing agency would be CCTA.

16. **Transit Networking and communication** – Enabling communication among users and between vehicles could present considerable benefit for the users as well as the transit authority. By enabling, expanding, and improving WiFi communication, the service becomes more competitive. The implementing agency would be CCTA.
17. **Transit Reporting/Data Management** – There is currently a lack of coordination and integration across the different data sources, and its management and uses among different stakeholders. This project aims to seek opportunities to manage the data sets available and integrate streamlined reporting. This project could be benefit from the ATMS Bluetooth project. The implementing agency would be CCTA, in coordination with CCRPC, and Vermont’s ATMS.

18. **Transit Security** – Interior bus cameras would help reduce incidents and provide a safer environment to the users. This project considers new camera installation, as well as monitoring facilities. The implementing agency would be CCTA possibly in coordination with municipal police departments.

19. **Improve Paratransit Services** – Paratransit services could be enhanced by implementing AVL/CAD dispatch, and providing an on-demand and real-time scheduling and dispatch system. The implementing agency would be CCTA, in coordination with different paratransit service providers.

### 4.4 Other Modes of Transportation Projects

20. **Weigh-In-Motion (WIM)** – In order to better understand commercial vehicle activities, control and pavement maintenance, deployment of Weigh-In-Motion technology would allow the Vermont DMV have better enforcement over commercial vehicles. The implementing agency would be VTrans.

21. **Airport Real-Time Information** – Among the needs identified during the stakeholders meeting, workshops, and focus groups, a need for improved information on the Burlington International Airport parking facilities was identified. ITS technology would allow the airport users to find parking faster and more easily. The implementing agency would be the City of Burlington, in coordination with Burlington International Airport.

22. **Plow Services** – Given Vermont’s weather conditions, plow vehicles services are of great importance. To improve the plow services’ efficiency, AVL and TSP can be considered, providing adequate maintenance over the road infrastructure and reducing delays for users. Knowing the location of plowing vehicles could lead not only to more efficient plowing, but to provide users with real-time information of plowing activities in the city, across different modes, including bicycles and pedestrians. The implementing agency would be VTrans, in coordination with local municipalities and different plow service providers.

### 4.5 Data Management Projects

23. **Chittenden County Regional Data Warehouse** – A Regional Data Warehouse would be beneficial for transportation data users across different stakeholders. Having a data repository in the region would allow different
public and private entities to have adequate information, without duplicating efforts. The implementing agency could be VTrans, and/or CCRPC.

24. **Web-based Data Portal** – Making an easy and accessible data portal allows users to get involved with the service. This would allow easier access to information to users and other stakeholders interested in knowing more about the transportation services available in the region. The implementing agency could be VTrans and/or CCRPC.

### 4.6 EMERGENCY/WEATHER MANAGEMENT PROJECTS

25. **RWIS** – Road Weather Information Systems provide valuable information on the effect of weather on the transportation infrastructure. As of today, there are plans for the installment of three RWIS stations on I-89 in the Municipalities of Bolton, Milton, and Williston. Five mobile Environmental Sensor Stations (ESS) are being deployed statewide, one in the CCRPC region, in Essex. Additional potential locations should be evaluated. An automated tie to VMS for off-hours should be considered. This project would seek to include other stations in the southern region. The implementation agency would be VTrans.

26. **National Weather Service** – Having an accurate weather service is an important consideration in transportation services. ITS can help communicate weather events to users to change travel patterns accordingly and provide transportation services with resilience to weather conditions. The implementation agency would be Lyndon State College Meteorological Department, with the support of UVM Climatology Group, in coordination with the National Weather Service. These will provide detailed weather forecasts to VTrans which will be included on the ATMS and 511, and will be available to CCRPC and CCTA.

27. **Vermont Alert and 511** – One of the most important uses of transportation services is during emergencies. Having an operational and efficient alert system can be the difference between an unusual event and a disaster. For this reason, this project suggests the incorporation of alert systems with the transportation stakeholders to have planned protocols in place when these unfortunate events occur. The implementing agency would be Vermont State Emergency Operations Center (SEOC) in coordination with CCRPC, VTrans and the different stakeholders identified.

28. **University of Vermont Medical Center** – An important regional transportation node is the University of Vermont Medical Center. This project aims to upgrade hospital’s vehicles, considering the implementation of AVL and CAD, to improve emergency vehicles performance measures. The implementing agency would be the University of Vermont Medical Center.
4.7 VANGUARD PROJECTS

29. **Connected Vehicles** – One of the most important ITS technologies currently being developed are Connected Vehicles (CV). CV enables communication across vehicle (V2V) and infrastructure (V2I), opening windows of opportunities for safety improvements, operation enhancements, among many other transportation issues. Currently in Vermont, VTrans and CCRPC have submitted an AID Grant Application to implement a CV pilot. Furthermore, VTrans has kicked off a series of discussions with Maine and New Hampshire for a regional Tri-State Concept of Operations for the US DOT Pilot Deployment of Connected Vehicle Road Weather Application Solicitation. UVM is also currently researching CV technology and its application in the region. Further research would allow public and private entities understand the possible benefits of this application and accelerate its deployment. The implementing agency for this project would be VTrans, in coordination with CCRPC.

30. **Unmanned Aerial Vehicles** – With the successful deployment of Unmanned Aerial Vehicles (UAV), their use in transportation has been researched and its application on data collection and enforcement is being researched across different institutions, UVM included. This technology can be used to identify road conditions in situations such as flooding where areas are not accessible by vehicles, or to evaluate bridge conditions where access is time-consuming and expensive. As UVM has started this initiative as a research project, the implementing agency could be them, in coordination with CCRPC and VTrans.

4.8 SUMMARY OF PROJECTS

Tables 4.1, 4.2, and 4.3, show a summary of the projects to be included in the ITS Architecture Update. The tables contain the project title, the gap or need that it addresses, the proposed action, the project’s next steps, and the performance measures and Architecture services associated with them. The tables are organized according to the implementation term. For this purpose, the following time frames were used:

- **Short term**: 0-3 years
- **Medium term**: 4-7 years
- **Long term**: 8+ years

As the projects identified in Tables 4.1 and 4.2 below are scoped in greater detail CCRPC, Vtrans or other local agencies may want to develop benefit/cost evaluation of these projects. Benefit/cost is one of several methods for evaluating how well a project meets its original goals and objectives. Benefits for ITS projects generally include estimated improvement in travel time, safety (crash reduction), fuel consumption and air quality. Each of these can be
assigned a monetary value; for example $14/hour for work commuting time. These benefits are then annualized and compared to costs which include annualized capital cost and yearly operations and maintenance costs. Given the variability of the monetized benefits, an ITS or operational project is generally considered feasible when the benefit cost ratio exceeds 2:1. Studies have indicated that for most ITS or operational projects ratios are generally higher. The tables below show there are a variety of performance measures, besides the benefit/cost analysis that can be tailored to different types of projects. Calculation of performance measures is most effective when agencies can use actual data collected before and after project implementation. As actual data are collected, these can be incorporated into the sketch planning tool to improve the accuracy of future forecasts. When the Advanced Traffic Management System (ATMS – Project 01) is on-line and operational it will compile much of the data that agencies can use for project evaluation. More detail on the benefit/cost estimation and the specifically FHWA’s TOPS-BC benefit/cost tool is shown in Appendix B.
### Table 4.1  Project Characteristics – Short-Term Projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Gap/Need</th>
<th>Information/Description</th>
<th>Proposed Action</th>
<th>Next Steps</th>
<th>Performance Measures</th>
<th>Architecture Services</th>
</tr>
</thead>
</table>
| 01 - VTrans ATMS Adoption | Lack of traffic coordination within region. | VTrans has recently implemented an Advanced Transportation Management System (ATMS) project to manage the State’s freeway system. However, the structure of the ATMS allows the inclusion of local signal programs. | Adopt the Vermont ATMS to manage control system for the region. The ATMS will incorporate State and local signal systems and bike/pedestrian facilities. | Start dialogue with VTrans and different stakeholders to evaluate and determine how local authorities can be incorporated in the VTrans ATMS system. VTrans signalized corridors are being incorporated into the ATMS. Local signals can be incorporated as well. GIS files or other location data is needed along with phasing and timing information. | • Travel Time  
• User delay  
• Volumes  
• Level of Service  
• Vehicle Miles Traveled (VMT) | ATMS01 – Network Surveillance  
ATMS07 – Regional Traffic Management  
ATMS08 – Traffic Incident Management System  
ATMS09 – Transportation Decision Support and Demand Management |
| 02 - Adaptive Signal Control on Selected Corridors | Corridors with recurrent congestion | This project aims to improve mobility conditions in corridors with recurrent congestion. The process incorporates the timings to the ATMS system. Corridors in process are:  
• Route 15, from VT 289 to Essex/Jericho town line  
• Route 2A south from Industrial Ave. to I-89 Exit 12 | Implement Adaptive Signal Control (ASC) on corridors with recurrent congestion. | Identify corridors and study traffic conditions to determine feasibility of ASC implementation and incorporate to the VTrans ATMS system. Corridors considered for future ASC implementation are:  
• Route 7 (Shelburne Road)  
• Route 2  
• Champlain Parkway Corridor  
• VT 127 | • Travel Time  
• User delay  
• Volumes  
• Level of service  
• Vehicle Miles Traveled (VMT) | Data required for benefit/cost analysis and evaluation:  
• Cost of ATMS  
• Regional daily VHT |
| 04 - Advanced Traffic | Lack of travel time data on | Implement the real-time traffic monitoring system using | Implement the real-time traffic | Mobilize the project by developing the System | • Travel Time  
• Speed | ATMS02 – Probe Surveillance |

- ATMS01 – Network Surveillance
- ATMS07 – Regional Traffic Management
- ATMS08 – Traffic Incident Management System
- ATMS09 – Transportation Decision Support and Demand Management
<table>
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<th>Architecture Services</th>
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</thead>
<tbody>
<tr>
<td>Monitoring System using Bluetooth Technology</td>
<td>key roadways</td>
<td>Bluetooth technology. The project was awarded for the Accelerated Innovation Deployment (AID) Demonstration grant</td>
<td>monitoring project using Bluetooth</td>
<td>Structure, Specifications, and Deployment Plan. Initial installation on 5 Adaptive Signal Corridors.</td>
<td>Data required for benefit/cost analysis and evaluation: * Volumes, capacity and travel times on served routes. * Capital and O&amp;M cost for Bluetooth system.</td>
<td>AD1 – ITS Data Mart</td>
</tr>
<tr>
<td>05 - 5 Corners Intersection Signal Timing</td>
<td>Delays at 5 Corners intersection due to railroad traffic</td>
<td>The 5-Corners intersection, in the Village of Essex Junction, is one of the intersections with worst level of service in the area, partly due to the interaction of important corridors and the railway system.</td>
<td>Reevaluate the signal timings in this intersection to accommodate current traffic conditions. Include in VTrans ATMS.</td>
<td>Do a traffic analysis of the signal timings in this intersection and optimize its performance. Include timings in ATMS.</td>
<td>* Travel Time * User delay * Volumes (throughput) * Level of service</td>
<td>ATMS07 – Regional Traffic Management APTS7 – Multi-modal Coordination</td>
</tr>
<tr>
<td>07 - Permanent VMS</td>
<td>Lack of Variable Message Signs (VMS)</td>
<td>Replace portable VMS with permanent installation. Four new permanent VMS being deployed on I-89 to service upcoming construction near Waterbury. Two are just south of CCPRPC region, two in Williston and one in Colchester within CCRPC region</td>
<td>Look to implement permanent VMS to replace portable ones.</td>
<td>Evaluate where portable VMS are currently implemented to determine opportunity places for permanent installation. Budget for 2 additional locations 4 more signs. Mounted on side of road.</td>
<td>* Location of portable VMS installations Data required for benefit/cost analysis and evaluation: * Volume passing signs * Capital and O&amp;M costs for VMS</td>
<td>ATMS06 – Traffic Information Dissemination</td>
</tr>
<tr>
<td>11 - AVL on Transit Vehicles</td>
<td>Improve transit services through</td>
<td>The agency currently has buses AVL-enabled. The objective is to increase the coverage of AVL technology</td>
<td>Increase coverage of AVL on transit buses with a public-</td>
<td>Evaluate possible integration of AVL with feasibility study.</td>
<td>* On-time performance * Transit reliability * Planning time index</td>
<td>APTS1 – Transit Vehicle Tracking APTS2 – Transit Fixed-Route</td>
</tr>
<tr>
<td>Project</td>
<td>Gap/Need</td>
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</tbody>
</table>
| 12 – Transit CAD | Improve transit reliability index and operations through better dispatch system | Computer-Aided Dispatch (CAD) can be deployed, allowing the transit authority to have better control over the service, improving its reliability, and making the service more attractive. | Implement Computer-Aided Dispatch (CAD) to complement AVL. | Review the available technologies and develop a cost estimate and timeline for implementation when funding is available. | Data required for benefit/cost analysis and evaluation:  
- Transit ridership, passenger-revenue hours.  
- Capital and operating cost per bus for AVL system | Operations  
- APTS1 – Transit Vehicle Tracking  
- APTS2 – Transit Fixed-Route  
- Operations |
| 13 - Fixed Information Signs for Transit | Provide better quality information to transit users. | CCTA envisions the installment of 4 fixed bus arrival signs along planned BRT routes and bus information screens in Downtown Burlington. This includes methods to provide information to those with sight, hearing, and other disabilities | Continue the evaluation of the fixed bus information screens. | Look for opportunities to implement real-time arrival and departures. This activity can incorporate prediction systems such as Next Bus or innovative systems like UVM’s TransLoc to locate UVM’s shuttle buses. | Data required for benefit/cost analysis and evaluation:  
- On-time performance  
- Planning time index | APTS8 – Transit Traveler Information  
- ATIS01 – Broadcast Traveler Information |
<p>| 23 – Chittenden County Regional Data Warehouse | Improve Chittenden County’s data management | Having a data repository in the region would allow different public and private entities to have adequate information, without reproducing efforts. Currently, VTrans collects most of the data, however the region could benefit from the | Develop the Chittenden County Regional Data Warehouse. This would be a data repository for the region. | Develop a Data Management Plan for the region. Coordinate with VTrans in building a data repository. Turning movement, AADT and crash data already underway. Expand existing | N/A | AD2 – ITS Data Warehouse |</p>
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<tr>
<th>Project</th>
<th>Gap/Need</th>
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</tr>
</thead>
<tbody>
<tr>
<td>26 - National Weather Service</td>
<td>Improve reliability of weather service alert</td>
<td>ITS can help communicate weather events to users to change travel patterns accordingly and provide transportation services with resilience to weather conditions</td>
<td>Evaluate the incorporation of Meteorological information providers, to provide detailed weather forecasts to VTrans, CCRPC, and CCTA to communicate with Emergency Managers and key transportation agency personnel.</td>
<td>Coordinate with weather information providers VTrans, CCRPC, and CCTA, and Emergency Managers to design the framework for communicating weather information to transportation stakeholders</td>
<td>• Number of accidents due to weather conditions. • Weather prediction reliability index.</td>
<td>EM07 – Early Warning System</td>
</tr>
<tr>
<td>27 - Vermont Alert and 511</td>
<td>Coordinate Vermont Alert with 511</td>
<td>This project suggests the incorporation of alert systems among different transportation stakeholders to have planned protocols and react upon these unfortunate events.</td>
<td>Design a framework for coordination and joint efforts between Vermont Alert and 511. Accomplished with ATMS.</td>
<td>Coordinate communication to design a framework for collaborative emergency responses</td>
<td>• Number of reports registered. • Response rate</td>
<td>ATMS08 – Traffic Incident Management System EM01 – Emergency Call-Taking and Dispatch EM02 – Emergency Routing EM03 – Mayday and Alarms Support EM06 – Wide-Area Alert</td>
</tr>
<tr>
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<tr>
<td>EM07 – Early Warning System</td>
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<tr>
<td>EM08 – Disaster Response and Recovery</td>
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</tr>
</tbody>
</table>
### Table 4.2 Project Characteristics – Medium-Term Projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Gap/Need</th>
<th>Description/Information</th>
<th>Proposed Action</th>
<th>Next Steps</th>
<th>Performance Measures</th>
<th>Architecture Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>03 - Updating Signal Timings</td>
<td>Need for signal timing upgrades on local/ regional corridors</td>
<td>VTrans updates signal timings on a four-year cycle. This represents technology upgrades and lower maintenance costs.</td>
<td>Develop regional program that parallels VTrans program.</td>
<td>Identify priority signal corridors for upgrade and develop 4-year plan to be updated annually.</td>
<td>• Travel Time • User Delays • Intersection LOS • Volumes (throughput)</td>
<td>ATMS03 – Traffic Signal Control</td>
</tr>
<tr>
<td>06 - CCTV Implementation</td>
<td>Increase CCTV coverage</td>
<td>CCTV helps monitor and improve traffic performance by helping detect incidents particularly on freeways but privacy concerns have been raised about their use.</td>
<td>Look for opportunities to install planned and proposed CCTV cameras in the region. Address privacy concerns of the public regarding use of the CCTV cameras.</td>
<td>Determine location of planned and proposed camera installation. Potential locations include Exit 14, Route 15 Bridge, and Exits 10 (from workshops), 16 and 17.</td>
<td>• Number of CCTV cameras installed. Data required for benefit/cost analysis and evaluation: • Volumes, capacity and travel times on selected corridors • Cost per signal of upgrade, number of signals</td>
<td>ATMS01 – Network Surveillance ATMS08 – Traffic Incident Management System</td>
</tr>
<tr>
<td>08 - Parking Management System</td>
<td>Insufficient parking information</td>
<td>Burlington is currently implementing a new parking management system, evaluating residential and downtown parking needs and developing a parking management plan.</td>
<td>Seek for ITS opportunities in parking management deployment.</td>
<td>Study the possibilities to develop a Parking Management System, considering ITS to address parking issues.</td>
<td>• Parking occupancies • Parking turn-over rates • Travel time on parking facility access routes Data required for benefit/cost analysis and evaluation: • Traffic volumes and travel times on parking access routes</td>
<td>ATMS16 – Parking Facility Management ATMS17 – Regional Parking Management</td>
</tr>
<tr>
<td>09 - TSP Implementation</td>
<td>Improve transit service with Transit signal priority could improve the performance of current transit services and Implementation of Transit Signal Priority (TSP) on</td>
<td>Coordinate with ATMS and CCTA to evaluate the</td>
<td>• Transit delays • Transit ridership</td>
<td>APTS09 – Transit Signal Priority</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td>Gap/Need</td>
<td>Description/Information</td>
<td>Proposed Action</td>
<td>Next Steps</td>
<td>Performance Measures</td>
<td>Architecture Services</td>
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<tr>
<td>14 - Smart Cards</td>
<td>Improve fare collection methods across transit services</td>
<td>New fare collection technologies could enhance the ease and speed of transit</td>
<td>Implement more flexible fare payment methods, such as smartcards and mobile ticketing. Location may be established to purchase/add value to the cards</td>
<td>Study the feasibility of implementing a smart card system for fare collection across CCTA with the potential to integrate with other transit services and transportation modes.</td>
<td>Data required for benefit/cost analysis and evaluation:</td>
<td>APTS4 – Transit Passenger and Fare Payment</td>
</tr>
<tr>
<td>15 – Automatic Passenger Counters</td>
<td>Collect better ridership data</td>
<td>Data collection of boarding and alighting can be useful for accountability and planning efforts. With GPS integration, ridership can be linked to stop location.</td>
<td>Install APC’s to allow for ongoing collection of boarding and alighting.</td>
<td>Include APC’s as part of AVL system or design AVL system for future APC integration</td>
<td>• Transit ridership</td>
<td>APTS10 – Transit Passenger Counting</td>
</tr>
<tr>
<td>16 – Transit Networking and Communication</td>
<td>Lack of communication with passengers and within</td>
<td>Better communication with users and communication within vehicles could result in a better transit service.</td>
<td>Improved vehicle communications with dispatch and other vehicles as well as improved/expanded</td>
<td>Look for opportunities to enhance communication to and between transit vehicles and to offer improved on-board</td>
<td>• Number of buses with WiFi available</td>
<td>APTS08 – Transit Traveler Information</td>
</tr>
</tbody>
</table>

Chittenden County ITS Plan
Cambridge Systematics, Inc.
<table>
<thead>
<tr>
<th>Project</th>
<th>Gap/Need</th>
<th>Description/Information</th>
<th>Proposed Action</th>
<th>Next Steps</th>
<th>Performance Measures</th>
<th>Architecture Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 - Web-based Data Portal</td>
<td>Develop web-based portal with archived data</td>
<td>Making an easy and accessible data portal allows users to get involved with the service. This would allow easier access to information to users and other stakeholders interested in knowing more about the transportation services available in the region.</td>
<td>Promote the implementation of the Regional Integrated Transportation Information System (RITIS) for data archiving and diffusion</td>
<td>Start communications with VTrans to look for opportunities to incorporate RITIS in the region.</td>
<td>N/A</td>
<td>AD3 – ITS Virtual Data Management</td>
</tr>
<tr>
<td>25 - RWIS (Road Weather Information System)</td>
<td>Additional RMS are needed in the region</td>
<td>RMS provide valuable information on the effect of weather on the transportation infrastructure. Given Vermont’s weather conditions, it is important to have a detailed understanding of how this Deploy new RMS stations. Five mobile Environmental Station Sensors are being deployed statewide, one in the CCRPC region,</td>
<td>Evaluate funding opportunities to increase the coverage of mobile RMS stations on desired corridors</td>
<td>Weather conditions, IRI</td>
<td>MC03 – Road Weather Data Collection</td>
<td></td>
</tr>
</tbody>
</table>

- WiFi quality of service
- passenger revenue hours on WiFi-enabled routes.
- Capital and O&M cost per WiFi-enabled bus
<table>
<thead>
<tr>
<th>Project</th>
<th>Gap/Need</th>
<th>Description/Information</th>
<th>Proposed Action</th>
<th>Next Steps</th>
<th>Performance Measures</th>
<th>Architecture Services</th>
</tr>
</thead>
</table>
| 28 – University of Vermont Medical Center | Improve conditions on University of Vermont Medical Center emergency vehicles | An important regional transportation node is the University of Vermont Medical Center. This project aims to improve condition on the hospital’s vehicles. | Look for opportunities to incorporate AVL/CAD to improve hospital’s emergency vehicles service. | Look to incorporate and use GPS tracking on emergency vehicles to study and determine windows of opportunity on their everyday performance and maintenance | - Emergency vehicles’ performance measures | - EM01 – Emergency Call-Taking and Dispatch  
- EM02 – Emergency Routing  
- EM03 – Mayday Support |
| 29 – Connected Vehicles | Incorporate Connected Vehicle technology into transportatio process. | Currently in Vermont, VTrans and CCRPC have submitted an AID Grant Application to implement a CV pilot. Furthermore, VTrans has kicked off a series of discussions with Maine and New Hampshire for a regional Tri-State Concept of Operations for the US DOT Pilot Deployment of Connected Vehicle Technology. Opportunities for Connected Vehicle technology including both DSRC and other technologies should be identified in new projects. Focus should be on Vehicle-to-Infrastructure deployments related. | Develop a process for evaluating CV technology as part of planning products and processes. Material from both FHWA and AASHTO is available to support these efforts. | - Number of projects incorporating CV technologies. | - ATMS02 – Probe Surveillance  
- AVSS11 – Automated Vehicle Cooperation  
- AVSS12 – Cooperative Vehicle Safety Systems  
- ATIS10 – Short Range Communications Traveler Information |
<table>
<thead>
<tr>
<th>Project</th>
<th>Gap/Need</th>
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<th>Proposed Action</th>
<th>Next Steps</th>
<th>Performance Measures</th>
<th>Architecture Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Road Weather Application Solicitation</td>
<td>UVM is also currently researching CV technology and its application in the region. The region will want to capitalize on opportunities presented as this technology appears in vehicles.</td>
<td>to safety, emergency response and traveler information.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Project</td>
<td>Gap/Need</td>
<td>Description/Information</td>
<td>Proposed Action</td>
<td>Next Steps</td>
<td>Performance Measures</td>
<td>Architecture Services</td>
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</tbody>
</table>
| 10 - TSP Implementation in Tertiary Corridors | Improve transit service on tertiary corridors. | Transit signal priority could improve the performance of current transit services and make it more competitive. With the implementation of VTrans ATMS, TSP could be incorporated. | Implement TSP to transit tertiary corridors. | Develop a feasibility study for the project. | • Transit delays  
• Transit ridership  
Data required for benefit/cost analysis and evaluation:  
• Transit ridership and passenger revenue hours on TSP routes.  
• Capital and O&M cost per TSP intersection  
• Software costs | APTS09 – Transit Signal Priority |
| 17 – Transit Reporting/Data Management | Lack of coordination with data collection and management. | This project aims to seek for opportunities to manage the data sets available and integrate streamlined reporting. | Improve coordination and integration of multiple data sources, including driver schedules, passenger schedules, ridership data, stop location, and real-time data. | Look for opportunities to better manage large data sets and methods to integrate for streamlined reporting.  
Look for integration with Chittenden Regional Data Warehouse project. | N/A | ATIS06 – Transportation Operation Management |
| 18 – Transit Security | Improve traffic safety on transit users | Transit services need to take care of the passenger as well as the service provided. For this reason, interior bus cameras would help reduce incidents and provide a safer environment to the users. This project considers new camera installation, as well as monitoring facilities. | Improve transit safety and security through more proactive use of security video footage for accident and incident prevention. | Look for opportunities to enhance CCTA’s security system through new camera and monitoring technology and improved methods to review and analyze footage. | • Number of CCTV-enabled buses.  
• Safety incident report rate | APTS05 – Transit Security |
<p>| 19 - Improve Paratransit | Improve the Paratransit services could be enhanced by Demand response scheduling and dispatch | Study costs and benefits associated to this improvement | • Number of passengers. | APTS1 – Transit |</p>
<table>
<thead>
<tr>
<th>Project</th>
<th>Gap/Need</th>
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<th>Proposed Action</th>
<th>Next Steps</th>
<th>Performance Measures</th>
<th>Architecture Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Services</td>
<td>service in the region</td>
<td>implementing AVL/CAD dispatch, and providing an on-demand and real-time scheduling and dispatch system.</td>
<td>management software for paratransit contractors. Including equipping vehicles with Mobile Data Computers (MDC), and AVL/CAD.</td>
<td>for paratransit service providers and users to consider</td>
<td>• On-time performance</td>
<td>Vehicle Tracking</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Data required for benefit/cost analysis and evaluation:</td>
<td>APTS3 – Demand Response Operations</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Paratransit ridership, passenger service hours.</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>• Cost of AVL/CAD scheduling and response system</td>
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</tr>
<tr>
<td>20 - Weigh-In-Motion</td>
<td>Improve truck traffic monitoring and data capture activity.</td>
<td>Commercial vehicles often have the greatest effect on transportation infrastructure. Having control and monitoring these vehicles could result in better infrastructure management.</td>
<td>Look to implement portable Weigh-In-Motion (WIM) for DMV enforcement. Coordinate with enforcement.</td>
<td>Evaluate commercial corridors of interest and determine possible location for ITS implementation. Initial installation - Colchester</td>
<td>• Truck VMT</td>
<td>CVC06 – Weigh-In-Motion</td>
</tr>
<tr>
<td>21 - Airport Real-Time Information</td>
<td>Provide real-time information to airport users</td>
<td>ITS technology would allow the airport users to find parking faster and easily.</td>
<td>Evaluate the implementation of permanent signs with arrivals and departure information, flight changes and parking availability outside airport facilities</td>
<td>Evaluate the implementation of permanent VMS to provide user information outside airport facilities</td>
<td>N/A</td>
<td>ATMS06 – Traffic Information Dissemination</td>
</tr>
<tr>
<td>22 - Plow Services</td>
<td>Improve conditions on plow truck for better service</td>
<td>Given Vermont’s weather conditions, plow vehicles services are of great importance.</td>
<td>VTTrans plows have AVL technology. Extend this technology to local plows and promote</td>
<td>Evaluate plow truck services to determine feasibility of ITS technology implementation.</td>
<td>• Plow truck performance measures</td>
<td>MC01 – Maintenance and Construction Vehicle and</td>
</tr>
<tr>
<td>Project</td>
<td>Gap/Need</td>
<td>Description/Information</td>
<td>Proposed Action</td>
<td>Next Steps</td>
<td>Performance Measures</td>
<td>Architecture Services</td>
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<tr>
<td></td>
<td></td>
<td>Providing adequate maintenance over the road infrastructure would reduce delays</td>
<td>signal priority for plows. Look for TSP opportunities for plows</td>
<td></td>
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</tr>
<tr>
<td>30 -</td>
<td>Unmanned</td>
<td>Evaluate use of Unmanned Aerial Vehicles for transportation planning and operations</td>
<td>Can be used to identify road conditions in situations such as flooding where areas are not accessible by vehicle. Also for evaluating bridge conditions where access is time-consuming and expensive.</td>
<td>Support more research on this topic and seek for implementation opportunities,</td>
<td>Partner with UVM to evaluate potential UAV applications.</td>
<td>N/A</td>
</tr>
<tr>
<td>Equipment Tracking</td>
<td>MC06 - Winter Maintenance</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Automated Vehicle Cooperation</td>
</tr>
</tbody>
</table>
5.0 Operational Concept

An operational concept describes how systems, personnel, and data interact with each other to deliver transportation services. FHWA Rule 940 and the FTA policy requires that stakeholder roles and responsibilities be identified in the regional ITS Architecture. These roles and responsibilities are described in the operational concepts.

The Chittenden County ITS Architecture Update uses the National ITS Architecture as a base to define service areas and packages. In the National ITS Architecture, the term “service package” is used to described the flow of data amongst a collection of systems, equipment, and people. For the purpose of this project, the service packages were revised and modified accordingly to represent the region’s needs.

5.1 SERVICE PACKAGES

The ITS Architecture service packages used were the ones identified by Iteris and included in the National ITS Architecture. Further information for each package can be obtained directly from the source at the following link:


According to the projects considered for this study, the following services were considered:

- Archived Data Systems
- Transit Services
- Traveler Information
- Surface Street Management
- Vehicle Safety
- Commercial Vehicle Operations
- Emergency Management
- Maintenance and Construction Management.
- Parking Management

The National ITS Architecture provides a common language and framework for all ITS services. The following provides key definitions to aid in the comprehension of the diagrams presented in this document.

- **Subsystems and functional areas**: These are principal structural elements of an ITS Architecture. The subsystems are grouped in four: Centers, Fields, Vehicles, and Travelers. Functional areas represent equipment or data
processing components. Example subsystems are the Traffic Management Subsystem, the Vehicle Subsystem, and the Roadway Subsystem. These correspond to the physical world: respectively traffic operations centers, automobiles, and roadside signal controllers.

- **Terminator**: Representation of the people, systems or environment interacting with ITS. Examples are drivers and pedestrians, among others.

- **Architecture flows**: Representation of actions and communications needs.

## 5.2 Archived Data Systems

The objective of this service is to develop a multi-agency data collection, management, and procurement system. By creating an Archived Data Management System, different stakeholders can contribute and access more abundant and higher quality data for transportation planning and management purposes.

The operational concept of this service package considers a number of ITS subsystems, stakeholders, and functional areas. Table 5.1 shows an initial description of the operational concept, defining possible stakeholders and responsibilities. Figure 5.1 shows the architectural flows required for the implementation of this service package.

### Table 5.1 Archived Data Systems Operational Concept

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Current/possible stakeholders</th>
<th>Roles and Responsibilities Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archived Data Center</td>
<td>CCRPC, VTrans. UVM</td>
<td>Collect and manage Archive Data Center</td>
<td>Planned</td>
</tr>
<tr>
<td>Traffic Data</td>
<td>VTrans, Municipalities, Private Traveler Information Systems</td>
<td>Provide traffic related data to Data Center</td>
<td>Planned</td>
</tr>
<tr>
<td>Transit Data</td>
<td>CCTA, Vermont transit agencies</td>
<td>Provide transit related data to Data Center</td>
<td>Planned</td>
</tr>
<tr>
<td>Commercial Vehicle Data</td>
<td>VTrans, DMV</td>
<td>Provide commercial vehicle related data to Data Center</td>
<td>Planned</td>
</tr>
<tr>
<td>Emergency Vehicle Data</td>
<td>University of Vermont Medical Center, Municipalities.</td>
<td>Provide emergency vehicle related data to Data Center</td>
<td>Planned</td>
</tr>
<tr>
<td>Maintenance Data</td>
<td>Municipalities, VTrans</td>
<td>Provide maintenance related data to Data Center</td>
<td>Planned</td>
</tr>
<tr>
<td>Weather Data</td>
<td>National Weather Service LSC Meteorological Dept.</td>
<td>Provide weather related data to Data Center</td>
<td>Planned</td>
</tr>
<tr>
<td>Map Update Provider</td>
<td>VCGI, UVM, CCRPC</td>
<td>Geo-process data to archive as map</td>
<td>Planned</td>
</tr>
<tr>
<td>Data Users</td>
<td>Archived Data Users, travelers, DMV</td>
<td>Request and use data appropriately</td>
<td>Planned</td>
</tr>
</tbody>
</table>
Figure 5.1 shows how this service package needs to operate, taking in consideration the projects proposed in this Architecture Update. The diagram shows the subsystems, terminators, and operational flows considered for this ITS Architecture to be operational. The projects considered include the following:

- 04 – Advanced Traffic Monitoring System using Bluetooth Technology
- 23 – Chittenden County Regional Data Warehouse
- 24 – Web-based Data Portal

The Architectural flow presented is a representation of the different subsystems, terminators, and flows in the National Architecture, under the following packages considered:

- AD1 – ITS Data Mart
- AD2 – ITS Data Warehouse
- AD3 – Virtual Data Warehouse

The main operational subsystem is an Archived Data Management. This could be the warehouse of all the data collection; responsible for collecting data, storing it, and managing it. This principal subsystem could be managed by VTrans, CCRPC, or even an external independent subsystem, like UVM.

The other subsystems: Traffic Management, Transit Management, Commercial Vehicle Management, Emergency Vehicle Management, Maintenance and Construction Management, Parking Management, and the Weather Service; are responsible for collecting information in their respective fields, and sharing it with the Archive Data Management.

The Archive Data Management system could then process the data through a Map Update Provider. This could allow the data to be stored and available in a format easy to visualize and transfer.

Finally, the last terminator and subsystem is the Data User, who would be able to request archived data from the Archive Data Management Subsystem.
Figure 5.1 Archived Data Systems Operational Diagram

Legend:

- **ITS Subsystem - Stakeholder**
- **Terminator**
- **Functional Area**

Existing Flow

Planned Flow
5.3 **TRANSIT SERVICES**

The purpose of this system is to show the operation of transit services, their vehicles, and their interactions with other stakeholders in the region. This service package will help identify the process to implement ITS technology in transit services, seeking to provide a better service across the Chittenden County region.

The operational concept of this service package considers a number of ITS subsystems, stakeholders, and functional areas. Table 5.2 shows an initial description of the operational concept, defining possible stakeholders and responsibilities. Figure 5.2 shows the architectural flows required for the implementation of this service packages.

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Current/possible stakeholders</th>
<th>Roles and Responsibilities Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit Management</td>
<td>CCTA, Vermont transit agencies</td>
<td>Act as transit manager, responsible of vehicle, service, and communication with corresponding stakeholders</td>
<td>Existing</td>
</tr>
<tr>
<td>Transit Vehicle</td>
<td>CCTA, Vermont transit agencies</td>
<td>Enable the necessary infrastructure and technology for service and projects considered.</td>
<td>Existing/planned</td>
</tr>
<tr>
<td>Traveler</td>
<td>Traveler</td>
<td>Use the transit service appropriately</td>
<td>Existing</td>
</tr>
<tr>
<td>Information Service Provider</td>
<td>CCRPC, VTrans, Private traveler information service</td>
<td>Collect and disseminate information on transit services in the region to users and stakeholders.</td>
<td>Planned</td>
</tr>
<tr>
<td>Traffic Management</td>
<td>VTrans, Municipalities, CCRPC</td>
<td>Collect transit data and adjust operations to improve the service. Communicate conditions to Transit Management</td>
<td>Planned</td>
</tr>
<tr>
<td>Roadways</td>
<td>Municipalities, VTrans</td>
<td>Provide the necessary infrastructure to provide the service and the proposed projects</td>
<td>Existing/planned</td>
</tr>
<tr>
<td>Traveler Information</td>
<td>Private traveler information system</td>
<td>Collect and disseminate transit information to travelers and users</td>
<td>Planned</td>
</tr>
<tr>
<td>Emergency management</td>
<td>Department of Public Safety, Vermont SEOC</td>
<td>Collect incident information and react upon it accordingly.</td>
<td>Existing/planned</td>
</tr>
</tbody>
</table>
Figure 5.2 shows the connections considered for the implementation of the following ITS projects presented in this ITS Architecture Update Report:

- 09 – TSP Implementation
- 10 – TSP Implementation Tertiary Corridors
- 11 – AVL on transit Vehicles
- 12 – Transit CAD
- 13 – Fixed Information Signs for Transit
- 14 – Smart Cards
- 15 – Automatic Passenger Counters
- 16 – Transit Networking and Communication
- 17 – Transit Reporting/Data Management
- 18 – Transit Security
- 19 – Improved Paratransit Services

The Architectural flow presented is a representation of the different subsystems, terminators, and flows in the National Architecture, under the following packages considered:

- APTS1 – Transit Vehicle Tracking
- APTS2 – Transit Fixed-Route Operations
- APTS3 – Demand Response Transit Operations
- APTS4 – Transit Fare Collection Management
- APTS5 – Transit Security
- APTS7 – Multi-modal Coordination
- APTS8 – Transit Traveler Information
- APTS9 – Transit Signal Priority
- APTS10 – Transit Passenger Counting

The main subsystem considered in the operation of the transit service in the Chittenden County region is the Transit Management. This subsystem, represented primarily by CCTA, but including all other transit service providers, is located in the center of the operation, interacting with transit vehicles, and other management and terminators. Figure 5 includes all functional areas considered in the National Architecture for the services considered.

An important subsystem in the transit service operation is the transit vehicle. This subsystem includes different projects and services, such as passenger counters and TSP. In order for these projects to work, a number of functional areas are needed, as presented in Figure 5.
Other subsystems considered are ISP to provide information to users, Traffic Management to coordinate TSP functionality, Emergency Management to react properly during emergency events and incidents, and the transit users themselves.
Figure 5.2 Transit Service Operational Diagram

Legend:
- **ITS Subsystem** - Stakeholder
- **Terminator**
- **Functional Area**

Existing Flow

Planned Flow
5.4 **Traveler Information Service**

This service describes the method to provide information to transportation users. This service supports both public and internal agency traveler information through different means. Providing adequate information among agencies and to the public is a key step to improve transportation performance. This package seeks to enhance information dissemination through ITS deployment.

The operational concept of this service package considers a number of ITS subsystems, stakeholders, and functional areas. Table 5.3 shows an initial description of the operational concept, defining possible stakeholders and responsibilities. Figure 5.3 shows the architectural flows required for the implementation of this service packages.

**Table 5.3  Traveler Information Service Operational Concept**

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Current/possible stakeholders</th>
<th>Roles and Responsibilities Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Service Provider</td>
<td>CCRPC, VTrans, Private traveler information systems</td>
<td>Act as information service provider management, in charge of gathering data from different transportation entities and broadcasting to through the appropriate channels</td>
<td>Planned</td>
</tr>
<tr>
<td>Traffic Management</td>
<td>VTrans, municipalities, CCRPC</td>
<td>Collect traffic data to communicate with the Information Service Provider Manager.</td>
<td>Planned</td>
</tr>
<tr>
<td>Transit Management</td>
<td>CCTA, Vermont transit agencies</td>
<td>Collect transit data through the transit management center and coordinate communication with the information service provider.</td>
<td>Planned</td>
</tr>
<tr>
<td>Emergency Management</td>
<td>Department of Public Safety, Vermont SEOC</td>
<td>Collect data on incidents and emergencies and coordinate communication with Information Service Provider.</td>
<td>Planned</td>
</tr>
<tr>
<td>Maintenance Management</td>
<td>VTrans, Municipalities</td>
<td>Collect data on construction and maintenance events and coordinate communication with Information Service Provider.</td>
<td>Planned</td>
</tr>
<tr>
<td>Parking Management</td>
<td>CCRPC, City of Burlington</td>
<td>Collect data on parking availability and share it with the Information Service Provider.</td>
<td>Planned</td>
</tr>
<tr>
<td>Weather Data</td>
<td>National Weather Service LSC Meteorological Dept.</td>
<td>Provide information on weather events to Information Service Provider.</td>
<td>Planned</td>
</tr>
</tbody>
</table>
Figure 5.3 shows how the Information Service Provider need to interact with each other for an adequate implementation, taking in consideration the following projects:

- 07 – Permanent VMS
- 08 – Parking Management System
- 13 – Fixed Information Signs for Transit
- 21 – Airport Real-Time Information
- 24 – Web-Based Data Portal
- 29 – Connected Vehicles

Figure 5.3 shows the subsystems, terminators, functional areas, and flows defined in the National Architecture for the following services:

- ATIS1 – Broadcast Traveler Information
- ATIS2 – Interactive Traveler Information
- ATIS6 – Transportation Operations Data Management
- ATIS10 – Short Range Communication Traveler Information

This service revolves around a principal subsystem: the Information Service Providers. This subsystem includes different stakeholders from private and public organizations. The Information Service Providers are responsible for interacting with other transportation management entities.

Once information is collected, the Information Service Providers need to provide quality control and transmit it to the public and agencies accordingly. Among the
subsystems involved are the Media, responsible for broadcasting information to the public, as well as other ISPs, that may provide information of higher detail to users, such as transit schedules.

Included in this service is the consideration of new technologies, such as Dedicated Short Range Communications (DSRC). This technology would allow vehicles to communicate with other vehicles and infrastructure. This type of communication would be the precursor of Connected and Autonomous Vehicles.
Figure 5.3  Traveler Information Service Operational Diagram
5.5 **Surface Street Management**

This service provides the architectural flow for the operation of surface street transportation. This service package is in charge of showing the operational needs for ITS deployment in traffic and operations instances.

The operational concept of this service package considers a number of ITS subsystems, stakeholders, and functional areas. Table 5.4 shows an initial description of the operational concept, defining possible stakeholders and responsibilities. Figure 5.4 shows the architectural flows required for the implementation of this service packages.

**Table 5.4 Surface Street Operational Concept**

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Current/possible stakeholders</th>
<th>Roles and Responsibilities Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Management Center</td>
<td>VTrans, Vermont 511, CCRPC</td>
<td>Surveille and manage the day-to-day surface traffic network operations.</td>
<td>Planned</td>
</tr>
<tr>
<td>Roadways</td>
<td>VTrans, Municipalities</td>
<td>Provide the necessary technology for traffic control systems and the interaction with the Traffic Operation Center.</td>
<td>Existing</td>
</tr>
<tr>
<td>Vehicle</td>
<td>Traveler, CCTA</td>
<td>Technology enabled vehicles would provide status and conditions of network to Traffic Operation Center.</td>
<td>Existing</td>
</tr>
<tr>
<td>Traveler</td>
<td>Traveler</td>
<td>Use the surface infrastructure network properly.</td>
<td>Existing</td>
</tr>
<tr>
<td>Information Service Provider</td>
<td>CCRPC, VTrans</td>
<td>Request traffic information and network conditions for users.</td>
<td>Planned</td>
</tr>
<tr>
<td>Traffic Operations</td>
<td>Municipalities, CCRPC, VTrans</td>
<td>Operate the traffic control systems under each jurisdiction according to the Traffic Operations Center.</td>
<td>Existing</td>
</tr>
<tr>
<td>Transit Management</td>
<td>CCTA, Vermont transit agencies</td>
<td>Request and provide traffic network conditions and transit operations information to Traffic Operations Center.</td>
<td>Existing/Planned</td>
</tr>
<tr>
<td>Emergency Management</td>
<td>Department of Public Safety, Vermont SEOC</td>
<td>Request traffic conditions and incident information to act according to the situation.</td>
<td>Planned</td>
</tr>
<tr>
<td>Emergency Vehicle</td>
<td>University of Vermont Medical Center, Municipalities</td>
<td>Provide Emergency Management information on actions taken due to</td>
<td>Planned</td>
</tr>
<tr>
<td>Subsystem</td>
<td>Current/possible stakeholders</td>
<td>Roles and Responsibilities Description</td>
<td>Status</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------------</td>
<td>----------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Maintenance Management</td>
<td>VTrans, Municipalities</td>
<td>Provide construction and maintenance information to Traffic Operation Center</td>
<td>Planned</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parking Management</td>
<td>CCRPC, City of Burlington</td>
<td>Provide parking information to Traffic Operations Center</td>
<td>Planned</td>
</tr>
</tbody>
</table>

The ITS Architecture Update includes a series of traffic related projects:

- 01 – VT ATMS Adoption
- 02 – Adaptive Signal Control on Selected Corridors
- 03 – Updating Signal Timings
- 04 – Advanced Traffic Monitoring System using Bluetooth Technology
- 05 – 5-Corners Intersection Signal Timings
- 06 – CCTV Implementation
- 07 – Permanent VMS

Evaluating these projects with the National ITS Architecture, we observe that the following service packages would be required for consideration:

- ATMS1 – Network Surveillance
- ATMS2 – Traffic Probe Surveillance
- ATMS3 – Traffic Signal Control
- ATMS6 – Traffic Information Dissemination
- ATMS7 – Regional Traffic Management
- ATMS8 – Traffic Incident Management System
- ATMS9 – Transportation Decision Support and Demand Management

The principal component of the Surface Street Management component is the Traffic Management subsystem. This entity is responsible for the operation of traffic control signals in the region, including signals related to pedestrians and bicyclists. In Chittenden County’s case, the best-suited stakeholder for this task is VTrans. VTrans is currently deploying an Advanced Traffic Management System for the state. This system would allow a swifter and more efficient control of traffic signals included in the system, optimizing signal plans and implementing them accordingly. The Chittenden County region could take advantage of this project and adopt its operation to expand and enhance traffic signal coordination. This is represented in Figure 5.4 through the interaction with the Traffic Management subsystem.
The second most important subsystem in this service are the Roadways. This subsystem includes the infrastructure placed on the traffic network in the regions, and involves the different stakeholders that are infrastructure owners. This subsystem is responsible for interacting with vehicles and pedestrians, and communicating the information collected to the ATMS and Traffic Operations Center. The interactions in this subsystem include DSRC technology and signal preemption technology.

Other important subsystems in this service are the communications with the Emergency Management subsystem, Transit Management, and Information Service Providers. These subsystems allow Traffic Management to communicate to users and react upon incidents or emergency events, through traveler information providers, media, portable DMS, and permanent DMS.

Finally, the Traffic Management subsystem should also interact with surface operational subsystems like Maintenance Management and Parking Management. This allows the network to be properly maintained and utilized for a better day-to-day performance and safety.
Figure 5.4  **Surface Street Management Operational Diagram**

[Diagram showing the operational diagram with various stakeholders and processes related to traffic management, with labels such as Information service provider, Traffic operations, Municipalities, Transit Management, Emergency Management, and Traffic Management, among others.]

**Legend:**
- **ITS Subsystem - Stakeholder**
- **Terminator**
- **Functional Area**
5.6 **VEHICLE SAFETY**

This service package seeks to describe the necessary flow to implement technology to improve safety conditions on roadways. One of the most important prospects of technology application in transportation is the opportunity to improve safety conditions across all users, including bicycles and pedestrians.

The operational concept of this service package considers a number of ITS subsystems, stakeholders, and functional areas. Table 5.5 shows an initial description of the operational concept, defining possible stakeholders and responsibilities. Figure 5.5 shows the architectural flows required for the implementation of this service packages.

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Current/possible stakeholders</th>
<th>Roles and Responsibilities Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Management</td>
<td>VTrans, Municipalities, CCPRC</td>
<td>Collect and manage Roadway status through short range communication technology</td>
<td>Planned</td>
</tr>
<tr>
<td>Roadways</td>
<td>VTrans, Municipalities</td>
<td>Incorporate necessary technology to communicate with Traffic Management and Vehicles</td>
<td>Planned</td>
</tr>
<tr>
<td>Vehicle</td>
<td>Travelers</td>
<td>Send and request location and network status information through short-range communication technology</td>
<td>Planned</td>
</tr>
<tr>
<td>Potential Obstacles</td>
<td>Travelers</td>
<td>Interact with technology enabled vehicles</td>
<td>Planned</td>
</tr>
<tr>
<td>Roadway Environment</td>
<td>VTrans, Municipalities, National Weather Service</td>
<td>Provide information of status and environment to Roadway technology</td>
<td>Planned</td>
</tr>
</tbody>
</table>

This report takes into consideration the implementation of Connected Vehicle (CV) technology. CV allows communication between vehicles (V2V) and infrastructure (V2I). The communication allows vehicles to provide their precise location, speed, and other characteristics that could enable strategies to reduce crashes. This technology is being considered in this ITS Architecture, in the Connected Vehicle project.

Figure 5.5 shows how the service packages in the National Architecture involved with CV technology would interact. These service packages are the following:

- AVSS11 – Automated Vehicle Operations
- AVSS12 – Cooperative Vehicle Safety Systems
This service relies on three main subsystems: Vehicles, Roadways, and Traffic Management. The interaction among these subsystems and the appropriate transfer of data between would allow the development of strategies, like automatic braking systems or emergency steering maneuvers, to avoid crashes with other users.
Figure 5.5 Vehicle Safety Operational Diagram

Legend:
- ITS Subsystem - Stakeholder
- Terminator
- Functional Area

- Existing Flow
- Planned Flow
5.7 COMMERCIAL VEHICLE OPERATIONS

This section seeks to describe the process to implement the only service package considered in the projects presented: CVO6 - Weigh-In-Motion. Table 5.5 and Figure 5.5 present the operational concept and flow to implement such service.

Table 5.6 Commercial Vehicle Operations Operational Concept

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Current/possible stakeholders</th>
<th>Roles and Responsibilities Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Vehicle Check</td>
<td>VTrans</td>
<td>Request vehicle check to commercial vehicles</td>
<td>Existing</td>
</tr>
<tr>
<td>Commercial Vehicle</td>
<td>VTrans</td>
<td>Analyze and process the information collected from vehicle checks</td>
<td>Existing</td>
</tr>
<tr>
<td>Administration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial Vehicle Traveler</td>
<td>Traveler</td>
<td>Provide information requested in vehicle check</td>
<td>Existing</td>
</tr>
<tr>
<td>Commercial Vehicle Driver</td>
<td>Traveler</td>
<td>Pass/pull in if requested</td>
<td>Existing</td>
</tr>
<tr>
<td>Basic Commercial Vehicle</td>
<td>Traveler</td>
<td>Provide information of vehicle requested.</td>
<td>Existing</td>
</tr>
<tr>
<td>Enforcement Agency</td>
<td>VTrans, Municipalities, DMV</td>
<td>Enforce sanctions according to Commercial Vehicle Administration request.</td>
<td>Existing</td>
</tr>
</tbody>
</table>

Figure 5.6 shows the operational diagram, as described in the National ITS Architecture, for the successful operation of WIM systems. The operation of this service relies on three main subsystems: the Commercial Vehicle, the Commercial Vehicle Check, and the Commercial Vehicle Administration. The correct communication among these subsystems would allow the commercial vehicle control WIM to be operational.

Through a message sent to the commercial vehicle, the driver could be asked to park (or stop at revision area) for a check-up, and the information collected would be transferred to the Commercial Vehicle Administration, which would process the information and act upon it. The two stakeholders involved would be VTrans, and commercial vehicle travelers.
Figure 5.6 Commercial Vehicle Operations Operational Diagrams

Legend:
- **ITS Subsystem - Stakeholder**
- **Terminator**
- **Functional Area**

---

- **Request tag data**
- **Electronic screening request**
- **Pass/pull in**

- **Commercial Vehicle Driver**
- **Traveler**

- **Commercial Vehicle Check**
- **VTrans**

- **CVO weight presence**
- **Identification information**

- **Commercial Vehicle Administration**
- **VTrans**

- **CV Information Exchange**

- **Enforcement agency**
- **VTrans Municipalities**

- **Existing Flow**
- **Planned Flow**
5.8 **EMERGENCY MANAGEMENT**

This service package describes the operations of different stakeholders in the event of an incident or emergency. One of the most important applications of transportation infrastructure is to help users react to an unexpected incident or emergency. ITS technology could help improve the collective response to these events, easing communication across all stakeholders, and enhancing mobility during emergency events.

The operational concept of this service package considers a number of ITS subsystems, stakeholders, and functional areas. Table 5.7 shows an initial description of the operational concept, defining possible stakeholders and responsibilities. Figure 5.7 shows the architectural flows required for the implementation of these service packages.

### Table 5.7 Emergency Management Operational Concept

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Current/possible stakeholders</th>
<th>Roles and Responsibilities Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency Management</td>
<td>Department of Public Safety, Vermont SEOC</td>
<td>Manage, surveille and react to emergency and incident occurrences</td>
<td>Planned</td>
</tr>
<tr>
<td>Emergency Vehicle</td>
<td>University of Vermont Medical Center, Municipalities</td>
<td>Receive dispatch order and react accordingly</td>
<td>Existing</td>
</tr>
<tr>
<td>Roadway</td>
<td>VTrans, Municipalities</td>
<td>Receive emergency signal control commands and implement them</td>
<td>Planned</td>
</tr>
<tr>
<td>Traffic Management</td>
<td>VTrans, Municipalities, CCRPC</td>
<td>Define emergency and incident control plans and implement them when necessary</td>
<td>Planned</td>
</tr>
<tr>
<td>Transit Management</td>
<td>CCTA, Vermont transit agencies</td>
<td>Define and implement an emergency operations plan and communicate with Traffic Management for changes in operations.</td>
<td>Planned</td>
</tr>
<tr>
<td>Maintenance Management</td>
<td>VTrans, Municipalities</td>
<td>Define and manage an incident response plan and implement when necessary</td>
<td>Planned</td>
</tr>
<tr>
<td>Weather Data</td>
<td>National Weather Service LSC Meteorological Dept.</td>
<td>Provide alarm notification to Emergency Management</td>
<td>Existing</td>
</tr>
<tr>
<td>Media</td>
<td>TV and Radio stations</td>
<td>Disseminate information provided by Emergency Management</td>
<td>Existing</td>
</tr>
<tr>
<td>Remote Traveler Support</td>
<td>Traveler</td>
<td>Provide alarm notifications to Emergency Management</td>
<td>Existing</td>
</tr>
</tbody>
</table>
This report presents projects that involve emergency operations. The following projects were considered:

- 26 – National Weather Service
- 27 – Vermont Alert and 511
- 28 – University of Vermont Medical Center

This service package considers the different stakeholders described in the ITS National Architecture, taking in consideration the following service packages for the projects presented:

- EM1 – Emergency Call-Taking and Dispatch
- EM2 – Emergency Routing
- EM3 – Mayday and Alarm Support
- EM6 – Wide-Area Alert
- EM7 – Early Warning System
- EM8 – Disaster Response and Recovery

The operations of these packages rely on a very important subsystem: Emergency Management. The main stakeholder considered for this task is Vermont 911, which is in charge of providing help and assistance during emergency events. Other stakeholders involved would be the municipal emergency management centers in the region. The Emergency Management subsystem is responsible for collecting emergency and incident reports, and provide assistance for them.

To optimize the emergency response, Emergency Management needs to be in contact with the different transportation subsystems, including Traffic Management, Transit Management, and Maintenance Management. When an incident is reported, these subsystems would react upon it to improve mobility both within and outside of the incident-impacted area. Traffic Management could help by reconfiguring the traffic signals accordingly, the Transit Management would implement an emergency plan, and Maintenance would
help support the network performance during these events by responding to damaged infrastructure.

Another important subsystem is the Emergency Vehicle. These vehicles need to be properly dispatched and equipped to respond to different types of incidents. Their communication with Roadways could improve their performance and mobility during these events.

The final important sector to consider are the users. The Emergency Management subsystem needs to communicate with all users to deal with different incidents. Users, represented as Travelers, Vehicles, and Weather Services, provide information on conditions, so the Emergency Management can react according to the situation. Emergency Management is responsible for the communication with Information Service Providers and the Media, to communicate with other users.
Figure 5.7 Emergency Management Operational Diagram

Legend:

- **ITS Subsystem** - Stakeholder
- **Terminator**
- **Functional Area**

Existing Flow

Planned Flow
5.9 **MAINTENANCE AND CONSTRUCTION MANAGEMENT**

This service package describes the processes considered by the projects presented to improve and manage maintenance and construction plans. Maintenance and Construction Management is an important activity in transportation infrastructure. With use and time, infrastructure deteriorates thus providing adequate maintenance allows better performance across all users. Furthermore, maintenance and construction often impacts day-to-day transportation operations, resulting in delays to users. ITS technology could help optimize maintenance and construction activities to minimize the effect on users.

The operational concept of this service package considers a number of ITS subsystems, stakeholders, and functional areas. Table 5.8 shows an initial description of the operational concept, defining possible stakeholders and responsibilities. Figure 5.8 shows the architectural flows required for the implementation of this service packages.

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Current/possible stakeholders</th>
<th>Roles and Responsibilities Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance and Construction Management</td>
<td>VTrans, Municipalities</td>
<td>Collect data on infrastructure and weather conditions for a maintenance and construction plan.</td>
<td>Planned</td>
</tr>
<tr>
<td>Maintenance and Construction Vehicle</td>
<td>VTrans</td>
<td>Have the technology necessary enabled for vehicle tracking and data collection activities.</td>
<td>Planned</td>
</tr>
<tr>
<td>Weather Data</td>
<td>National Weather Service, LSC Meteorological Dept.</td>
<td>Provide weather data to Maintenance and Construction Management</td>
<td>Planned</td>
</tr>
<tr>
<td>Traffic Management</td>
<td>VTrans ATMS, Municipalities, CCRPC, Vermont 511</td>
<td>Provide information of infrastructure and equipment status to Maintenance and Construction Management</td>
<td>Planned</td>
</tr>
<tr>
<td>Roadway</td>
<td>VTrans, Municipalities</td>
<td>Have the necessary equipment to collect field data and send it to Maintenance and Construction Management</td>
<td>Planned</td>
</tr>
</tbody>
</table>

For this service, the following projects were considered:

- 22 – Plow Services
- 25 – RWIS
• 30 – Unmanned Aerial Vehicles

The projects presented in this Architecture Update consider three different service packages, as described in the National ITS Architecture:

• MC1 – Maintenance and Construction Vehicle and Equipment Tracking
• MC3 – Road Weather Data Collection
• MC6 – Winter Maintenance

The operation of these packages relies on a main subsystem: Maintenance and Construction Management. This subsystem considers the involvement of stakeholders such as VTrans and Municipalities, who own and are responsible for transportation infrastructure.

The Maintenance and Construction Management subsystem needs to be in regular communication with Weather Data, Maintenance and Construction Vehicles, and Roadway equipment to know the status of the network. Identifying maintenance and construction needs would help in the implementation and monitoring of traffic management plans and their success in meeting goals for traffic flow and safety. Maintenance and Construction Management should communicate performance measures with the Traffic Management subsystem, so that plans can be modified as needed to minimize negative impacts on the network’s users.
Figure 5.8 Maintenance and Construction Management Operational Diagram

Legend:
- **ITS Subsystem** - Stakeholder
- **Terminator**
- **Functional Area**

- **Existing Flow**
- **Planned Flow**
5.10 **PARKING MANAGEMENT**

This service package describes the operational flow for a parking management system. The operational concept of this service package considers a number of ITS subsystems, stakeholders, and functional areas. Table 5.9 shows an initial description of the operational concept, defining possible stakeholders and responsibilities. Figure 5.9 shows the architectural flows required for the implementation of this service package.

### Table 5.9 Parking Management Operational Concept

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Current/possible stakeholders</th>
<th>Roles and Responsibilities Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parking Management</td>
<td>CCRPC, City of Burlington, City of Winooski, Burlington International Airport</td>
<td>Develop and manage a parking management system at facility and regional level.</td>
<td>Existing/planned</td>
</tr>
<tr>
<td>Vehicle</td>
<td>Traveler</td>
<td>Follow the parking management changes and pay accordingly</td>
<td>Existing/planned</td>
</tr>
<tr>
<td>Traffic Management</td>
<td>VTrans, Municipalities, CCRPC</td>
<td>Request parking data from Parking Management</td>
<td>Planned</td>
</tr>
<tr>
<td>Information Service Provider</td>
<td>Private traveler information system</td>
<td>Request parking data and disseminate to users properly</td>
<td>Planned</td>
</tr>
</tbody>
</table>

There are two projects considered in this ITS Update that involve parking management: the Burlington International Airport project and the City of Burlington Parking Management project. These projects include the involvement of two National ITS service packages:

- **ATMS16 – Parking Facility Management**
- **ATMS17 – Regional Parking Management**

The main subsystem involved in these service packages is the Parking Management subsystem. Given that the same stakeholder is involved in both projects, the City of Burlington is identified as the main stakeholder in this subsystem. Parking Management is responsible for deploying parking strategies in the regions, and provide the information to users through Traffic Management and Information Service Providers. Vehicles interact with the parking strategies deployed.
Figure 5.9 Parking Management Operational Diagram

Legend:
- ITS Subsystem - Stakeholder
- Terminator
- Functional Area

Existing Flow
- Planned Flow
5.11 **INTERCONNECTION**

In order to summarize all existing and planned connection between ITS elements in the region, a high-level interconnection diagram can be defined. This diagram is often used in ITS Architectures to define a high level connectivity process, and it is often known as the ‘sausage diagram’. This diagram displays the regional systems and the connection between each other. Figure 5.10 shows the Interconnection Diagram within the Chittenden ITS Architecture.

**ITS Elements and Subsystems**

Figure 5.10 shows all the planned and existing ITS elements or subsystems considered for Chittenden County. Out of the 22 subsystems identified in the National ITS Architecture, this update considers 16 of them. The subsystems considered are represented in Figure 5.10 as white boxes. The subsystems not considered are represented by gray boxes.

**Types of communication**

The types of communication between subsystems are identified and shown in Figure 5.10 as rounded pink rectangles. There are four types of communications:

- **Wide Area Wireless (Mobile) Communications.** This type of communications connects a wireless device between users and infrastructure-based systems. This is considered a wide area communication link because both broadcast (one-way) and interactive (two-way) communications services are grouped into this category. This type of communication supports real-time traveler information and fleet communications.

- **Fixed Point – Fixed Point Communications.** Also known as FP2FP, this type of communication links stationary subsystems. Technology that supports this communication includes fiber optic, twisted pair, coaxial cable, microwave relay networks, among others.

- **Vehicle – Vehicle Communications.** This type of communication connects users through a dedicated wireless system. The benefits include advance collision avoidance technologies, road condition collection data, and coordination to control systems, among others.

- **Field– Vehicle Communications.** Wireless communication between vehicles and infrastructure. This type of communication includes close proximity channels and dedicated wireless systems. Among the benefits found are the communication with signals for priority, toll collection, transit vehicle management, among others.

This architecture considers the upcoming inclusion of Connected Vehicles (CV) and Dedicated Short-Range Communications (DSRC) and its implementation in different types of vehicles.
Figure 5.10 Interconnection Diagram
6.0 ITS Strategic Deployment Plan

The objective of this section is to develop an implementation timeline for the projects considered. This timeline will take into consideration project costs, based on the project descriptions and basic assumptions. The main source to define project costs was the ‘Cost Database’, developed by the USDOT Intelligent Transportation Joint Program Office (USDOT ITS-JPO) Knowledge Resources program. “The Knowledge Resources contain over fifteen years of summaries of the benefits, costs, lessons learned, and deployment status of specific ITS implementations, drawn primarily from written sources such as ITS evaluation studies, research syntheses, handbooks, journal articles, and conference papers”6.

Tables 6.1 through 6.3 show the projects considered in this report, according to time terms defined in Section 4.8 of this document:

- Short term: 0-3 years
- Medium term: 4-7 years
- Long term: 8+ years

The tables show the projects considered, assumptions made to characterize unit costs, sources referenced, and an estimated total project cost. It is important to state that these project costs are not meant to be considered as final, but an initial magnitude for project planning and prioritization.

---

6 http://www.itskrs.its.dot.gov/
<table>
<thead>
<tr>
<th>Project</th>
<th>Assumptions Considered</th>
<th>Total Cost</th>
<th>Stakeholders</th>
<th>Agreements</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 - VTrans ATMS Adoption</td>
<td>The TOC will require Hardware for signal control. This includes one server and multiple new workstations. O&amp;M includes responsive and preventative maintenance.</td>
<td>$11,000 + $4,000 per year</td>
<td>VTrans lead</td>
<td>- ATMS Software Use Agreement with users in CCRPC region</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CCRPC</td>
<td>- Data Privacy Agreement for SP information</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Urban Communities</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Emergency Management</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>State Police</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>02 - Adaptive Signal Control on Selected Corridors</td>
<td>Four corridors are considered in this project: Routes 2, 2A, 7, and 15, assuming 15 intersections each.</td>
<td>$340,000</td>
<td>VTrans lead</td>
<td>- Cooperative Agreement between VTrans and communities regarding signal timing and operations particularly where multiple jurisdictions are operating in the same corridor. Agreement could also include maximum queues allowed on certain approaches and accommodation of pedestrian/bicycle moves.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CCRPC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Urban Communities</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Labor, costs include man hours for installing traffic control signal and maintenance.</td>
<td>$55,000 per year</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$340,000 + $55,000 per year</td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td>Assumptions Considered</td>
<td>Total Cost</td>
<td>Stakeholders</td>
<td>Agreements</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------</td>
<td>------------</td>
<td>--------------</td>
<td>------------</td>
</tr>
<tr>
<td>04 - Advanced Traffic Monitoring System using Bluetooth Technology</td>
<td>The cost information for this project was obtained from the Federal Accelerated Innovation Deployment (AID) grant application.</td>
<td>$1,227,225</td>
<td>CCRPC lead VTrans Urban Communities CCTA Private traveler information vendors</td>
<td>Data use agreements between VTrans and other stakeholders and private vendors</td>
</tr>
<tr>
<td>05 - 5 Corners Intersection Signal Timing</td>
<td>The cost of this project can be included in the project 01 – VTrans ATMS Adoption</td>
<td>N/A</td>
<td>Town of Essex lead VTrans</td>
<td></td>
</tr>
<tr>
<td>07 - Permanent VMS</td>
<td>This project seeks to implement permanent VMS to replace portable ones. Five new permanent VMS are being deployed on I-89 to service upcoming construction near Waterbury. Two are just south of CCRPC region, two are in Williston, and one in Colchester within CCRPC region. Roadside infrastructure includes a DMS tower for small structure for arterials.</td>
<td>$160,000 + $8,000 per year</td>
<td>VTrans</td>
<td></td>
</tr>
<tr>
<td>11 - AVL on Transit Vehicles</td>
<td>This project seeks to increase coverage of AVL technology across passenger buses. The main assumption is the</td>
<td>$75,000 + $6,000 per year</td>
<td>CCTA</td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td>Assumptions Considered</td>
<td>Total Cost</td>
<td>Stakeholders</td>
<td>Agreements</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------</td>
<td>------------</td>
<td>--------------</td>
<td>------------</td>
</tr>
<tr>
<td>12 – Transit CAD</td>
<td>installment of AVL technology on 50 buses</td>
<td>$150,000 + $22,500 per year</td>
<td>CCTA</td>
<td>-</td>
</tr>
<tr>
<td>13 - Fixed Information Signs for Transit</td>
<td>This project considers the integration of CAD to complement AVL technology</td>
<td>$16,000 + $640 per year</td>
<td>CCTA</td>
<td>-</td>
</tr>
<tr>
<td>23 – Chittenden County Regional Data Warehouse</td>
<td>This project assumes that physical facilities are available for computer equipment. The cost considers 4 TB server for data storage. O&amp;M considers 1/2 technician salary ($80K)</td>
<td>$4,600 + $40,000 per year</td>
<td>CCRPC lead</td>
<td>Data sharing agreements between CCRPC, VTrans and CCTA including data to stored, formats, submittal schedule and access/availability by stakeholders.</td>
</tr>
<tr>
<td>26 - National Weather Service</td>
<td>This project considers the integration of new weather services in the Traffic Management Center operations. For this purpose, a similar project in Nebraska was used as a reference.</td>
<td>$120,000 + $20,000 per year</td>
<td>VTrans/NMS lead</td>
<td>Data sharing and use agreements between NWS and VTrans.</td>
</tr>
<tr>
<td>27 - Vermont Alert and 511</td>
<td>This cost assumes data communication translation software, processor, and new workstations. O&amp;M costs assume 1/2 technician salary ($80K)</td>
<td>$110,000 + $40,000 per year</td>
<td>Vermont EMA lead</td>
<td>Data Privacy Agreement for SP information</td>
</tr>
<tr>
<td>Project</td>
<td>Assumptions Considered</td>
<td>Total Cost</td>
<td>Stakeholders</td>
<td>Agreements</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>---------------------</td>
<td>------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>03 - Updating Signal Timings</td>
<td>This project assumes the involvement of consultants to re-define signal timings across all municipalities’ maintained intersections.</td>
<td>$200,000</td>
<td>CCRPC lead</td>
<td>Agreement between VTrans and communities, and within communities regarding signal timing and operations particularly where multiple jurisdictions are operating in the same corridor.</td>
</tr>
<tr>
<td>06 - CCTV Implementation</td>
<td>This project considers the installation of 8 CCTV cameras. This cost considers the installation of 8 CCTV Camera Towers</td>
<td>$56,000 + $8,000 per year</td>
<td>VTrans, Communities where CCTV are located</td>
<td>Sharing and priority use agreements between VTrans and communities that want access to CCTV cameras.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$40,000</td>
<td></td>
<td>Agreements to address privacy concerns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$96,000 + $8,000 per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08 - Parking Management System</td>
<td>This project assumes that there will be one parking lot in Downtown Burlington with new parking monitoring system equipment (detectors and controllers). Current O&amp;M will not be impacted by it.</td>
<td>$25,000</td>
<td>City of Burlington, CCRPC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$65,000 + $10,000 per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$90,000 + $10,000 per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09- TSP Implementation</td>
<td>This project considers the upgrade of signals across 55 intersections, to accommodate for the three TSP corridors considered: Route 2 to Milton, BRT Route 2 to Williston, and</td>
<td>$1,375,000</td>
<td>CCTA, CCRPC, VTrans, Communities on TSP corridors</td>
<td>Operating agreement between CCTA and owners of intersections where TSP will be operating</td>
</tr>
</tbody>
</table>

Table 6.2 Project Costs – Medium-Term Projects
<table>
<thead>
<tr>
<th>Project</th>
<th>Assumptions Considered</th>
<th>Total Cost</th>
<th>Stakeholders</th>
<th>Agreements</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRT Route 15 to Essex.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 - Smart Cards</td>
<td>This project considers the installment of a new electronic fare system across all the CCTA bus services, including on-board and outdoor infrastructure. This estimation assumes installment of electronic fareboxes on 50 buses.</td>
<td>$35,000</td>
<td>- CCTA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>This cost assumes the development of 5,000 smart cards.</td>
<td>$7,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>This cost assumes the installment of 5 smart card vending machines</td>
<td>$110,000 +</td>
<td>$5,500 per year</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Implementation of electronic fare collection software</td>
<td>$41,000 + $4,100</td>
<td>$193,500 +</td>
<td>$9,600 per year</td>
</tr>
<tr>
<td>15 – Automatic Passenger Counters</td>
<td>This cost assumes the installment of infrared APC on 50 buses.</td>
<td>$125,000 +</td>
<td>- CCTA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$5,000 per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 – Transit Networking and Communication</td>
<td>This cost assumes the installation of Wi-Fi enabling equipment for 50 buses, along with O&amp;M costs for internet service charges</td>
<td>$17,500 + $25,000</td>
<td>- CCTA</td>
<td></td>
</tr>
<tr>
<td>24- Web-based Data Portal</td>
<td>Average costs of RITIS implementation are presented. This cost assumes the integration of this project in the ATMS project. It considers ½ an</td>
<td>$40,000 per year</td>
<td>- VTrans lead</td>
<td>- Software user agreements</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- CCRPC</td>
<td>- Urban Communities wanting access to RITIS</td>
</tr>
<tr>
<td>Project</td>
<td>Assumptions Considered</td>
<td>Total Cost</td>
<td>Stakeholders</td>
<td>Agreements</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------------------------------------------------------------------------</td>
<td>---------------------</td>
<td>--------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>25 - RMS</td>
<td>This cost assume the installation of a RMS station in Chittenden County</td>
<td>$50,000 + 1,000 per year</td>
<td>VTrans</td>
<td></td>
</tr>
<tr>
<td>28 – University of Vermont Medical Center</td>
<td>This cost assumes AVL equipment implementation across a fleet of 15 vehicles</td>
<td>$22,500 + $1,800 per year</td>
<td>UVM Medical Center</td>
<td></td>
</tr>
<tr>
<td>29 - Connected Vehicles</td>
<td>This project requires more information to consider its cost</td>
<td>N/A</td>
<td>CCRPC</td>
<td></td>
</tr>
</tbody>
</table>
### Table 6.3  Project Costs – Long-Term Projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Assumptions Considered</th>
<th>Total Cost</th>
<th>Stakeholders</th>
<th>Agreements</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - TSP Implementation in Tertiary Corridors</td>
<td>This project considers the upgrade of signals across 55 intersections, to accommodate for new TSP corridors considered.</td>
<td>$1,375,000</td>
<td>CCTA lead</td>
<td>Operating agreement between CCTA and owners of intersections where TSP will be operating</td>
</tr>
<tr>
<td>17 – Transit Reporting/Data Management</td>
<td>More information is required to identify the costs of this project</td>
<td>N/A</td>
<td>CCTA lead</td>
<td></td>
</tr>
<tr>
<td>18 – Transit Security</td>
<td>This project proposes the installation of CCTV cameras on board 50 buses.</td>
<td>$125,000</td>
<td>CCTA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Installation of hardware for security systems. Costs include one server and three workstations</td>
<td>$8,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Labor, including two technicians ($80K)</td>
<td>$160,000 per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$133,000 + $160,000 per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 - Improve Paratransit Services</td>
<td>This cost assumes AVL equipment implementation across a fleet of 15 vehicles</td>
<td>$22,500 + $900 per year</td>
<td>CCTA</td>
<td>Private transit providers</td>
</tr>
<tr>
<td>20 - Weigh-In-Motion</td>
<td>This cost considers the installation of a WIM site, following costs from similar installations in NJ.</td>
<td>$95,000</td>
<td>VTrans</td>
<td></td>
</tr>
<tr>
<td>21 - Airport Real-Time Information</td>
<td>This project assumes similar costs to the Parking Management project costs.</td>
<td>$25,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$50,000 +</td>
<td>Burlington Airport</td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td>Assumptions Considered</td>
<td>Total Cost</td>
<td>Stakeholders</td>
<td>Agreements</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>-----------------------------</td>
<td>------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td></td>
<td>$4,000 per year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$75,000 + $4,000 per year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 - Plow Services</td>
<td>This cost assumes AVL equipment implementation across a fleet of 5 vehicles</td>
<td>$7,500 + $300 per year</td>
<td>VTrans lead</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Study to integrate plow services in ATMS operations</td>
<td>$50,000</td>
<td>All CCRPC Communities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Study to integrate plow services in ATMS operations</td>
<td></td>
<td>Private plow operators</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$57,500 + $300 per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 - Unmanned Aerial Vehicles</td>
<td>This project requires more information to consider its cost</td>
<td>N/A</td>
<td>CCRPC</td>
<td></td>
</tr>
</tbody>
</table>
6.1 **PROJECT COST SUMMARY**

Based on the information presented from Table 6.1 to 6.3, it is possible to classify the projects considered to develop a broad implementation plan. Table 6.4 shows a summary of all the projects, based on the project time-term, and costs considered.

**Table 6.4  Projects’ General Costs**

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Project Name</th>
<th>Term</th>
<th>Capital Cost Type</th>
<th>O&amp;M Cost Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VTrans ATMS Adoption</td>
<td>Short</td>
<td>$118,000</td>
<td>$169,000</td>
</tr>
<tr>
<td>2</td>
<td>Adaptive Signal Control on Selected Corridors</td>
<td>Short</td>
<td>$340,000</td>
<td>$55,000</td>
</tr>
<tr>
<td>3</td>
<td>Updating Signal Timings</td>
<td>Medium</td>
<td>$200,000</td>
<td>$-</td>
</tr>
<tr>
<td>4</td>
<td>Bluetooth Monitoring System</td>
<td>Short</td>
<td>$1,227,225</td>
<td>$-</td>
</tr>
<tr>
<td>5</td>
<td>5 Corners Intersection Signal Timing</td>
<td>Short</td>
<td>$-</td>
<td>$-</td>
</tr>
<tr>
<td>6</td>
<td>CCTV Implementation</td>
<td>Medium</td>
<td>96,000</td>
<td>$8,000</td>
</tr>
<tr>
<td>7</td>
<td>Permanent VMS</td>
<td>Short</td>
<td>$280,000</td>
<td>$8,000</td>
</tr>
<tr>
<td>8</td>
<td>Parking Management System</td>
<td>Medium</td>
<td>$90,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>9</td>
<td>TSP Implementation</td>
<td>Medium</td>
<td>$1,375,000</td>
<td>$-</td>
</tr>
<tr>
<td>10</td>
<td>TSP Implementation in Tertiary Corridors</td>
<td>Long</td>
<td>$1,375,000</td>
<td>$-</td>
</tr>
<tr>
<td>11</td>
<td>AVL on Transit Vehicles</td>
<td>Short</td>
<td>$75,000</td>
<td>$6,000</td>
</tr>
<tr>
<td>12</td>
<td>Transit CAD</td>
<td>Short</td>
<td>$150,000</td>
<td>$22,500</td>
</tr>
<tr>
<td>13</td>
<td>Fixed Information Signs for Transit</td>
<td>Short</td>
<td>$16,000</td>
<td>$640</td>
</tr>
<tr>
<td>14</td>
<td>Smart Cards</td>
<td>Medium</td>
<td>$193,500</td>
<td>$9,600</td>
</tr>
<tr>
<td>15</td>
<td>Automatic Passenger Counters</td>
<td>Medium</td>
<td>$125,000</td>
<td>$5,000</td>
</tr>
<tr>
<td>16</td>
<td>Transit Networking and Communication</td>
<td>Medium</td>
<td>$17,500</td>
<td>$25,000</td>
</tr>
<tr>
<td>17</td>
<td>Transit Reporting/Data Management</td>
<td>Long</td>
<td>$-</td>
<td>$-</td>
</tr>
<tr>
<td>18</td>
<td>Transit Security</td>
<td>Long</td>
<td>$133,000</td>
<td>$160,000</td>
</tr>
<tr>
<td>19</td>
<td>Improve Paratransit Services</td>
<td>Long</td>
<td>$22,500</td>
<td>$900</td>
</tr>
<tr>
<td>20</td>
<td>Weigh-In-Motion</td>
<td>Long</td>
<td>$95,000</td>
<td>$-</td>
</tr>
<tr>
<td>21</td>
<td>Airport Real-Time Information</td>
<td>Long</td>
<td>$75,000</td>
<td>$4,000</td>
</tr>
<tr>
<td>22</td>
<td>Plow Services</td>
<td>Long</td>
<td>$57,500</td>
<td>$300</td>
</tr>
<tr>
<td>23</td>
<td>Chittenden County Regional Data Warehouse</td>
<td>Short</td>
<td>$4,600</td>
<td>$40,000</td>
</tr>
<tr>
<td>24</td>
<td>Web-based Data Portal</td>
<td>Medium</td>
<td>$-</td>
<td>$40,000</td>
</tr>
<tr>
<td>25</td>
<td>RWIS</td>
<td>Medium</td>
<td>$50,000</td>
<td>$1,000</td>
</tr>
<tr>
<td>26</td>
<td>National Weather Service</td>
<td>Short</td>
<td>$120,000</td>
<td>$20,000</td>
</tr>
<tr>
<td>Project Number</td>
<td>Project Name</td>
<td>Term</td>
<td>Capital Cost Type</td>
<td>O&amp;M Cost Type</td>
</tr>
<tr>
<td>----------------</td>
<td>------------------------------------</td>
<td>---------</td>
<td>-------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>27</td>
<td>Vermont Alert and 511</td>
<td>Short</td>
<td>$110,000</td>
<td>$40,000</td>
</tr>
<tr>
<td>28</td>
<td>University of Vermont Medical Center</td>
<td>Medium</td>
<td>$22,500</td>
<td>$1,800</td>
</tr>
<tr>
<td>29</td>
<td>Connected Vehicles</td>
<td>Medium</td>
<td>$-</td>
<td>$-</td>
</tr>
<tr>
<td>30</td>
<td>Unmanned Aerial Vehicles</td>
<td>Long</td>
<td>$-</td>
<td>$-</td>
</tr>
</tbody>
</table>

Given that the projects defined have been categorized in three different time frames (short, medium, and long term projects), it is possible to define an initial timeframe for project deployment. Figure 6.1 shows a proposed order of deployment, with the correspondent capital cost for each project, and the cumulative operations and maintenance costs considered. This figure represents a proposed implementation strategy. However, each project implementation will vary depending on funding opportunities and operational requirements.
Figure 6.1  Proposed Project Implementation Strategy

Short-term Capital Costs  | Medium-term Capital Costs  | Long-term Capital Costs  | O&M Cumulative Costs
A. Updating the Turbo Architecture File

A.1 Updating Turbo Architecture General Information

The first step to update the Turbo Architecture was to update the general Architecture information file. For this purpose, the following steps were followed:

1. Open the file. In Turbo, select File → Open and select the file you want to use.
2. Select the ‘Start’ tab. This tab contains the general information of the project. On the right side of the window, you can edit the general information of the Architecture. In this case, the time frame was updated to 2015-2025, the version was updated to version 3. The ‘Maintainer’ was set to CCRPC.
3. Save the changes. To save the changes made, select ‘Apply’.

Figure A.1 Screen caption for updating Turbo Architecture General Information
A.2 Updating Projects

Given that the previous Turbo Architecture did not have projects associated with it, one of the main activities of this update was to include projects in the architecture. For this task, the following steps were followed:

1. Open the file. In Turbo, select File → Open and select the file you want to use.

2. Select the ‘Start’ tab. To add/modify a project, click ‘New’ on the left side of the window. Once a new project is generated (or a project to modify is selected), you can add the project’s information on the right side of the window. In this case, the 30 projects were update, with the information presented on tables 4.1, 4.2, and 4.3, following the numeric order presented in these tables.

3. Save the changes. To save the changes made, select ‘Apply’.

4. Save the Turbo File, going to File → Save/Save As.

Figure A.2 Screen caption for updating Projects

A.3 Updating Stakeholders

The next task consisted in updating the list of stakeholders and assigning stakeholders to the projects uploaded. The following stakeholders were added to the Architecture:

- Burlington International Airport

To add/delete/modify stakeholders, the following steps were followed:
1. Open the file. In Turbo, select File → Open and select the file you want to use.

1. Select the ‘Stakeholders’ tab. On the left you can see the list of stakeholders involved. You can add or delete a stakeholder by selecting it and clicking ‘New’ or ‘Delete’. To modify the stakeholder’s characteristics, you select the stakeholder and modify the information on the right side of the window.

2. Save the edits by clicking ‘Apply’.

3. Assign stakeholders to projects. Go to the ‘Start’ tab, select the project you want to assign stakeholders to, go to the ‘Stakeholders’ tab, under the ‘All Stakeholders’ tab, and select all the stakeholders involved in each project.

4. Save the edits by clicking ‘Apply’.

5. Save the Turbo File, going to File → Save/Save As.

Figure A.3 Screen caption for updating stakeholders

A.4 UPDATING INVENTORY ITEMS

The next step involved in the ITS Turbo Architecture update is to update the inventory list. The following items were added to the architecture, to the following stakeholders:

- Burlington International Airport: Burlington International Airport Operations
- CCTA: CCTA On-board WiFi, CCTA On-board Vehicle Cameras

For this task, the next steps were followed:
1. Open the file. In Turbo, select File → Open and select the file you want to use.

1. Go to the Inventory tab. Go to the ‘All Elements’ sub-tab. Here you can add/delete inventory, by clicking the ‘Add’ button, or selecting the item and clicking ‘Delete’. To add or modify information for each item, select the item and modify the information on the right side of the window. You can change the name, the type, the owner of the item, the status, the subsystem/terminator involved with and the project involved with.

2. After modifying the information for each item, select ‘Apply’ to save the changes.

3. Save the Turbo File, going to File → Save/Save As.

**Figure A.4 Screen caption for updating inventory items**

---

**A.5 UPDATING SERVICE PACKAGES**

The next step in the ITS Architecture Update is to update the service packages involved in the Architecture. For this purpose, these steps were followed:

1. Open the file. In Turbo, select File → Open and select the file you want to use.

1. Go to the ‘Services’ tab. Go to the ‘All Services Packages’. Here you will find a list of all service packages available. Select the folder you want to add. On the right window, you will see Iteris description of the service packages available. For each folder, select the ITS elements involved from the right window, under the ‘All Element’ sub-tab. Select also the project that each service package is involved with.
2. Once a service package is selected and assigned projects, you can add/modify a service instance. You can see the instances already defined by opening the service package on the left window, by clicking the [+] sign. To add/modify an instance, select the service package folder and click add to add a new instance or select the instance to modify. On the right window you can add a new name, a description, select elements for each instance, and select the projects involved with each instance.

3. Once all the information is selected for each service package and instance created, select ‘Apply’ to save changes.

4. Save the Turbo File, going to File → Save/Save As.

Figure A.5 Screen caption for updating Service Packages

A.6 UPDATING OPERATIONAL CONCEPTS

The next step taken to update the Turbo Architecture file was to define roles and responsibilities to each stakeholder, according to the areas they are involved in. The process to update the Operational Concepts is the following:

1. Open the file. In Turbo, select File → Open and select the file you want to use.

1. Go to the ‘Ops Concept’ tab. Go to the ‘All Areas’. Click on the ‘Autoselect’ button and follow the instructions to automatically create the areas from the information already provided. To add a new Area, select ‘New’, and add the Service Packages, Stakeholders involved, and Projects involved through the list in the right side of the window.
2. The next step is to add Roles and Responsibilities. For each Area involved, expand its content by clicking the ‘+’ button on the left of each area.

3. Select the stakeholder and describe its roles and responsibilities for this Area in the right side of the window.

4. Save your changes by selecting ‘Apply’ after every change.

**Figure A.6 Screen caption for updating Operational Concepts**

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**A.7 BUILDING THE ARCHITECTURE INTERFACES**

Finally, having identified the Architecture’s Elements, Stakeholders, Service Packages and Operational Concepts, it is required to create the communication flows between them. This step generates the Architecture’s connection between elements. To create these connection the following steps need to be followed:

1. Open the file. In Turbo, select File → Open and select the file you want to use.

2. Go to the ‘Interaces’ tab.

3. Click the ‘Build’ button. Follow the instruction in the pop-up window to allow Turbo to generate the flows according to the information provided.
A.8 ITS ARCHITECTURE STANDARDS

Having identified projects and service packages, and after building the interfaces between Elements, a list of suggested Standards are provided by Turbo. Table 6.1 shows a list of suggested Standards according to the Architecture built.

<table>
<thead>
<tr>
<th>Standard Title</th>
<th>SDO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Traveler Information Systems (ATIS) Bandwidth Limited</td>
<td>SAE</td>
</tr>
<tr>
<td>Advanced Traveler Information Systems (ATIS) General Use</td>
<td>SAE</td>
</tr>
<tr>
<td>Data Element Definitions for Transportation Sensor Systems (TSS)</td>
<td>AASHTO/ITE/NEMA</td>
</tr>
<tr>
<td>Dedicated Short Range Communication at 5.9 GHz Standards Group</td>
<td>ASTM/IEEE/SAE</td>
</tr>
<tr>
<td>Dedicated Short Range Communication at 915 MHz Standards Group</td>
<td>ASTM</td>
</tr>
<tr>
<td>Field Management Stations (FMS) - Part 1: Object Definitions for Signal System Masters</td>
<td>AASHTO/ITE/NEMA</td>
</tr>
<tr>
<td>Global Object Definitions</td>
<td>AASHTO/ITE/NEMA</td>
</tr>
<tr>
<td>Incident Management Standards Group</td>
<td>IEEE</td>
</tr>
<tr>
<td>NTCIP Center-to-Center Standards Group</td>
<td>AASHTO/ITE/NEMA</td>
</tr>
<tr>
<td>NTCIP Center-to-Field Standards Group</td>
<td>AASHTO/ITE/NEMA</td>
</tr>
<tr>
<td>Object Definitions for Actuated Traffic Signal Controller (ASC) Units</td>
<td>AASHTO/ITE/NEMA</td>
</tr>
<tr>
<td>Object Definitions for Closed Circuit Television (CCTV) Camera Control</td>
<td>AASHTO/ITE/NEMA</td>
</tr>
<tr>
<td>Standard Title</td>
<td>SDO</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>Object Definitions for Closed Circuit Television (CCTV) Switching</td>
<td>AASHTO/ITE/NEMA</td>
</tr>
<tr>
<td>Object Definitions for Conflict Monitor Units (CMU)</td>
<td>AASHTO/ITE/NEMA</td>
</tr>
<tr>
<td>Object Definitions for Data Collection and Monitoring (DCM) Devices</td>
<td>AASHTO/ITE/NEMA</td>
</tr>
<tr>
<td>Object Definitions for Dynamic Message Signs (DMS)</td>
<td>AASHTO/ITE/NEMA</td>
</tr>
<tr>
<td>Object Definitions for Environmental Sensor Stations (ESS)</td>
<td>AASHTO/ITE/NEMA</td>
</tr>
<tr>
<td>Object Definitions for Signal Control and Prioritization (SCP)</td>
<td>AASHTO/ITE/NEMA</td>
</tr>
<tr>
<td>On-board Vehicle Mayday Standards Group</td>
<td>SAE</td>
</tr>
<tr>
<td>Standard for the Interface Between the Rail Subsystem and the Highway Subsystem at a Highway Rail Intersection</td>
<td>IEEE</td>
</tr>
<tr>
<td>Standard for Transit Communications Interface Profiles</td>
<td>APTA</td>
</tr>
<tr>
<td>Standard Practice for Metadata to Support Archived Data Management Systems</td>
<td>ASTM</td>
</tr>
<tr>
<td>Standard Specifications for Archiving ITS-Generated Traffic Monitoring Data</td>
<td>ASTM</td>
</tr>
<tr>
<td>Traffic Management Data Dictionary (TMDD) and Message Sets for External Traffic Management Center Communications (MS/ETMCC)</td>
<td>AASHTO/ITE</td>
</tr>
</tbody>
</table>

Source: Iteris Turbo Architecture
B. TOPS BC Summary

The proposed analysis tool for strategy effectiveness for the CMP is the Tool for Operations Benefit Cost Analysis (TOPS-BC) developed by FHWA to provide benefit and cost estimates for a variety of ITS and operational alternatives. TOPS-BC was developed as a follow-up tool to the ITS Deployment Analysis System (IDAS), which is a network model that evaluated ITS and operational options based on the regional travel demand model. IDAS is now over 15 years old and is no longer supported by FHWA. TOPS-BC operates in a spreadsheet format, is easy to learn and highly-transparent. It provides the ability to conduct numerous “what-if” analyses of different assumptions related to both benefits and costs. The program contains a range of default values for both benefits and costs and provides documentation of various studies used to derive those values.

TOPS-BC is a spreadsheet-based tool that does not require a transportation network to operate. The analysis is based on roadway segments and analysis can thus be confined only to those segments that are subject to project alternatives. Like similar benefit/cost tools TOPS-BC annualizes capital costs based on assumed equipment life and adds this to operations and maintenance costs to get a total annualized cost. Default parameters used to estimate project benefits are based on studies compiled by FHWA and disseminated through the ITS website: http://www.itskrs.its.dot.gov. Benefits can include travel time savings, improved travel time reliability, crash reduction savings and reduced fuel consumption. Each of these are assigned economic values and in TOPS-BC they are rolled together to provide a single dollar value of benefits. Default costs and benefits can be easily modified within the spreadsheet to reflect available localized data. A range of parameters may be tested; particularly on the benefits side where there is less certainty regarding the actual impacts of ITS improvements.

Tables B-1 and B-2 below show the output from a TOPS-BC evaluation of a series of operational improvements on a regional freeway system. The treatments proposed including included:

- Improved pre-trip information
- Dynamic Message Signs; and
- Traffic Incident Management services.

Table B.1 TOPS BC Freeway Project Inputs

<table>
<thead>
<tr>
<th>Project</th>
<th>Road Type</th>
<th>Segment</th>
<th>Seg. Length</th>
<th>AM Peak Capacity</th>
<th>VDT</th>
<th>VHT</th>
<th>Vehicles passing DMS</th>
<th>Pre Trip Views</th>
<th>Avg. Vehicles for TIM</th>
<th>Avg Speed</th>
<th>Speed Limit</th>
<th>Lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>699</td>
<td>East Fwy</td>
<td>Freeway</td>
<td>69901</td>
<td>4.49</td>
<td>19734</td>
<td>36608</td>
<td>627</td>
<td>8914</td>
<td>2229</td>
<td>8153</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>699</td>
<td>East Fwy</td>
<td>Freeway</td>
<td>69902</td>
<td>4.49</td>
<td>19734</td>
<td>23188</td>
<td>395</td>
<td>5363</td>
<td>1341</td>
<td>5164</td>
<td>65</td>
<td>65</td>
</tr>
</tbody>
</table>
Table B.2  TOPS BC Freeway Project Outputs

<table>
<thead>
<tr>
<th>Project</th>
<th>Road</th>
<th>Type</th>
<th>AM Benefit</th>
<th>TotBenefit</th>
<th>Project Cost</th>
<th>B/C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>699</td>
<td>East Fwy</td>
<td>Freeway</td>
<td>$5,015,010</td>
<td>$10,030,020</td>
<td>$2,847,075</td>
<td>6.1</td>
</tr>
<tr>
<td>699</td>
<td>East Fwy</td>
<td>Freeway</td>
<td>$3,657,427</td>
<td>$7,314,854</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure B-1 shows inputs for Traffic Incident Management systems, which require traffic volumes, number of lanes and/or capacity and free flow speed. Default values can be used to estimate the impact of TIM improvements on capacity, and the program then uses a speed-flow curve to calculate hours saved. It should be noted that the speed improvement can be directly input by the user as well, and any of the default parameters can be overridden. TOPS-BC also estimates improvements in crash rates resulting from TIM implementation. Base rates can be calculated by the program or input directly. Benefits are then monetized and compared to costs. Figure A-2 shows an example of how results are summarized using monetary values of the benefit parameters, life cycle of the equipment/systems used and annualized estimates for the benefits.

Figure B.1 Incdent Management Inputs
As noted above, the TOPS-BC benefits estimate combines the following benefit categories, monetizes them and converts them to annual estimate shown above in Table A-2:

- Travel Time Savings
- Improved Travel Time Reliability
- Crash Reduction
- Fuel Consumption Savings

Additional information, including both sample spreadsheet tools and documentation of the TOPS-BC, can be obtained at FHWA’s TOPS-BC website:

http://www.ops.fhwa.dot.gov/plan4ops/topsbctool/index.htm

Arterial improvements can also be analyzed and can include both signal timing improvements and ITS improvements along arterial corridors, such as incident management programs and Dynamic Message Signs.
C. 11/06/2014 Focus Group Meeting Notes

CCRPC ITS Architecture Update - Focus Group

November 6, 2014

- 17,000 commute into Chittenden County - need to worry about moving people, multimodal solutions

- Need ITS infrastructure where there is recurring congestion - adaptive signal control corridors.

- National Weather Service has model that combines NWS forecasts with RWIS observations

- National Weather Service email alerts to Emergency Managers and key transportation agency personnel

- Vermont Alert - Coordinate with 511, instrumentation is of value to support emergency operations

- Need research system to keep up with rapidly-changing technologies and support approval of new vendor products

- Web-based portal with archived data from different sources is possibility

- WIM data can be used for planning and deployment of additional stations. Generate monthly weight reports.
  - Using rest areas for electronic screening
  - 43 screening sites around the State
  - Use DriveWyze system - more Canadian trucks are adopting
  - UVM has project that uses passively collected speed/counter data from WIM stations to measure the performance of roadway snow and ice control by measuring the "time-to-normal" of traffic speeds after the onset of a winter storm

- Airport - cell lots with signs that provide arrival times. Interested in moving information outside the terminal. Had parking management system with sensor over each space - no longer in operation.

- Emergency Management - opportunities for exchanging video from key locations - CCTVs at Exit 14 and Route 15 bridge. Additional CCTV to monitor backups at Exit 10.
  - CAD system coordination between State Police and local municipalities is issue
  - Coordination with VTrans Web Crash system - many municipalities provide data but minor crashes serviced by local emergency responders do not always get in the system
- Probe data is key goal going forward. Problem in getting adequate sample in a rural area.

- Challenges in getting information out to the public.
  - Email notifications through VT Alerts
  - Notification of delays are a problem. 911 incident reports are not always accurate. Coordination between VSP and VTrans

- Adoption of new technologies by UVM Transit System
  - Messages going out through a mobile website
  - Also collecting passenger load information

- Fletcher Allen Hospital emergency transportation could be used to provide real-time information

- Send pictures to PSAP and TOC from mobile cameras on LE and emergency vehicles

- UVM research project on UAVs to get conduct surveillance when roadways were out. How much information is needed?
D. 11/06/2014 Workshop Meeting Notes

CCRPC ITS Architecture Update Workshop

November 6, 2014

- VTrans looking at bluetooth solution but this is short-term
  - Reduced power on bluetooth devices
  - DSRC will eventually replace with better signal and higher market penetration
  - Connected Vehicle Architecture is being developed for DSRC

- Weather information is priority. RWIS are being updated to provide grip factor. Plan to start using “Deep Thunder” system with 2km grid weather forecasts.

- Problem with video detection in some areas – loop detectors are more reliable

- CCTA starting to work with IBI to develop technology plan

- Adaptive signal control corridors being implemented in Burlington area

- AVL on plow trucks - able to track, better manage dispatch and show location on website. Looking at mobile RWIS and implementation of Management Decision Support System (MDSS).

- RITIS being implemented in conjunction with ATMS. Will be available to local agencies.

- Permanent VMS being installed in Colchester and both directions in Williston

- Currently using portable VMS

- Plan for portable RWIS and WIMs

- Parking management plan is being developed for downtown. Looking at automated signs to guide drivers to available parking. Fixed wayfinding signs for parking and other major destinations are being considered as well.

- Looking at electronic bicycle lockers at dispersed locations around the region

Projects for architecture and strategic plan

- Adaptive corridors with DSRC
- ATMS
- RITIS
- Permanent VMS
- Portable RWIS and WIMs
- Deep Thunder weather forecast system
- CCTA Transit ITS deployments
- Parking Management System
E. 06/29/2015 Meeting Notes

CCRPC ITS Plan Update

Steering Committee Meeting, June 30, 2015

Cambridge Systematics gave a presentation on the Draft ITS Architecture and Plan Update. The presentation walked through the contents of the report, focusing on the project list which was presented in draft on March 30th. The following comments were received at the meeting:

- Video detection is being installed as part of a intersection upgrade at Route 2A and James Brown in Williston
- Fletcher Allen Hospital is now UVM Medical Center
- Forms should be provided for updating the ITS architecture
- Will the inventory developed for this project be maintained by CCRPC? Anticipate an update every 6 to 12 months.
- CCTA ITS Plan is being finalized and will result in an RFP for an AVL system. Other ITS projects and services may be included.
- The Vtrans TOC is working with Michigan, Minnesota and Idaho on a winter road weather management pooled fund study.
- Vermont EMS needs to be added a stakeholder.
- The Archived Data Services should include mapping of health providers and related transportation services.
- Radiation/nuclear detection is being added to border surveillance and should be included in CVO architecture package.
- Parking management may relate to other municipalities than Burlington. Winooski is looking at parking management strategies for its business district.
- The revised document will be submitted in July
- A presentation on the project will be scheduled for the TAC meeting on 9/1