Michigan Department of Transportation
Regional ITS Architectures and Deployment Plans

TCRPC

Final
Regional ITS Architecture and Deployment Plan

Prepared for:

MDOT

Prepared by:

HNTB

In association with:

Kimley-Horn of Michigan, Inc.

CAMBRIDGE SYSTEMATICS

June 2011

TABLE OF CONTENTS

FINAL REGIONAL ITS ARCHITECTURE AND DEPLOYMENT PLAN – TCRPC

TABLE OF CONTENTS

FINAL REGIONAL ITS ARCHITECTURE AND DEPLOYMENT PLAN – TCRPC

TABLE OF CONTENTS

FINAL REGIONAL ITS ARCHITECTURE AND DEPLOYMENT PLAN – TCRPC

LIST OF FIGURES

TABLE OF CONTENTS

FINAL REGIONAL ITS ARCHITECTURE AND DEPLOYMENT PLAN – TCRPC

LIST OF TABLES

List of Acronyms

AASHTO	American Association of State Highway and Transportation Officials
AD	Archive Data
AHS	Automated Highway System
AMBER	America's Missing: Broadcast Emergency Response
APTA	American Public Transportation Association
APTS	Advance Public Transportation Systems
ASC	Actuated Traffic Signal Controller
ASTM	American Society for Testing and Materials
ATIS	Advance Traveler Information System
ATMS	Advanced Traffic Management System
AVL	Automated Vehicle Location
AVSS	Advance Vehicle Safety Systems
AWOS	Automated Weather Observing System
CATA	Capital Area Transit Authority
CCTV	Closed Circuit Television
CJIC	Criminal Justice Information Center
CMAQ	Congestion Mitigation and Air Quality
CMS	Congestion Management System
CRC	County Road Commission
CVISN	Commercial Vehicle Information Systems and Networks
CVO	Commercial Vehicle Operations
DATEX-ASN	Data Exchange in Access Service Network (AP-DATEX)
DCM	Data Collection and Monitoring
DMS	Dynamic Message Sign
DNRE	Department of Natural Resources and Environment
DPW	Department of Public Works
DSRC	Dedicated Short Range Communication
EATRAN	Eaton County Transportation Authority
EM	Emergency Management
EMS	Emergency Management System
EOC	Emergency Operations Center

LIST OF ACRONYMS

ESS	Environmental Sensor Station
FCP	Freeway Courtesy Patrol
FHWA	Federal Highway Administration
FMS	Field Management Stations
FTA	Federal Transit Administration
HAR	Highway Advisory Radio
HAZMAT	Hazardous Materials
HOV	High Occupancy Vehicle
HRI	Highway Rail Intersection
ICM	Integrated Corridor Management
ICRC	Ingham County Road Commission
IEEE	Institute of Electrical and Electronics Engineers
IMMS	Incident Management Message Sets
ISP	Information Service Provider
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation System
LAN	Capital Regional International Airport
LRTP	Long Range Transportation Plan
MAC	Medium Access Control
MC	Maintenance and Construction
MDT	Mobile Data Terminal
MDOT	Michigan Department of Transportation
MIOC	Michigan Intelligence Operations Center
MITSC	Michigan Intelligent Transportation Systems Center
MOU	Memorandum of Understanding
MS/ETMCC	Message Sets for External Traffic Management Center Communications
MSP	Michigan State Police
MSU	Michigan State University
MPO	Metropolitan Planning Organization
NEMA	National Emergency Management Association
NOAA	National Oceanic and Atmospheric Administration

LIST OF ACRONYMS

NTCIP	National Transportation Communications for ITS Protocol
NWS	National Weather Service
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act – A Legacy for Users
SCP	Signal Control and Prioritization
SDO	Standards Development Organization
SE	Systems Engineering
STMF	Simple Transportation Management Framework
STOC	Statewide Transportation Operations Center
TCP/IP	Transmission Control Protocol/Internet Protocol
TCRPC	Tri-County Regional Planning Commission
TEA-21	Transportation Equity Act for the 21st Century
TIA	Traffic Improvement Association
TIP	Transportation Improvement Program
TMC	Transportation Management Center
TMDD	Traffic Management Data Dictionary
TOC	Traffic Operations Center
TSC	Transportation Service Centers
TSS	Transportation Sensor System
UDP/IP	User Datagram Protocol/Internet Protocol
USDOT	United States Department of Transportation
UTCS	Universal Time, Coordinated Synchronization
VII	Vehicle Infrastructure Integration
VIVDS	Vehicle Imaging Video Detection Systems
XML	Extensible Markup Language

1 Introduction

1.1 Project Overview

Development of a regional intelligent transportation system (ITS) architecture is one of the most important steps in planning for and implementing ITS in a region. ITS architectures provide a framework for implementing ITS projects, encourage interoperability and resource sharing among agencies, identify applicable standards to apply to projects, and allow for cohesive long-range planning among regional stakeholders. The ITS architecture allows stakeholders to plan for what they want their system to look like in the long-term, and then divide the system into smaller, more modular pieces that can be implemented over time as funding permits.

ITS architectures satisfy the conformity requirements first established in the Transportation Equity Act for the 21st Century (TEA-21) highway bill and continued in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) bill passed in 2005. In response to Section 5206(e) of TEA-21, the Federal Highway Administration (FHWA) issued a final rule and the Federal Transit Administration (FTA) issued a final policy that required regions implementing any ITS projects using federal funds to have an ITS architecture in place by April 2005. After this date, any ITS project must show conformance with their regional ITS architecture to be eligible for funding from FHWA or FTA. Regions that had not yet deployed ITS were given four years to develop an ITS architecture after their first ITS project proceeded to final design.

In July 2010, the Michigan Department of Transportation (MDOT) began an update of the Tri-County Regional Planning Commission (TCRPC) Regional ITS Architecture. The regional ITS architecture has the same geographic boundaries of the TCRPC Region and focuses on a 10- to 15-year vision of ITS for the Region. In addition, a separate ITS Deployment Plan was developed to identify and prioritize specific ITS projects recommended for the Region in order to implement the ITS architecture. The update for the TCRPC was completed in tandem with an update for the Grand Valley Metro Council (GVMC) of Governments. These updates successfully align all of the ITS architectures and deployment plans into a consistent format for the state of Michigan. This not only provides a consistent ITS vision for the state, but also provides a consistent benefit/cost analysis for all ITS projects that can be used for prioritizing projects at the statewide level.

The update of the regional ITS architecture and the development of the ITS deployment plan were assembled with significant input from local, state, and federal officials. A series of workshops have been held to solicit input from stakeholders and ensure that the plans reflect the unique needs of the Region. This draft report was provided to all stakeholders for comment. The regional ITS architecture and deployment plan reflects an accurate snapshot of existing ITS deployments and future ITS plans in the Region. The needs and priorities of the Region will change over time; to remain effective this plan should be reviewed and updated periodically.

1.2 Document Overview

The TCRPC Regional ITS Architecture report is organized into five key sections:

Section 1 – Introduction

This section provides an overview of the National ITS Architecture requirements, the TCRPC Regional ITS Architecture, and the key features and stakeholders in the TCRPC Region.

Section 2 – Regional ITS Architecture Development Process

An overview of the key steps involved in updating the regional ITS architecture for the TCRPC Region is provided in this section. It includes a discussion of stakeholder involvement, architecture workshops, and the architecture update process.

Section 3 – Customization of the National ITS Architecture for the TCRPC Region

This section contains a summary of regional needs and details the customization of the National ITS Architecture to meet the ITS vision for the Region. The market packages that were selected for the Region are included in this section. Additionally, the interconnect diagram, or "sausage diagram," is presented to show the relationships of the key subsystems and elements in the Region.

Section 4 – Application of the Regional ITS Architecture

Functional requirements and standards that apply to the Region, as indicated by the regional ITS architecture, are presented in Section 4. Operational concepts identifying stakeholder roles and responsibilities have been prepared and potential agreements to support the data sharing and resources will be identified. Based on feedback received at the Architecture Workshop, this section provides some "next step" guidelines for agencies that wish to take a market package forward and implement a project.

Section 5 – Maintaining the Regional ITS Architecture

A use and maintenance plan was developed for the TCRPC Regional ITS Architecture and is included in this section. The plan outlines the procedure for updating the regional ITS architecture over time.

The TCRPC Regional ITS Architecture also contains five appendices.

- Appendix A – National ITS Architecture Market Package Definitions
- Appendix B – Customized Market Packages
- Appendix C – Element Functional Requirements
- Appendix D – Stakeholder Database
- Appendix E – Architecture Conformance and Maintenance Documentation Form

1.3 Assessment

The TCRPC Regional ITS Architecture and Deployment Plan has been assessed based on twelve items derived from both the April 8, 2001 USDOT ITS Architecture and Standards Conformity Rule/Policy and from the architecture development process described in the *Regional ITS Architecture Guidance Document*. A listing of these items is shown in **Table 1**.

Table 1 – Summary of Architecture Assessment Categories

Content Criteria	Architecture Implementation Criteria
1. Architecture Scope	8. Implementation Plan (use)
2. Stakeholder Identification	9. Maintenance Plan
3. System Inventory	10. Agreements
4. Needs and Services	11. Standards Identification
5. Operational Concept	12. Project Sequencing
6. Functional Requirements	
7. Interfaces/Flows	

1.4 The TCRPC Region

1.4.1 Geographic Overview

The TCRPC Regional ITS Architecture geographic area is defined by the boundaries of the TCRPC MPO, which includes Ingham County, Eaton County, and Clinton County. The largest city within the Region is Lansing, which is the capital of Michigan and has an estimated 2009 population of 113,810 according to the US Census. Other cities and townships within the Region include Meridian, Delta, and East Lansing, the home of Michigan State University. A map of the TCRPC Region is included in **Figure 1**.

To update the TCRPC Regional ITS Architecture, the project team coordinated with MDOT and TCRPC to identify and invite the appropriate cities, townships, state and federal agencies, and transit providers. Stakeholders included representatives from transportation, transit, and public safety agencies throughout the Region.

As part of the TCRPC Regional ITS Architecture update, a 10- to 15-year vision for ITS in the Region was documented. In the ITS Deployment Plan, the 10- to 15-year time frame was divided into smaller time periods to prioritize and sequence the projects. The naming convention used for elements in the TCRPC Regional ITS Architecture is consistent with the naming convention that is used in the Grand, SEMCOG, Superior, Bay, North, and Southwest Regions as well as the Statewide ITS Architecture. This consistency provides seamless connections to those architectures without requiring that they be specifically identified. Statewide initiatives, such as statewide commercial vehicle operations and 511 traveler information service, are referenced in the TCRPC Regional ITS Architecture, but are addressed in further detail in the Statewide ITS Architecture.

1.4.2 Transportation Infrastructure

The TCRPC Region is served by a number of significant federal and state highways, including I-69, I-96, I-496, and US 127. The I-496 corridor runs straight through the Lansing metropolitan area providing freeway access from I-69/I-96 into downtown Lansing. For a portion of the freeway, it runs concurrently with US 127. Based on MDOT average daily traffic (ADT) counts for 2009, the I-496 corridor through downtown and the I-69/I-96 corridor west of downtown have the heaviest volumes of traffic with some segments of each corridor experiencing ADTs over 60,000. The US 127/I-496 corridor that runs north and south through downtown has ADTs over 50,000 as does the I-96 corridor to the east of Lansing. Other key corridors with high ADTs in the TCRPC Region include Business 69 and M-43, both of which are east-west corridors that travel through Lansing and East Lansing. There currently are no toll roads or high occupancy vehicle lanes in the Region.

The key corridors through the TCRPC Region for intrastate and interstate travel include I-69, I-96, and US 127. I-96 is an east-west corridor and serves as the primary route to connect the Tri-County area with Grand Rapids to the west and with Detroit and Windsor, Canada to the east. I-69 connects the Tri-County area with Indianapolis to the south and with Flint and Port Huron at the Canadian border to the northeast. US 127 provides the primary route for travelers heading north towards the Upper Peninsula.

Transit is provided by several different service providers depending on the county. In Clinton and Eaton Counties, demand response curb-to-curb public transportation is available. Clinton Transit is the provider in Clinton County and EATRAN is the provider in Eaton County and Delta and Bath Townships. EATRAN also provides a connector bus service from Eaton County to downtown Lansing that operates during the morning and afternoon commute period.

The Capital Area Transportation Authority (CATA) provides service in Clinton, Eaton, and Ingham Counties. CATA offers fixed-route, demand response, and paratransit service as well as a rural service that operates in outlying areas of Ingham County. CATA's fixed-route service includes limited express services into Lansing and multiple routes serving Michigan State University in East Lansing. Cities and townships serviced by CATA's fixed routes include Lansing, East Lansing, Delhi, Meridian, Williamston, Webberville, Mason, and Dansville. CATA also provides car and vanpooling matching programs.

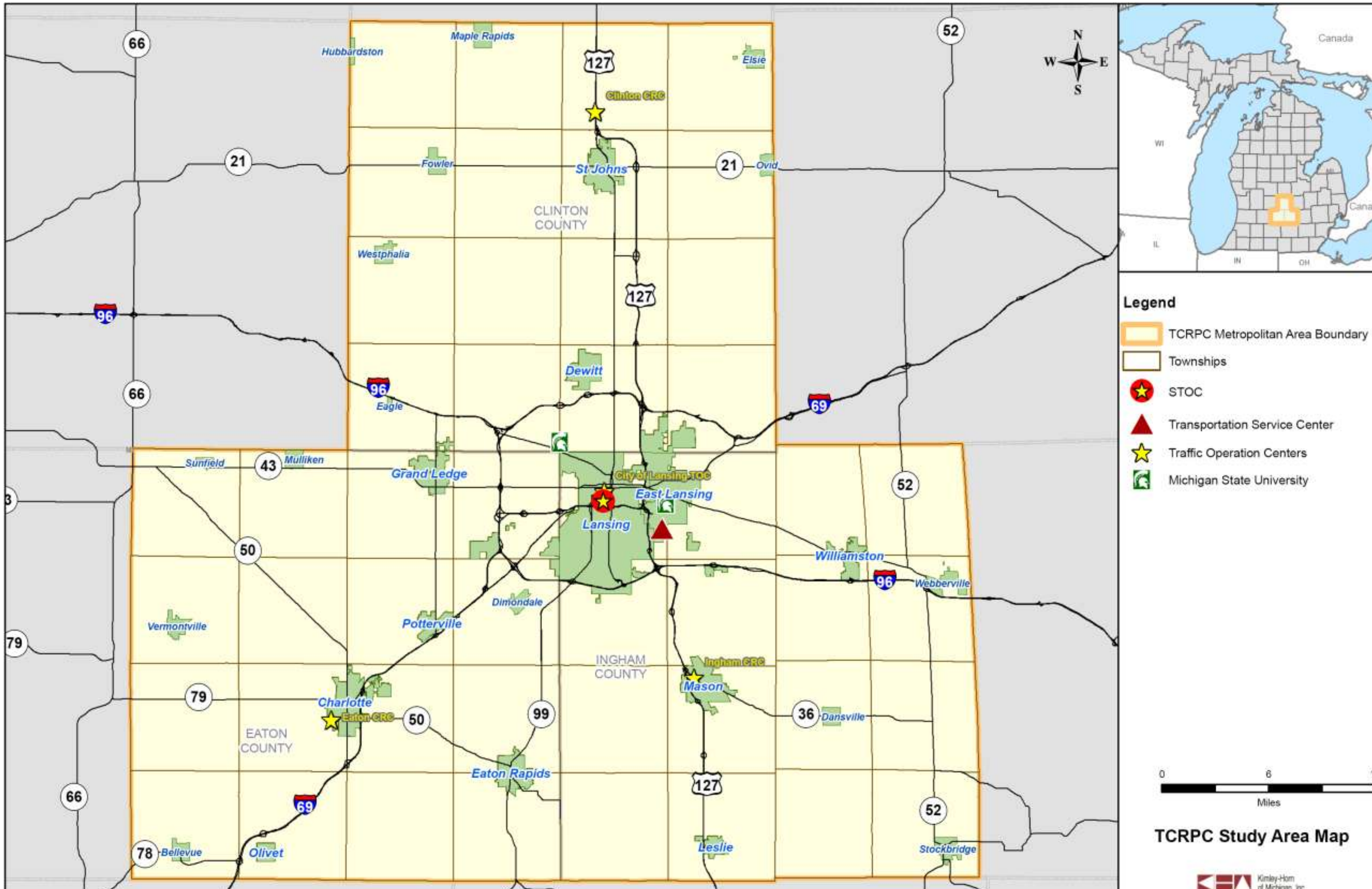


Figure 1 – TCRPC Regional Boundaries

1.4.3 TCRPC Regional ITS Plans

The MDOT partnered with TCRPC and other regional stakeholders to initiate the update of the existing TCRPC Regional ITS Architecture in 2010. The TCRPC Regional ITS Architecture provides a vision for deployment and operations of ITS and establishes how future systems in the Region will be integrated. Version 6.1 of the National ITS Architecture and Version 5.0 of Turbo Architecture were used to complete the regional ITS architecture updates.

Since the first regional ITS architecture was completed in 2001, the TCRPC has moved forward with several local and regional ITS programs and deployments. These have come from a number of different agencies and cover multiple system types such as freeways, arterial streets, transit, and public safety. A brief summary highlighting some of the ITS programs and deployments in the TCRPC Region is provided below.

- **MDOT Statewide Transportation Operations Center (STOC)** – MDOT is completing the first step of the construction of the STOC, located in downtown Lansing. The STOC will serve as the center of operations for MDOT staff to monitor and operate the CCTV cameras, DMS, variable speed limit signs, and vehicle detectors from a statewide perspective. This includes the primary operations of devices not located within the jurisdictions of the MDOT West Michigan Transportation Operations Center (WMTOC) in Grand Rapids or MDOT Michigan Intelligent Transportation Service Center (MITSC), in Detroit. It also will serve as a back-up for these facilities and provide interregional coordination for incidents with multi-regional impacts.
- **Ingham County 911 Joint Dispatch Center** – East Lansing and the City of Lansing have agreed to combine services for the new joint dispatch center in Ingham County. The new center will combine East Lansing, Meridian, and Ingham County dispatch centers with the City of Lansing and will handle calls throughout the county. Additionally, the facility will receive calls for Michigan State University (MSU). Construction is scheduled to begin in 2011.
- **City of Lansing TOC** – The City of Lansing is completing a new center to serve as the Traffic Operations Center for the City. It currently is in the planning and design phase.
- **MDOT Device Implementation** – MDOT is in the process of implementing several devices, including dynamic message signs (DMS) and closed-circuit television (CCTV) cameras, along US 127 and I-96 east of Lansing. The devices will be controlled by the STOC.
- **AVL for Demand Response Operations** – CATA, EATRAN, and Clinton Transit either have technology integrated on their vehicles or will have it on their vehicles in the near future. CATA and Clinton Transit currently are in the process of installing AVL equipment. EATRAN has established funding to implement it in the near future.

1.4.4 Stakeholders

Stakeholder involvement is one of the key elements necessary for the successful development of a regional ITS architecture and deployment plan. The vision for how ITS will be deployed, integrated, and operated needs to be developed with input from all stakeholder agencies within the Region in order for the plan to truly reflect regional needs and priorities. Because ITS incorporates much more than traditional surface transportation infrastructure, it is important that other transportation system stakeholders are brought into the regional ITS architecture development process. Stakeholder agencies in the TCRPC Region include transit and public safety agencies in addition to transportation agencies. Stakeholders at the local, county, and state levels were invited and encouraged to participate.

In **Table 2,** a list is presented of the stakeholder agencies that participated in the TCRPC Regional ITS Architecture and Deployment Plan workshops or provided direct input to the study team. Other stakeholders that were invited to participate, but were not able to attend, were provided with notification when minutes of the workshops or copies of the draft and final reports were available for review. Throughout the regional ITS architecture and deployment plan development, the project website was kept up to date with the latest version of all draft and final documents to allow as much opportunity as possible for any stakeholder to review and comment on all documents. **Appendix D** contains a complete list of the invited stakeholders and workshop attendance.

Table 2 – TCRPC Stakeholder Agencies and Contacts

Stakeholder Agency	Address	Contact
Capital Region International Airport	Capital City Airport (LAN) Lansing, MI 48906	
CATA	420 South Grand Avenue Lansing, MI 48933	Debbie Alexander
CATA	420 South Grand Avenue Lansing, MI 48933	Edgar Hammer
CATA	420 South Grand Avenue Lansing, MI 48933	Matt Mayes
CATA	420 South Grand Avenue Lansing, MI 48933	Jason Ball
City of East Lansing	410 Abbot Road East Lansing, MI 48823	Steven Roach
City of Lansing	219 North Grand Avenue Lansing, MI 48933	Andy Kilpatrick
City of Lansing Emergency Management	815 Marshall Street Lansing, MI 48912	Barbara Hamilton
City of Leslie and Consumer Energy	P.O. Box 496 Leslie, MI 49251	Jeannie King
Clinton County Road Commission	3536 S. US 27 St. Johns, MI 48879	Joseph Pulver
Delta Charter TWP	913 W. Holmes Road, Suite 201 Lansing, MI 48910	Howard Pizzo
Eaton County Road Commission	1112 Reynolds Road Charlotte, MI 48813	Mathew Hannahs
EATRAN	916 E. Packard Highway Charlotte, MI 48813	Linda Tokar
Ingham County Road Commission	301 Bush Street Mason, MI 48854	Bob Peterson
Ingham County 911 Joint Dispatch Center	Not yet completed	

Table 2 – TCRPC Stakeholder Agencies and Contacts

Stakeholder Agency	Address	Contact
FHWA – Michigan	315 West Allegan, Suite 201 Lansing MI 48933	Morrie Hoevel
DTMB	320 S. Walnut Street Lansing, MI 48909	Kirk Parrish
DTMB	320 S. Walnut Street Lansing, MI 48909	Mark Burrows
MDOT – University Region	4701 W. Michigan Avenue Jackson, MI 49201	Stephanie Palmer
MDOT – University Region	4701 W. Michigan Avenue Jackson, MI 49201	Jennifer Foley
MDOT – Lansing TSC	3101 Technology Boulevard, Suite H Lansing, MI 48910	Hilary Owen
MDOT – ITS Program Office	2750 N. Elm Rd. Jackson MI 49201-6802	Kurt Coduti
MDOT – ITS Program Office	8885 Ricks Road Lansing MI 48917	Collin Castle
MDOT Bay Region (currently assisting the ITS Program Office)	55 E. Morley Dr. Saginaw MI 48601	Kim Zimmer
MDOT – Statewide	6333 Old Lansing Road Lansing MI 48917	Lee Nederveld
MDOT – Statewide (Operations)	6333 Old Lansing Road Lansing, MI 48917	Jason Gutting
MDOT – Statewide (Planning)	6333 Old Lansing Road Lansing, MI 48917	Ray Lenzer
MIOC	425 West Ottowa Street Lansing MI 48933	Eileen Phifer
Michigan State University	87 Red Cedar Road, MSU East Lansing, MI 48824	Stephanie Fox
Tri-County Regional Planning Commission	913 W. Holmes Road, Suite 201 Lansing, MI 48910	Paul Hamilton
Tri-County Regional Planning Commission	913 W. Holmes Road, Suite 201 Lansing, MI 48910	Steve Skinker
URS – TMC Operations	3950 Sparks Drive, S.E. Grand Rapids MI 49546	Marc Start

2 Regional ITS Architecture Development Process

The update of the TCRPC Regional ITS Architecture and Deployment Plan relies heavily on stakeholder input to ensure that the architecture reflects local needs. A series of two workshops were held with stakeholders to gather input, and draft documents were made available to stakeholders for review and comment. The workshops were conducted with stakeholders over nine months and included:

- TCRPC Regional ITS Architecture Development Workshop, August 26, 2010; and
- TCRPC ITS Deployment Plan Workshop January 18, 2011.

The process followed for the TCRPC Region was designed to ensure that stakeholders could provide input and review for the update of the Region's ITS Architecture and development of the Deployment Plan. **Figure 2** illustrates the process followed.

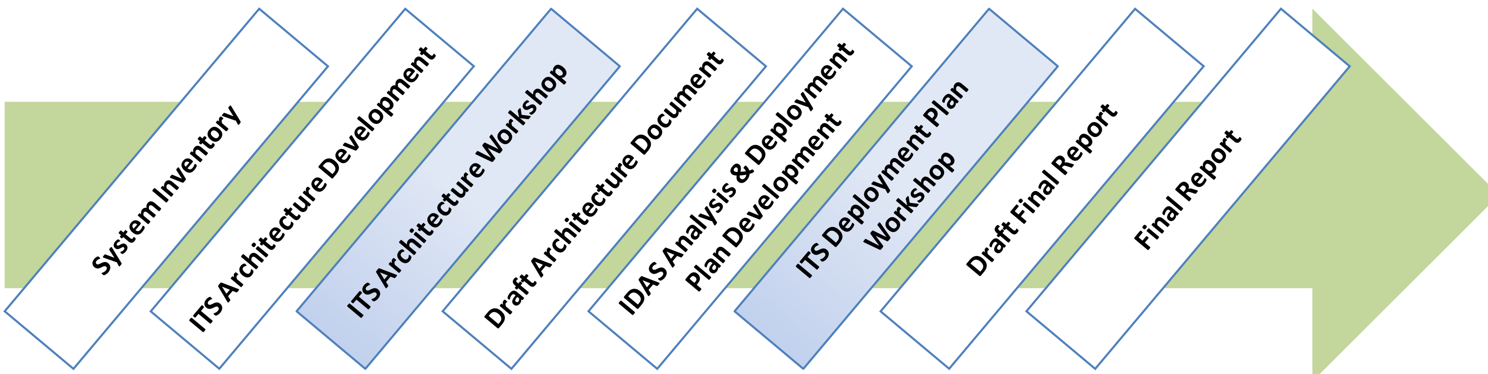


Figure 2 – TCRPC Regional ITS Architecture and Deployment Plan Development Process

Key components of the process are described below:

Task 1 – System Inventory: A literature review of existing documents, including the 2001 Lansing Sector ITS Architecture Report and Section 7 of the MDOT ITS Deployment Study – Lansing Sector was conducted to establish the baseline for the region. This baseline then was revised based on changes in project status since 2001. Secondly, a stakeholder group was identified that included representatives from regional transportation, transit, and public safety agencies. Preliminary conversations with stakeholders were conducted prior to the TCRPC Regional ITS Architecture Workshop to confirm the inventory of existing and planned ITS elements in the Region. Additional conversations were conducted after the workshop to clarify and gain additional insight into the details of the inventory.

Task 2 – ITS Architecture Workshop and ITS Architecture Development: The purpose of the TCRPC Regional ITS Architecture Workshop was to review the system inventory with stakeholders and update the TCRPC Regional ITS Architecture. Information on the National ITS Architecture was integrated into the workshop so that key elements of the architecture, such as market packages, could be explained prior to the selection and editing of these elements. The result of the TCRPC Regional ITS Architecture Workshop was a regional ITS architecture for the TCRPC Region that included a system inventory, interconnect diagram, customized market packages, functional requirements, and relevant ITS standards. As a next step, this draft regional ITS architecture document was submitted to stakeholders for review and comment.

Task 3 – ITS Deployment Plan Workshop and ITS Deployment Plan Development: A draft project listing for the TCRPC Region along with the process taken to develop costs and rankings of the projected projects was presented to stakeholders at the TCRPC Regional ITS Deployment Plan Workshop. Additionally, the results from the IDAS analysis were presented for feedback and comment. Stakeholders were asked to provide input on the recommended projects, responsible agencies, associated costs, and deployment timeframe. Incorporating feedback from the workshop, the IDAS results and project priorities were refined and the summarized within the Deployment Plan.

Task 4 – Draft Final and Final Report: Comments received from the Architecture and Deployment Plan Workshops were integrated into the documents and compiled into the Draft Final report. After a brief review period, all comments were addressed and the Final Regional ITS Architecture and Deployment Plan Report was assembled and submitted to the stakeholders.

3 Customization of the National ITS Architecture for the TCRPC Region

3.1 Systems Inventory

An important initial step in the architecture update process is to establish an inventory of existing ITS elements. Through subsequent discussions with agency representatives, TCRPC Region stakeholders provided the team with information about existing and planned systems that would play a role in the Region's ITS Architecture.

The National ITS Architecture has eight groups of ITS service areas. Existing, planned, and future systems in the Region were identified in the following service areas:

- ***Traffic Management*** – example includes the West Michigan Transportation Operations Center (WMTOC) located in Grand Rapids as well as the Statewide Transportation Operations Center (STOC) in Lansing, the Michigan Intelligent Transportation System center (MITSC) in Detroit, and local agency traffic operations centers (TOCs); surveillance equipment such as detection systems and closed circuit television (CCTV) cameras; fixed and portable dynamic message signs (DMS), and other related technologies.
- ***Emergency Management*** – example includes emergency operations/management centers, improved information sharing among traffic and emergency services, automated vehicle location (AVL) on emergency vehicles, traffic signal preemption for emergency vehicles, and wide-area alerts.
- ***Maintenance and Construction Management*** – example includes work zone management, roadway maintenance and construction information and environmental sensor stations (ESS).
- ***Public Transportation Management*** – example includes transit and para-transit AVL, transit travel information systems, electronic fare collection, and transit security.
- ***Commercial Vehicle Operations*** – example includes coordination with Commercial Vehicle Information Systems and Networks (CVISN) efforts, and hazardous material (HAZMAT) management.
- ***Traveler Information*** – example includes broadcast traveler information such as MiDrive, or obtaining information through personal computers.
- ***Archived Data Management*** – example includes electronic data management and archiving systems.
- ***Vehicle Safety*** – example includes collision avoidance and automated highway systems.

3.2 Regional Needs

Needs from the Region were identified by stakeholders at the Regional ITS Architecture Workshop held in August of 2010. The needs identified provided guidance for determining which market packages should be included in the architecture. Needs were identified in all service areas except for vehicle safety.

Section 3.4.3 contains additional information about the specific needs identified and relates those needs to the market packages that document the corresponding ITS service.

3.3 Element Customization

The inventory and needs documented through the first phase of this process are the starting point. The identified user services, including ITS systems and the associated components, are used to customize the National ITS Architecture and update the regional ITS architecture specific to the TCRPC Region.

When developing customized elements, the stakeholder group agreed not to establish individual traffic, maintenance, and emergency management elements for individual cities within the TCRPC Region. City of Lansing, East Lansing, Michigan State University (MSU), and Ingham County Road Commission (ICRC), were the only local agencies individually identified and documented. The smaller communities in the Region were documented as part of the local agency stakeholder names and the elements for those agencies are captured accordingly. For ease in maintenance of the regional ITS architecture, the stakeholders agreed to this collective grouping under "Local Agencies". This documentation allows the communities to be included in the TCRPC Regional ITS Architecture, and therefore eligible to use federal monies on ITS deployments. As individual communities or counties deploy user services, the Architecture can be updated to uniquely capture those agencies and their flows.

3.3.1 Subsystems and Terminators

Each identified system or component in the TCRPC Regional ITS inventory was mapped to a subsystem or terminator in the National ITS Architecture. Subsystems and terminators are the entities that represent systems in ITS. Subsystems are the highest level building blocks of the physical architecture; the National ITS Architecture groups them into four major classes: centers, field, vehicles, and travelers. Each of these major classes includes various components that represent a set of transportation functions (or processes). Each set of functions is grouped under one agency, jurisdiction, or location, and corresponds to physical elements such as: traffic operations centers, traffic signals, or vehicles.

Figure 3 shows the National ITS Architecture subsystems. This figure, also known as the "sausage diagram," is a standard interconnect diagram, showing the relationships of the various subsystems within the architecture. A customized interconnect diagram for the TCRPC Region is shown in **Figure 4**. Communication functions between the subsystems are represented in the ovals. It is important to remember that the architecture is technology agnostic, but examples of fixed-point to fixed-point communications include not only twisted pair and fiber optic technologies, but also wireless technologies such as microwave and spread spectrum.

Terminators are the people, systems, other facilities, and environmental conditions that interface with ITS and help define the boundary of the National ITS Architecture as well as a regional system. Examples of terminators include drivers, weather information providers, and information service providers.

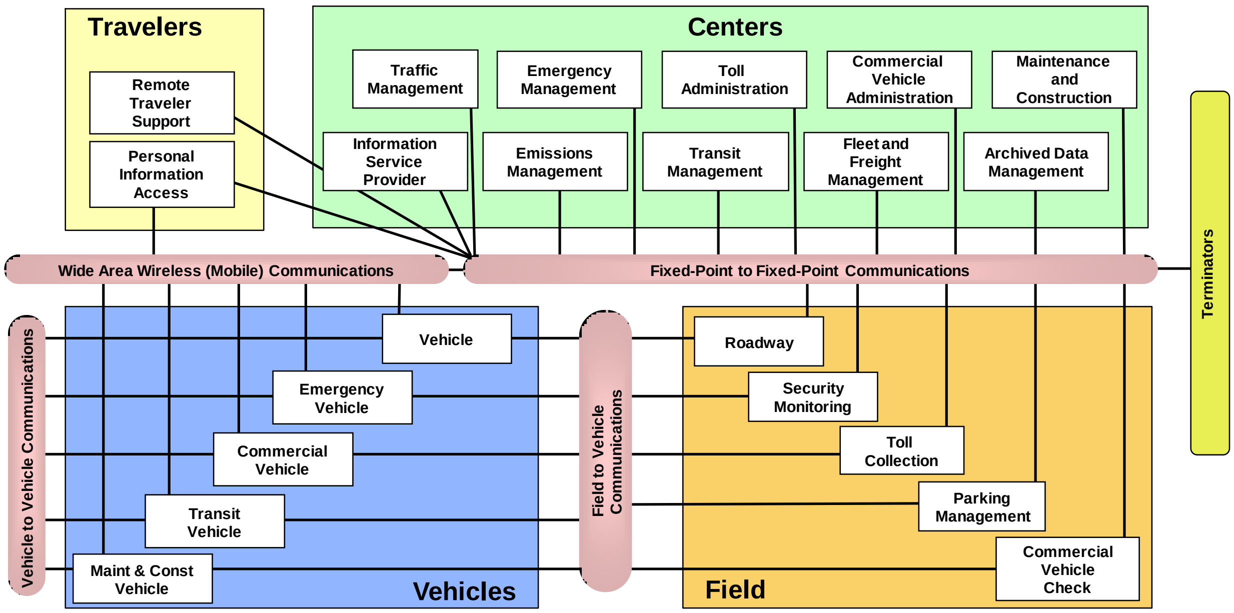


Figure 3 – National ITS Architecture Physical Subsystem Interconnect Diagram

3.3.2 ITS Inventory by Stakeholder

Each stakeholder is associated with one or more systems or elements (subsystems and terminators) that make up the transportation system in the TCRPC Region. A review of the existing regional ITS architecture was performed and an updated list of stakeholders was developed. Any stakeholder that was no longer included in the regional ITS architecture was either consolidated with similar stakeholders under a new stakeholder name or removed. **Table 3** shows the list of stakeholders that were simply removed from the regional ITS architecture. The stakeholders identified were removed because they were not represented within any of the selected market packages for the TCRPC region.

A listing of stakeholders, as identified in the architecture, can be found in **Table 4.** Where appropriate, the second column in the table includes the stakeholder or stakeholder name that was used in the 2001 regional ITS architecture. The last column in the table presents a description of the stakeholder as it is defined in the regional ITS architecture. For example, rather than individually documenting each of the smaller local agencies in the Region, a single stakeholder was named for local agencies, and represents the counties, cities, towns, and county road commission (CRC) not specifically identified in the architecture.

Table 5 sorts the inventory by stakeholder so that each stakeholder can easily identify and review all of the architecture elements associated with their agency. The table includes the status of the element, either existing or planned. In many cases, an element classified as existing might still need to be enhanced to attain the service level desired by the Region, but for purposes of the architecture it is identified as existing within the region.

Table 3 – Listing of Existing Stakeholders Omitted from Architecture Update

Stakeholder	Comment
Greater Lansing Convention and Visitors Bureau	There were no market packages identified with any elements associated with this stakeholder.
Michigan State Patrol	There were no market packages identified with any elements associated with this stakeholder.
Michigan Trucking Association	There were no market packages identified with any elements associated with this stakeholder.

Table 4 – Updated TCRPC Region Stakeholder Names and Descriptions

Updated/New Stakeholder Name	Stakeholder Name in Existing Architecture	Stakeholder Description
Capital Area Transit Authority (CATA)	Capital Area Transit Authority	CATA is responsible for the public transportation services and facilities in the Tri-County Region.
Capital Region Airport Authority	Capital City Airport	The Capital Region Airport Authority is responsible for the management and operation of the Capital Region International Airport (LAN) airfield and airport facilities.
City of Lansing	City of Lansing	The City of Lansing is responsible for designing and constructing; coordinating and inspecting utility and roadway, and optimizing traffic flow through the City. Covers all City departments, including those that deal with traffic and public safety.
Clinton Transit	Community Resource Volunteers (Clinton County Paratransit)	Clinton Transit is responsible for the public transportation services and facilities for all of Clinton County.
Department of Natural Resources and Environment (DNRE)		The Michigan Department of Natural Resources and Environment is responsible for the operations and maintenance of all parks and recreation facilities, including infrastructure components on those properties. DNRE uses weather stations to provide information to visitors at Parks and Recreation facilities.
Eaton County Transportation Authority (EATRAN)	EATRAN	EATRAN is responsible for the public transportation services and facilities for Eaton County, downtown Lansing, and some parts of Ingham County.
East Lansing		East Lansing is responsible for designing and constructing; coordinating and inspecting utility and roadway, and optimizing traffic flow through the city. Covers all city departments including those that deal with traffic and public safety.
Financial Institution		Handles exchange of money for electronic fare collection.
Ingham County Road Commission (ICRC)	Ingham County Road Commission	The Ingham County Road Commission is responsible for the construction and maintenance of countywide roads. Their duties also include signal operations and signal maintenance for Ingham County signals.
Local Agency	911 Service City of DeWitt City of East Lansing Fire Dispatch City of East Lansing Police Dispatch City of Mason City of St. Johns Clinton County Road Commission Clinton County Sheriff Department Delhi Charter Township Eaton County Dispatch Eaton County Road Commission Eaton County Sheriff Department Ingham County Sheriff Department Meridian Township	Represents the local government for all municipalities and county road commissions within the Region that are not specifically identified. Covers all city departments, including those dealing with traffic and public safety.

Table 4 – Updated TCRPC Region Stakeholder Names and Descriptions

Updated/New Stakeholder Name	Stakeholder Name in Existing Architecture	Stakeholder Description
Media	Media	Local media outlets. This can include television stations, newspapers, radio stations, and all associated websites.
Michigan Department of Transportation (MDOT)	MDOT	The Michigan Department of Transportation is responsible for planning, design, construction, maintenance, and operation for all aspects of a comprehensive integrated transportation system in the State of Michigan.
Michigan State Police (MSP)	MSP	State law enforcement agency that enforces traffic safety laws as well as commercial vehicle regulations.
Michigan State University (MSU)	Michigan State University Michigan State University Police Department	MSU is responsible for coordinating and optimizing traffic flow through the University and surrounding areas.
NOAA	Weather Information Providers	The National Oceanic and Atmospheric Administration gathers weather information and issues severe weather warnings.
Other Agencies		This stakeholder represents a wide variety of agencies. The associated elements are groups of agencies or providers that do not have a primary stakeholder agency.
Other Elements		Other elements include potential obstacles, roadway environment, and other vehicles.
Private Information Service Provider		Private sector business responsible for the gathering and distribution of traveler information. This service is typically provided on a subscription basis.
Private Operators		Private Operators manage privately owned resources that connect with public sector elements and sub-systems of the regional ITS architecture.
Private Transportation Providers	Private Providers	Private transportation service providers such as taxis and shuttle services.
Rail Operators	Railroads	Companies that operate trains and/or are responsible for the maintenance and operations of railroad tracks.
Regional Demand Response Transit Providers		Transit providers within the TCRPC Region other than CATA, EATRAN, and Clinton Transit, that provide demand response services.
System Users	End Users Travelers	All of the users of the transportation system.
Tri-County Regional Planning Commission (TCRPC)		TCRPC supports local government planning on regional issues in the areas of transportation, environment, community and economic development, and education.

Table 5 – TCRPC Region Inventory of ITS Elements

Stakeholder Name	Element Name	Element Description	Status
Capital Area Transit Authority (CATA)	CATA CCTV Surveillance	CCTV surveillance at CATA Dispatch Center. CCTV surveillance also is located on vehicles for security issues.	Existing
	CATA Data Archive	The transit data archive for CATA. Used by FTA and MDOT Office of Public Transportation.	Existing
	CATA Dispatch Center	Transit dispatch center is responsible for the tracking, scheduling, and dispatching of fixed route and paratransit vehicles operated by CATA.	Existing
	CATA Electronic Fare Payment Card	Medium for collection of transit fares electronically.	Planned
	CATA Google Transit™ Feed Specification (GTFS)	Data feed of CATA transit information made available via License Agreement to partner agencies.	Existing
	CATA Kiosks	Kiosks for dissemination of transit traveler information. Kiosks also can be used for the purchase and recharging of electronic fare payment cards.	Planned
	CATA Vehicles	Transit vehicles owned/operated by CATA.	Existing
	CATA Website	Website of CATA that provides real-time traveler information about fares, arrival times, and schedules information.	Planned
Capital Region Airport Authority	Capital Region International Airport (LAN)	Capital Region International Airport (LAN) is a small international airport in the City of Lansing, Michigan. It is managed by the Capital Region Airport Authority.	Existing
	Capital Region International Airport Operations Center	Capital Region International Airport (LAN) central command and control facility responsible for airport operations.	Existing
	Capital Region International Airport Security Monitoring Field Equipment	Roadside equipment located on Capital Region International Airport routes that is used for monitoring key infrastructure elements from damage or attacks.	Existing
	Capital Region International Airport Vehicle Parking Management System	System operated by the Capital Region International Airport that monitors available vehicle parking at key parking facilities.	Existing
City of Lansing	City of Lansing CCTV Cameras	Closed circuit television cameras operated by the City of Lansing TOC for traffic condition monitoring and management of incidents.	Existing
	City of Lansing Data Archive	Archive that contains historical traffic data, such as volume and speed information for the City of Lansing routes.	Existing
	City of Lansing DMS	Dynamic Message Signs operated by the City of Lansing to provide information to drivers, such as lane closures or travel times.	Planned
	City of Lansing DPW	Department of Public Works for the City of Lansing that is responsible for road and bridge construction and maintenance, snow removal and salting, surface treatments, street lane painting and markings, controlling roadside vegetation and mowing, gravel road grading, and roadside ditch and drain maintenance.	Existing
	City of Lansing ESS	Environmental sensor stations located on city routes that collect information about the roadways, such as temperature and moisture levels.	Planned
	City of Lansing Field Sensors	Roadway equipment used to detect vehicle volumes and/or speeds. Includes equipment, such as VIVDS, RTMS, or traditional loops.	Planned
	City of Lansing Maintenance Vehicles	City of Lansing vehicles used in maintenance operations.	Existing
	City of Lansing Public Safety	Local law enforcement, fire, and EMS vehicles. Includes the ITS equipment installed	Existing

Table 5 – TCRPC Region Inventory of ITS Elements

Stakeholder Name	Element Name	Element Description	Status
	Vehicles	on the vehicles (AVL, MDTs, etc.).	
City of Lansing (continued)	City of Lansing TOC	City of Lansing Traffic Operations Center responsible for the operations of the municipal signal system. The City of Lansing TOC operates City of Lansing traffic signals as well as MDOT traffic signals.	Existing
	City of Lansing Traffic Signals	Traffic signals within the jurisdictional boundaries of the City of Lansing and operated by the City of Lansing TOC.	Existing
	City of Lansing Vehicle Parking Management System	System operated by the City of Lansing that includes instrumentation, signs (DMS), and other infrastructure that monitors lot usage and provides information about availability and other general parking information. The system also collects parking fees and monitors parking meters.	Existing
	City of Lansing Website	Website of the City of Lansing that provides real-time traveler information for arterial travel conditions and updates for planned events.	Planned
Clinton Transit	Clinton Transit CCTV Surveillance	CCTV surveillance at Clinton Transit Dispatch Center. CCTV surveillance also is located on vehicles for security issues.	Planned
	Clinton Transit Data Archive	The transit data archive for Clinton Transit. Used by FTA and MDOT Office of Public Transportation.	Planned
	Clinton Transit Dispatch Center	Transit dispatch center responsible for the tracking of paratransit vehicles operated by Clinton Transit.	Existing
	Clinton Transit Electronic Fare Payment Card	Medium for collection of transit fares electronically.	Planned
	Clinton Transit Vehicles	Transit vehicles owned by Clinton Transit.	Existing
	Clinton Transit Website	Website for Clinton Transit that provides real-time traveler information about fares, arrivals, and schedule information.	Planned
Department of Natural Resources and Environment (DNRE)	DNRE Weather Stations	Department of Natural Resources and Environment field equipment that collects weather data, such as temperature and visibility.	Existing
EATRAN	EATRAN CCTV Surveillance	CCTV surveillance at EATRAN Dispatch Center. CCTV surveillance also is located on vehicles for security issues.	Planned
	EATRAN Data Archive	The transit data archive for the EATRAN. Used by FTA and MDOT Office of Public Transportation.	Planned
	EATRAN Dispatch Center	Transit dispatch center responsible for the tracking of paratransit vehicles operated by EATRAN.	Existing
	EATRAN Electronic Fare Payment Card	Medium for electronically collecting transit fares.	Planned
	EATRAN Vehicles	Transit vehicles owned by EATRAN.	Existing
	EATRAN Website	Website for EATRAN that provides real-time traveler information about fares, arrivals, and schedule information.	Planned

Table 5 – TCRPC Region Inventory of ITS Elements

Stakeholder Name	Element Name	Element Description	Status
East Lansing	East Lansing Data Archive	Archive that contains historical traffic data, such as volume and speed information for the East Lansing routes.	Planned
	East Lansing TOC	The City of East Lansing Traffic Operations Center responsible for the operating the municipal signal system. The East Lansing TOC operates East Lansing traffic signals only.	Existing
	East Lansing Traffic Signals	Traffic signals within the jurisdictional boundaries of East Lansing and operated by the East Lansing TOC.	Existing
	East Lansing Vehicle Parking Management System	System operated by East Lansing that includes instrumentation, signs (DMS), and other infrastructure that monitors lot usage and provides information about availability and other general parking information. The system also collects parking fees and monitors parking meters.	Existing
Financial Institution	Financial Service Provider	Handles exchange of money for electronic fare collection.	Existing
	Service Agency	Agency responsible for payment of transit fares for medical transportation as part of government subsidized medical care. This includes Medicare and VA programs.	Existing
Ingham County Road Commission (ICRC)	ICRC Traffic Signals	Traffic signals within the jurisdictional boundaries of the Ingham County Road Commission and operated by the ICRC TOC.	Existing
	ICRC TOC	Ingham County Road Commission Traffic Operations Center responsible for the operations of the municipal signal system.	Existing
Local Agency	County CCTV Cameras	Closed circuit television cameras operated by County TOC for traffic condition monitoring and incident management.	Planned
	County Commercial Vehicle Permitting System	County system for tracking and monitoring oversize and overweight permits for commercial vehicles.	Planned
	County Data Archive	Archive that contains historical traffic data, such as volume and speed information for County Road Commission routes.	Planned
	County Road Commission	Duties include road and bridge construction and maintenance, snow removal and salting, surface treatments, street lane painting and markings, controlling roadside vegetation and mowing, gravel road grading, and roadside ditch and drain maintenance on County routes. The County Road Commission can be a contract agency with MDOT responsible for MDOT routes within the County. Includes Clinton, Eaton, and Ingham Counties.	Existing
	County Road Commission Maintenance Vehicles	Vehicles operated by the County Road Commission for maintenance operations. Includes Clinton, Eaton, and Ingham Counties.	Existing
	County TOC	County Road Commission Traffic Operations Center responsible for signal system operations on County routes. Includes Clinton and Eaton Counties only.	Planned
	County Traffic Signals	Traffic signals within the County jurisdictional boundaries. These signals usually are operated by the County TOC. Includes Clinton and Eaton Counties only.	Planned
	County Website	Website for County Road Commission that provides real-time traveler information for arterial travel conditions and updates for planned events.	Planned
	Ingham County 911 Joint Dispatch Center	Joint facility combining dispatches from East Lansing, Lansing, Meridian, and Ingham County. Answers all 911 calls made within the local area and coordinates with other dispatch facilities. This includes counties and municipalities.	Existing
	Local Agency 911 Dispatch	Answers all 911 calls made from within the local area and coordinates with other dispatch facilities. This includes counties and municipalities.	Existing

Table 5 – TCRPC Region Inventory of ITS Elements

Stakeholder Name	Element Name	Element Description	Status
Local Agency (continued)	Local Agency CCTV Cameras	Closed circuit television cameras operated by the Local Agency TOC for traffic condition monitoring and incident management.	Planned
	Local Agency Commercial Vehicle Permitting System	Local agency system for tracking and monitoring oversize and overweight permits for commercial vehicles.	Planned
	Local Agency Data Archive	Archive that contains historical traffic data, such as volume and speed information on local agency routes.	Planned
	Local Agency DMS	Dynamic Message Signs operated by local agencies to provide information to drivers such as lane closures or travel times.	Planned
	Local Agency DPW	Department of Public Works for local agencies responsible for road and bridge construction and maintenance, snow removal and salting, surface treatments, street lane painting and markings, controlling roadside vegetation and mowing, gravel road grading, and roadside ditch and drain maintenance.	Existing
	Local Agency Emergency Operations Center (EOC)	Central command and control facility responsible for carrying out the principals of emergency preparedness, emergency management, or disaster management functions at a strategic level in an emergency situation.	Existing
	Local Agency Equipment Repair	Local repair facilities (garages) for maintenance and construction vehicles.	Planned
	Local Agency Field Sensors	Roadway equipment operated by local agencies used to detect vehicle volumes and/or speeds. Includes equipment such as VIVDS, RTMS, or traditional loops.	Planned
	Local Agency Maintenance Vehicles	Local agency vehicles used in maintenance operations.	Existing
	Local Agency Public Safety Vehicles	Local law enforcement, fire, and EMS vehicles. Includes the ITS equipment installed on the vehicles (AVL, MDTs, etc.).	Existing
	Local Agency Smart Work Zone Equipment	Work zone monitoring and alerting equipment owned by local agencies.	Planned
	Local Agency TOC	Local Traffic Operations Center responsible for municipal signal system operations.	Planned
	Local Agency Traffic Signals	Traffic signals within the jurisdictional boundaries of the local agency.	Planned
	Local Agency Website	Website of local agencies that provides real-time traveler information for arterial travel conditions and updates for planned events.	Planned
	Railroad Blockage Notification System	System shares highway-rail intersection (HRI) status for at-grade crossings with users through traveler information tools.	Planned
Media	Local Print and Broadcast Media	Local media that provide traffic or incident information to the public.	Existing
Michigan Department of Transportation (MDOT)	MDOT Anti-Icing Field Equipment	Roadside equipment located along MDOT routes that monitor roadway conditions for freezing conditions and automatically applies chemical or other anti-icing treatment as predetermined thresholds are met.	Planned
	ATMS Gateway Server	Statewide software that integrates the operations of ITS field devices via a single interface. Examples of access provide view and control of CCTV cameras and posting messages on DMS.	Existing
	MDOT CCTV Cameras	Closed circuit television cameras operated by MDOT STOC for traffic condition monitoring and incident management.	Existing

Table 5 – TCRPC Region Inventory of ITS Elements

Stakeholder Name	Element Name	Element Description	Status
Michigan Department of Transportation (MDOT) (continued)	MDOT Commercial Vehicle Permitting System	MDOT system for tracking and monitoring oversize and overweight permits for commercial vehicles.	Planned
	MDOT Data Warehouse	Archive that contains historical traffic data, such as volume and speed information for MDOT routes.	Existing
	MDOT DMS	Dynamic Message signs operated by MDOT to provide information to drivers such as lane closures or travel times.	Existing
	MDOT ESS	Environmental sensor stations located on MDOT routes that collect information about the roadways, such as temperature and moisture levels.	Planned
	MDOT University Region Equipment Repair	Local repair facilities (garages) for maintenance and construction vehicles.	Existing
	MDOT Field Sensors	Roadway equipment located on MDOT routes used to detect vehicle volumes and/or speeds. Includes equipment such as VIVDS, RTMS, or traditional loops.	Existing
	MDOT Freeway Service Patrol Dispatch	Manages MDOT resources to assist motorists in need on MDOT routes. It is operated through the MDOT STOC.	Planned
	MDOT Freeway Service Patrol Vehicles	Fully equipped vehicles that provide motorist assistance to vehicles in need on MDOT routes.	Planned
	MDOT HOV Lanes	High occupancy vehicle lanes designated only for vehicles with multiple passengers.	Planned
	MDOT Lansing TSC	MDOT field office that oversees road construction and maintenance on MDOT facilities. Winter maintenance operations in this region are handled exclusively through contract agencies.	Existing
	MDOT Maintenance Vehicles	MDOT vehicles used in maintenance operations.	Existing
	MDOT MI Drive Website	Michigan Department of Transportation website that provides real-time traveler information for arterial travel conditions and updates for planned events.	Existing
	MDOT MITSC	Transportation management center that operates the freeway management system and ITS deployments for the Detroit/SE Michigan area.	Existing
	MDOT Office of Communications	Michigan Department of Transportation office responsible for the dissemination of traffic information to the media and public.	Existing
	MDOT Probe Data Sensors	Roadway equipment located on MDOT routes used to detect vehicle volumes and/or speeds.	Planned
	MDOT Ramp Meters	Roadway equipment located on MDOT routes used to regulate traffic flow entering freeways based on current traffic conditions.	Planned
	MDOT Roadside Equipment for AHS	Equipment located along MDOT routes that allows communication between roadside devices and vehicles.	Planned
	MDOT Roadside Intersection Collision Avoidance Equipment	Equipment located along MDOT routes that communicate between multiple roadside devices and vehicles to alert of unsafe travel conditions or conditions conducive to crashes.	Planned
	MDOT Roadside Signing Equipment	Equipment located along MDOT routes that provide data through dynamic messaging or in-vehicle messaging.	Planned
	MDOT Signal Shop	Responsible for the operations and maintenance of MDOT signal system equipment.	Existing

Table 5 – TCRPC Region Inventory of ITS Elements

Stakeholder Name	Element Name	Element Description	Status
Michigan Department of Transportation (MDOT) (continued)	MDOT Smart Work Zone Equipment	Work zone monitoring and alerting equipment owned by MDOT.	Planned
	MDOT STOC	MDOT Statewide Traffic Operations Center located in City of Lansing. The STOC operates the freeway management system and Statewide ITS deployments outside of the areas operated by the MITSC and WMTOC.	Existing
	MDOT Traffic Signals	Traffic signals located on MDOT trunklines. Operations of the traffic signals are achieved through a partnership between MDOT and contract agencies.	Existing
	MDOT Weigh-in-Motion	In-road equipment that monitors vehicle weights.	Existing
MSP	CJIC Database	Criminal Justice Information Center Database stores criminal justice data and can be accessed by multiple agencies.	Existing
	MIOC	The Michigan Intelligence Operations Center operates 24-hours a day and provides statewide information sharing among local, state, and federal public safety agencies.	Existing
	MSP District 1 Dispatch – Lansing	Michigan State Police dispatch for the surrounding Lansing area. Provides call-taking and dispatch for MSP and coordinates with other public safety agencies.	Existing
	MSP Headquarters – East Lansing	Michigan State Police headquarters that oversees operations of MSP.	Existing
	MSP Office of Highway Safety Planning	Manages crash data for MDOT routes.	Existing
	MSP Traffic Safety Division	Responsible for monitoring commercial vehicle regulations on MDOT routes.	Existing
	MSP Vehicles	Public Safety vehicles owned and operated by Michigan State Police. Includes the ITS equipment installed on the vehicles (AVL, MDTs, etc.).	Existing
	MSP Winter Travel Advisory Website	Traveler Information website operated by Michigan State Police for dissemination of winter weather advisories.	Existing
	MSP Winter Travel Toll Free Number	Toll-free number operated by the Michigan State Police that provides travel information to the public.	Existing
Michigan State University (MSU)	MSU CCTV Cameras	Closed circuit television cameras operated by MSU TOC for traffic condition monitoring and incident management.	Planned
	MSU Field Sensors	Roadway equipment located on MSU routes used to detect vehicle volumes and/or speeds. Includes equipment such as VIVDS, RTMS, or traditional loops.	Planned
	MSU TOC	MSU Traffic Operations Center responsible for operations of signals on the MSU campus.	Existing
	MSU Traffic Signals	Traffic signals within the jurisdictional boundaries of MSU.	Existing
	MSU Vehicle Parking Management System	System operated by Michigan State University that includes instrumentation, signs (DMS), and other infrastructure that monitors lot usage and provides information about availability and other general parking information. The system also collects parking fees and monitors parking meters.	Existing
	MSU Website	Website for MSU that provides real-time traveler information for arterial travel conditions and updates for planned events.	Planned
NOAA	National Weather Service	Provides official US weather, marine, fire, and aviation forecasts; warnings; meteorological products; climate forecasts; and information about meteorology.	Existing

Table 5 – TCRPC Region Inventory of ITS Elements

Stakeholder Name	Element Name	Element Description	Status
NOAA (continued)	NWS Weather Stations	National Weather Service equipment that provides current weather conditions, such as temperature and precipitation.	Existing
Other Agencies	Arena/Convention Center	System operated by the local arena/convention center that monitors available vehicle parking at key parking facilities.	Planned
	Contractor Smart Work Zone Equipment	Work zone monitoring and alerting equipment owned by a contractor.	Planned
	Private Concierge Provider	Private entities that provide customized services to the traveler. This service is usually subscription based (such as On Star).	Existing
Other Elements	AWOS Weather Stations	Automated Weather Observation Stations are a type of automated airport weather station used to observe weather data (including temperature, wind speed, visibility, etc.) for aviation or meteorological purposes. They are operated either by the FAA or a state/local government.	Existing
	Potential Obstacles	Obstacles that could interfere with the safe operation of vehicles.	Existing
	Roadway Environment	All objects and conditions in the vicinity of the traveler that can affect the operations of the traveler.	Existing
Private Information Service Provider	Private Sector ISP	Private entities that collect and disseminate traffic information.	Existing
	Private Sector Traveler Information Services	Website sponsored by a private entity. MDOT is receiving NAVTEQ data through a contractual agreement. Other data sets could require similar contracts or subscriptions.	Existing
Private Operators	Private Fleet Operators	Private companies that proactively manage and operate their fleet routing. Includes reactions to incidents and possible delays.	Existing
	Private Parking Operators	Systems operated on private property that monitor available commercial vehicle parking.	Existing
Private Transportation Providers	Private Transportation Providers	Private providers of transportation services in the Region, such as taxis and intercity bus services.	Existing
Rail Operators	Rail Operator Wayside Equipment	Equipment located along the tracks, including railroad crossing gates, bells, and lights, as well as the interface to the traffic signal controller indicating the presence of a train.	Existing
Regional Demand Response Transit Providers	Regional Demand Response Transit Providers CCTV Surveillance	CCTV surveillance at the Regional Demand Response Transit Center or transfer facilities.	Planned
	Regional Demand Response Transit Providers Data Archive	The transit data archive for the Regional Demand Responsive Transit Providers. Used by FTA and MDOT Office of Public Transportation.	Planned
	Regional Demand Response Transit Providers Dispatch Center	Transit dispatch center responsible for the tracking, scheduling, and dispatching of demand response vehicles operated by Regional Demand Response Transit Providers.	Planned
	Regional Demand Response Transit Providers Electronic Fare Payment Card	Medium for collection of transit fares electronically.	Planned
	Regional Demand Response Transit Providers Vehicle	Transit Vehicles owned by the Regional Demand Responsive Transit providers.	Planned
	Regional Demand Response Transit Providers Website	Website of the Demand Response Transit Providers that provides real-time traveler information about fares, arrival times, and schedule information.	Planned

Table 5 – TCRPC Region Inventory of ITS Elements

Stakeholder Name	Element Name	Element Description	Status
System Users	Advanced Commercial Vehicle	Privately owned commercial vehicles that travel throughout the Region. Include additional advanced technology within the vehicles for electronic screening and tag data communication.	Existing
	Archived Data Users	Those who request information from the data archive systems.	Existing
	Commercial Vehicle Driver	The operator of the commercial vehicle.	Existing
	Commercial Vehicles	Privately owned commercial vehicles that travel throughout the Region.	Existing
	Driver	Operator of private vehicles.	Existing
	Event Promoter	Facilities that host and operate special events occurring in the TCRPC Region (e.g. Spartan Stadium, Dow Event Center, etc.).	Existing
	Multi-Modal Transportation Service Provider	Coordination between interfaces of different transportation systems to efficiently move people across multiple transportation modes.	Planned
	Other Vehicle	Vehicles outside of the control of the driver.	Existing
	Private Travelers Personal Computing Devices	Computing devices that travelers use to access public information.	Existing
	Private Vehicles	Vehicles operated by the public.	Existing
	Traveler	Individual operating a vehicle on routes within the region.	Existing
	Traveler Card	Medium for collection of electronic payments for parking management systems or departments.	Planned
Tri-County Regional Planning Commission	TCRPC Data Warehouse	Archive system that contains historical traffic data provided by other agency data archive systems.	Existing

3.3.3 Top Level Regional System Interconnect Diagram

A system interconnect diagram, or "sausage diagram" (shown previously in **Figure 3**), shows the systems and primary interconnects in the Region. The National ITS Architecture interconnect diagram has been customized for the TCRPC Region based on the system inventory and information gathered from the stakeholders.

Figure 4 summarizes the existing and planned ITS elements for the TCRPC Region in the context of a physical interconnect diagram. Subsystems and elements specific to the Region are identified in the boxes surrounding the main interconnect diagram; these are color-coded to the subsystem with which they are associated.

HNTB

MDOT

Legend

Subsystem — Regional Architecture Elements Map To National ITS Architecture

Subsystem ······ No Regional Architecture Elements Map To National ITS Architecture

Emergency Management
- Capital Region International Airport Operations Center
- CATA Dispatch Center
- Clinton Transit Dispatch Center
- EATRAN Dispatch Center
- Ingham County 911 Joint Dispatch Center
- Local Agency 911 Dispatch
- MDOT Freeway Service Patrol Dispatch
- MIOC
- MSP District 1 Dispatch - Lansing
- MSP Headquarters – East Lansing
- MSP Office of Highway Safety Planning
- Private Concierge Providers
- Regional Demand Response Transit Providers Dispatch Center

Commercial Vehicle Administration
- MDOT Commercial Vehicle Permitting System

Maintenance & Construction Mgmt.
- City of Lansing DPW
- County Road Commission
- Local Agency DPW
- MDOT Lansing TSC

Transit Management
- CATA Dispatch Center
- Clinton Transit Dispatch Center
- EATRAN Dispatch Center
- Private Transportation Providers
- Regional Demand Response Transit Providers Dispatch Center

Information Service Provider
- ATMS Gateway Server
- CATA Google Transit™ Feed Specification (GTFS)
- CATA Website
- City of Lansing Website
- Clinton Transit Website
- County Website
- EATRAN Website
- Local Agency Website
- MDOT MI Drive Website
- MDOT Office of Communications
- MSP Winter Travel Advisory Website
- MSP Winter Travel Toll Free Number
- MSU Website
- Private ISP
- Private Sector Traveler Information Services
- Regional Demand Response Transit Providers Website

Fleet and Freight Management
- Private Fleet Operations

Archived Data Management
- CATA Data Archive
- City of Lansing Data Archive
- CJIC Database
- Clinton Transit Data Archive
- County Data Archive
- East Lansing Data Archive
- EATRAN Data Archive
- Local Agency Data Archive
- MDOT Data Warehouse
- Regional Demand Response Transit Providers Data Archive
- TCRPC Data Warehouse

Traffic Management
- City of Lansing TOC
- County TOC
- Local Agency TOC
- MDOT Signal Shop
- MDOT STOC

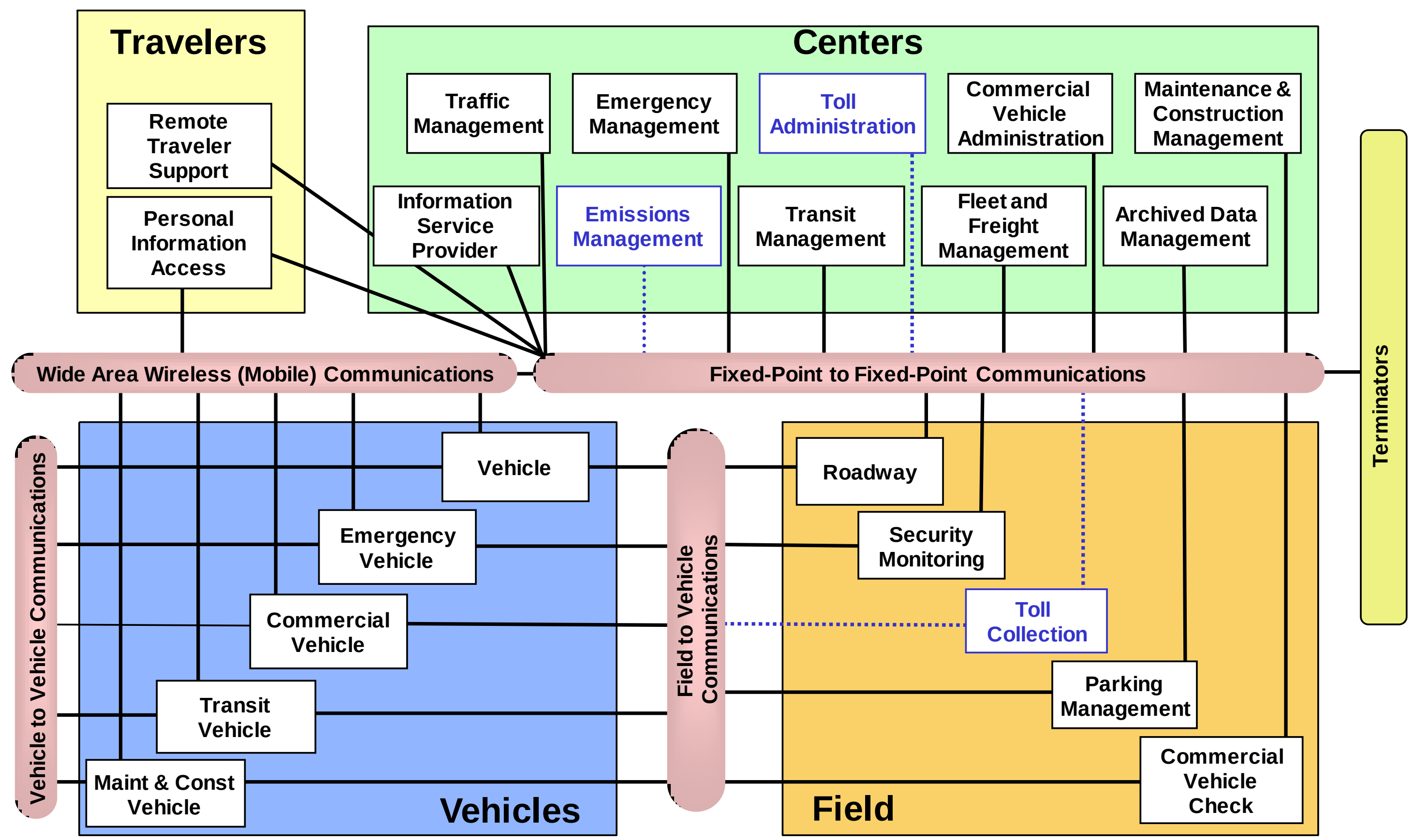
Remote Traveler Support
- CATA Kiosks
- Private Travelers Personal Computing Devices

Personal Information Access
- Private Traveler Personal Computing Device

Vehicle
- Private Vehicles

Emergency Vehicle
- City of Lansing Public Safety Vehicles
- Local Agency Public Safety Vehicles
- MDOT Freeway Service Patrol Vehicles
- MSP Vehicles

Commercial Vehicle
- Advanced Commercial Vehicles
- Commercial Vehicles



Transit Vehicle
- CATA Vehicles
- Clinton Transit Vehicles
- EATRAN Vehicles
- Regional Demand Response Transit Providers Vehicles

Maint. and Construction Vehicle
- City of Lansing Maintenance Vehicles
- County Road Commission Maintenance Vehicles
- Local Agency Maintenance Vehicles
- MDOT Maintenance Vehicles

Roadway
- AWOS Weather Stations
- City of Lansing CCTV Cameras
- City of Lansing ESS
- City of Lansing DMS
- City of Lansing Field Sensors
- City of Lansing Traffic Signals
- Contractor Smart Work Zone Equipment
- County CCTV Cameras
- County Traffic Signals
- DNRE Weather Stations
- East Lansing Traffic Signals

Roadway (cont.)
- ICRC Traffic Signals
- Local Agency CCTV Cameras
- Local Agency DMS
- Local Agency Field Sensors
- Local Agency Smart Work Zone Equipment
- Local Agency Traffic Signals
- MDOT Anti-Icing Equipment
- MDOT CCTV Cameras
- MDOT DMS
- MDOT ESS
- MDOT Field Sensors
- MDOT HOV Lanes

Roadway (cont.)
- MDOT Probe Data Sensors
- MDOT Roadside Equipment for AHS
- MDOT Roadside Intersection Collision Avoidance Equipment
- MDOT Roadside Signing Equipment
- MDOT Smart Work Zone Equipment
- MDOT Traffic Signals
- MSU CCTV Cameras
- MSU Field Sensors
- MSU Traffic Signals
- NWS Weather Stations
- Railroad Blockage Notification System

Archived Data User Systems
- Archived Data Users

Commercial Vehicle Driver
- Commercial Vehicle Driver

CVO Inspector
- MSP Motor Carrier Division Enforcement

Driver
- Driver

CVO Information Requestor
- County Commercial Vehicle Permitting System
- Local Agency Commercial Vehicle Permitting System

Enforcement Agency
- MSP Traffic Safety Division

Equipment Repair Facility
- Local Agency Equipment Repair
- MDOT Lansing Equipment Repair

Event Promoters
- Event Promoter

Financial Institution
- Financial Service Provider
- Service Agency

Media
- Local Print and Broadcast Media

Multimodal Transportation Service Provider
- Multimodal Transportation Service Provider

Other Emergency Management
- Ingham County 911 Joint Dispatch Center
- Local Agency 911 Dispatch
- MSP District 1 Dispatch - Lansing

Security Monitoring
- Capital Region International Airport Security Monitoring Field Equipment
- CATA CCTV Surveillance
- Clinton Transit CCTV Surveillance
- EATRAN CCTV Surveillance
- Regional Demand Response Transit Providers CCTV Surveillance

Other MCM
- MDOT Maintenance Garages

Other Parking
- Private Parking Operators

Other Traffic Management
- East Lansing
- ICRC TOC
- MDOT MITSC
- MDOT WMTOC
- MSU TOC

Other Vehicle
- Other Vehicles

Potential Obstacles
- Potential Obstacles

Roadway Environment
- Roadway Environment

Surface Transportation Weather Service
- Capital Region International Airport (LAN)

Traveler
- Traveler

Traveler Card
- CATA Electronic Fare Payment Card
- Clinton Transit Electronic Fare Payment Card
- EATRAN Electronic Fare Payment Card
- Regional Demand Response Transit Providers Electronic Fare Payment Card
- Traveler Card

Wayside Equipment
- Rail Operator Wayside Equipment

Weather Service
- National Weather Service

Parking Management
- Arena / Convention Center
- Capital Region International Airport Vehicle Parking Management System
- City of Lansing Vehicle Parking Management System
- East Lansing Vehicle Parking Management System
- MSU Vehicle Parking Management System

Commercial Vehicle Check
- MDOT Weigh-in-Motion

Figure 4 – TCRPC Regional System Interconnect Diagram

3.4 Market Packages

Upon completion of the system inventory, the next step in the update of the architecture was to identify the transportation services that are important to the TCRPC Region. In the National ITS Architecture, services are referred to as market packages. Market packages can include several stakeholders and elements that work together to provide a service in the Region. Examples of market packages from the National ITS Architecture include Network Surveillance, Traffic Information Dissemination, and Transit Vehicle Tracking. There are currently a total of 91 market packages identified in the National ITS Architecture Version 6.1. **Appendix A** provides a complete list and definitions for each of the National ITS Architecture market packages.

The market packages are grouped together into the following eight ITS service areas.

- Traffic Management
- Emergency Management
- Maintenance and Construction Management
- Public Transportation
- Commercial Vehicle Operations
- Traveler Information
- Archived Data Management
- Advanced Vehicle Safety Systems

3.4.1 Selection and Prioritization of Regional Market Packages

In the TCRPC Region, the National ITS Architecture market packages were reviewed by the stakeholders and selected based on the relevance of the service that the market package could provide to the Region. Fifty market packages were selected for implementation in the Region. They are identified in **Table 6**. The selected market packages then were prioritized based on need. The prioritization is not intended to represent the timeframe for funding of these deployments, but instead should capture the region's view of its low, medium, and high priority needs. The table organizes the market packages into service areas and priority groupings. These priorities can be affected by additional factors other than the identified level of the need such as existing infrastructure, dependence on other systems, and the market package's technological maturity.

After selecting the market packages that were applicable for the Region, stakeholders reviewed each market package and the elements that could be included to customize it for the Region. This customization is discussed further in the following section.

Table 6 – TCRPC Region Market Package Prioritization by Functional Area

High Priority Market Packages	Medium Priority Market Packages	Low Priority Market Packages	Non-selected Market Packages
Traffic Management			
ATMS01 Network Surveillance ATMS03 Surface Street Control ATMS06 Traffic Information Dissemination ATMS07 Regional Traffic Management ATMS08 Traffic Incident Management System	ATMS09 Traffic Decision Support and Demand Management ATMS10 Electronic Toll Collection	ATMS02 Probe Surveillance ATMS05 HOV Lane Management ATMS13 Standard Railroad Grade Crossing ATMS16 Parking Facility Management ATMS17 Regional Parking Management	*ATMS04 Freeway Control* *ATMS11 Emissions Monitoring and Management* *ATMS12 Roadside Lighting System Control* *ATMS14 Advance Railroad Grade Crossing* *ATMS15 Railroad Operations Coordination* *ATMS18 Reversible Lane Management* *ATMS19 Speed Monitoring* *ATMS20 Drawbridge Management* *ATMS21 Roadway Closure Management*
Emergency Management			
EM01 Emergency Call-Taking and Dispatch EM02 Emergency Routing EM04 Roadway Service Patrols EM06 Wide-Area Alert	EM03 Mayday and Alarm Support EM05 Transportation Infrastructure Protection		*EM07 Early Warning System* *EM08 Disaster Response and Recovery* *EM09 Evacuation and Reentry Management* *EM10 Disaster Traveler Information*
Maintenance and Construction Management			
MC01 Maintenance and Construction Vehicle and Equipment Tracking MC06 Winter Maintenance MC08 Work Zone Management	MC03 Road Weather Data Collection MC04 Weather Information Processing and Distribution MC07 Roadway Maintenance and Construction	MC02 Maintenance and Construction Vehicle Maintenance MC10 Maintenance and Construction Activity Coordination	*MC05 Roadway Automated Treatment* *MC09 Work Zone Safety Monitoring* *MC11 Environmental Probe Surveillance* *MC12 Infrastructure Monitoring*
Public Transportation			
APTS01 Transit Vehicle Tracking APTS02 Transit Fixed-Route Operations APTS03 Demand Response Transit Operations APTS05 Transit Security	APTS04 Transit Fare Collection Management APTS07 Multi-modal Coordination APTS08 Transit Traveler Information APTS09 Transit Signal Priority	APTS06 Transit Fleet Management APTS10 Transit Passenger Counting	

Table 6 – TCRPC Region Market Package Prioritization by Functional Area

High Priority Market Packages	Medium Priority Market Packages	Low Priority Market Packages	Non-selected Market Packages
Commercial Vehicle Operations			
CVO06 Weigh-in-Motion	CVO04 Administrative Processes	CVO10 HAZMAT Management	*CVO01 Fleet Administration* *CVO02 Freight Administration* *CVO03 Electronic Clearance* *CVO05 International Border Electronic Clearance* *CVO07 Roadside CVO Safety* *CVO08 On-board CVO and Freight Safety and Security* *CVO09 CVO Fleet Maintenance* *CVO11 Roadside HAZMAT Security Detection and Mitigation* *CVO12 CV Driver Security Authentication* *CVO13 Freight Assignment Tracking*
Traveler Information			
ATIS01 Broadcast Traveler Information ATIS06 Transportation Operations Data Sharing	ATIS02 Interactive Traveler Information ATIS05 ISP Based Trip Planning and Route Guidance	ATIS08 Dynamic Ridesharing ATIS09 In Vehicle Signing ATIS10 VII Traveler Information	*ATSI03 Autonomous Route Guidance* *ATIS04 Dynamic Route Guidance* *ATIS07 Yellow Pages and Reservations*
Archived Data Management			
	AD1 ITS Data Mart AD3 ITS Virtual Data Warehouse		*AD2 ITS Data Warehouse*
Advanced Vehicle Safety Systems			
	AVSS10 Intersection Collision Avoidance	AVSS11 Automated Highway System	*AVSS01 Vehicle Safety Monitoring* *AVSS02 Driver Safety Monitoring* *AVSS03 Longitudinal Safety Warning* *AVSS04 Lateral Safety Warning* *AVSS05 Intersection Safety Warning* *AVSS06 Pre-Crash Restraint Deployment* *AVSS07 Driver Visibility Improvement* *AVSS08 Advance Vehicle Longitudinal Control* *AVSS09 Advance Vehicle Lateral Control* *AVSS12 Cooperative Vehicle Safety Systems*

3.4.2 Customized Market Packages

The market packages in the National ITS Architecture were customized to reflect the unique systems, subsystems, and terminators in the TCRPC Region. Each market package is shown graphically with the market package name, agencies involved, and desired data flows included. Market packages represent a service that will be deployed as an integrated capability. **Figure 5** is an example of an ATMS market package for Surface Street Control that has been customized for the Region. This market package shows the two subsystems and the associated entities — Traffic Management (City of Lansing TOC) and Roadway (City of Lansing Traffic Signals and MDOT Traffic Signals) for Surface Street Control in the Region. Data flows between the subsystems indicate what information is being shared. The remainder of the market packages that were customized for the TCRPC Region are shown in **Appendix B**.

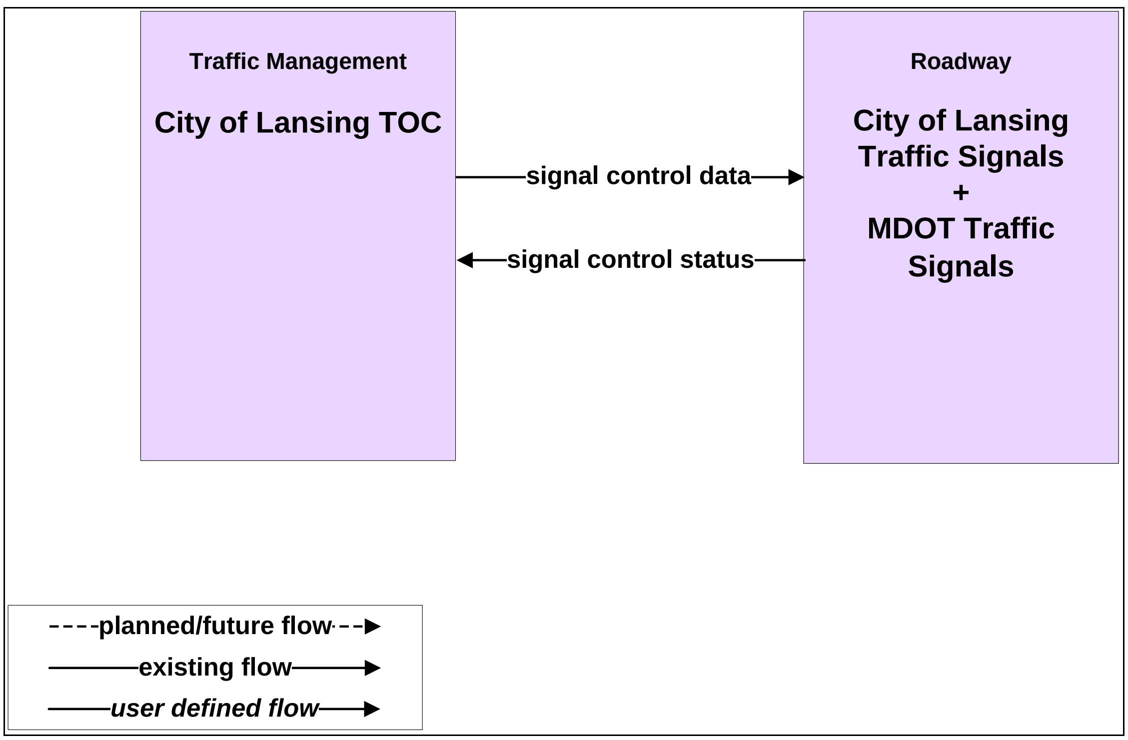


Figure 5 – Example Market Package Diagram: ATMS03 – Surface Street Control

3.4.3 Regional ITS Needs and Customized Market Packages

Stakeholder input during the Architecture Workshop provided the foundation for the market package customization process. The specific needs identified by the stakeholders are presented in **Table 7**. The table also communicates which market packages are identified to address the specific need. There were a number of institutional needs identified during the workshop that cannot be addressed with a technological solution, and therefore, are not included in **Table 7**. Those needs included issues related to funding, staffing levels, establishing performance measures, data sharing methods, and determining a process for defining future needs. These needs are driven more through policy or organizational decisions. While the architecture itself does not generate detailed solutions to these needs, it is important that they are clearly documented. As the region moves forward with each project, the original needs should remain a benchmark by which to evaluate the success of the resulting project.

Table 7 – Regional ITS Needs and Corresponding Market Packages

ITS Need	Market Package	
Traffic Management		
Need improved multi-modal coordination for road network conditions during winter weather conditions and special events (e.g. snow removal plan, MSU football games, etc.)	ATMS07 ATMS08 ATMS16 ATMS17 MC04	MC06 MC10 APTS07 ATIS06
Need real-time data collection	ATMS01 ATMS02 ATMS10 MC01	MC03 APT01 APTS10 CVO06
Need to provide real-time back-up when the system fails	ATMS07	APTS07
Need to provide wayfinding information (static/dynamic)	ATMS06 ATMS08	ATMS16 ATMS17
Public Transportation		
Need to integrate fare system with MSU	APTS04	
Need to incorporate bus priority lanes and/or signal priority	APTS02	APTS09
Traveler Information		
Need to provide real-time traveler information (transit, traffic, and weather)	ATIS01 ATIS02	ATMS06 APTS08
Archive Data Management		
Need to provide improved data management	AD1	AD3

3.5 Architecture Interfaces

While it is important to identify the various systems and stakeholders that are part of a regional ITS deployment, a primary purpose of the architecture is to identify the connectivity between transportation systems in the region. The system interconnect diagram shown previously in **Figure 4** showed the high-level relationships of the subsystems and terminators in the TCRPC Region. The customized market packages represent services that can be deployed as an integrated capability and the market package diagrams show the information flows between the subsystems and terminators that are most important to the operation of the market packages. How these systems interface with each other is an integral part of the overall regional ITS architecture.

3.5.1 Element Connections

There are a variety of different elements identified as part of the TCRPC Regional ITS Architecture. These elements include traffic management centers, transit vehicles, dispatch systems, emergency management agencies, media outlets, and others—essentially, all of the existing and planned physical components that contribute to the regional ITS. Interfaces have been identified for each element in the TCRPC Regional ITS Architecture and each element has been mapped to those other elements with which it must interface. The Turbo Architecture software can generate interconnect diagrams for each element in the Region that show which elements are connected to one another. **Figure 6** is an example of a context style interconnect diagram from the Turbo database output. A context diagram visually demonstrates all of the interactions between internal and external elements that interface with other elements within the system. This particular interconnect diagram is for the MDOT Mi Drive Web Site and it shows every element in the architecture that connects with the web site.

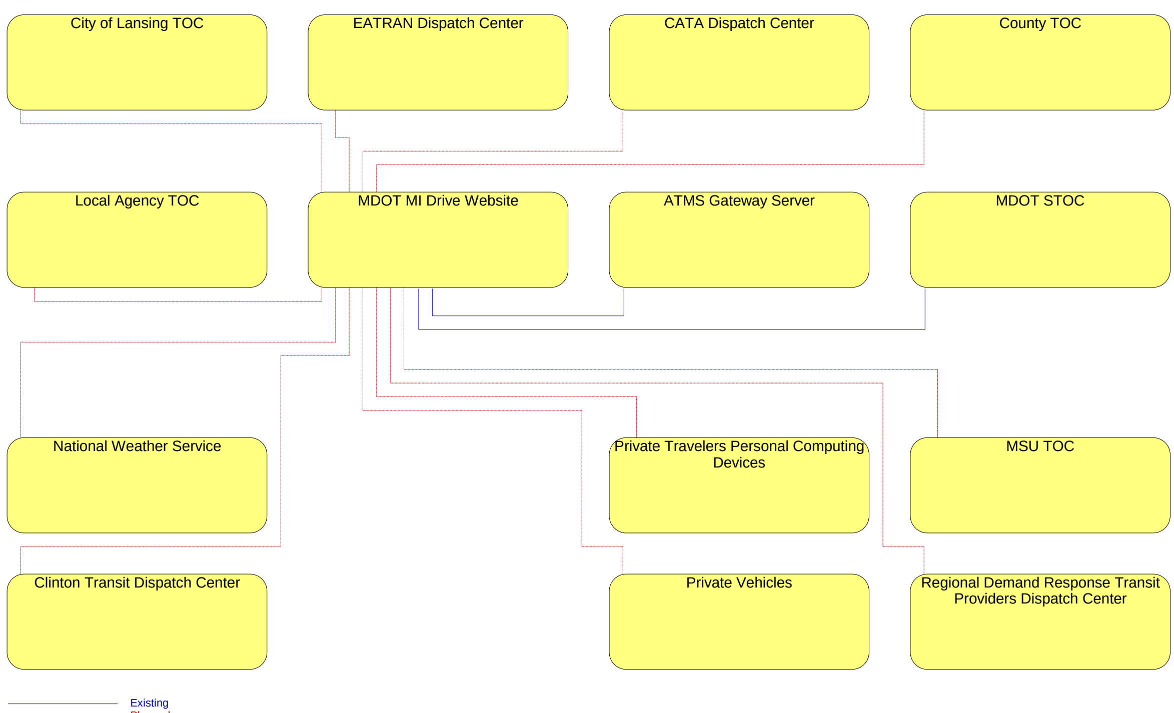


Figure 6 – Example Interconnect Diagram: MDOT Mi Drive

3.5.2 Data Flows between Elements

In the market package diagrams, flows between the subsystems and terminators define the specific information (data) that is exchanged between the elements and the direction of the exchange. The data flows could be requests for information, alerts and messages, status requests, broadcast advisories, event messages, confirmations, electronic credentials, and other key information requirements. Turbo Architecture can be used to output flow diagrams and can be filtered by market package for ease of interpretation; however, it is important to remember that within a Turbo generated diagram, custom data flows will not show up in diagrams filtered by market package. An example of a flow diagram for the TCRPC Region that has been filtered to show all of the Traffic Signals that connect to the City of Lansing TOC is shown in **Figure 7** (ATMS03 – Surface Street Control – City of Lansing).

The flow diagrams can vary greatly in complexity and, in turn, legibility. **Figure 8** shows a more complex flow diagram for ATMS06 – Traffic Information Dissemination – City of Lansing.

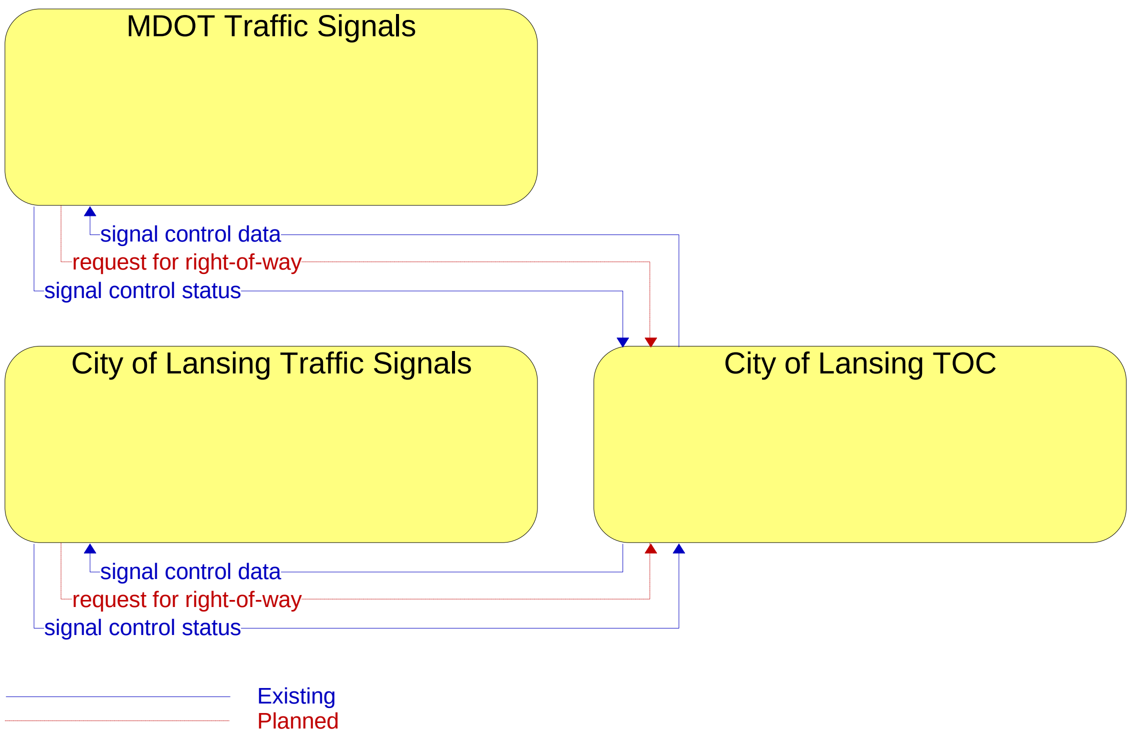


Figure 7 – Example Flow Diagram: ATMS03 – City of Lansing

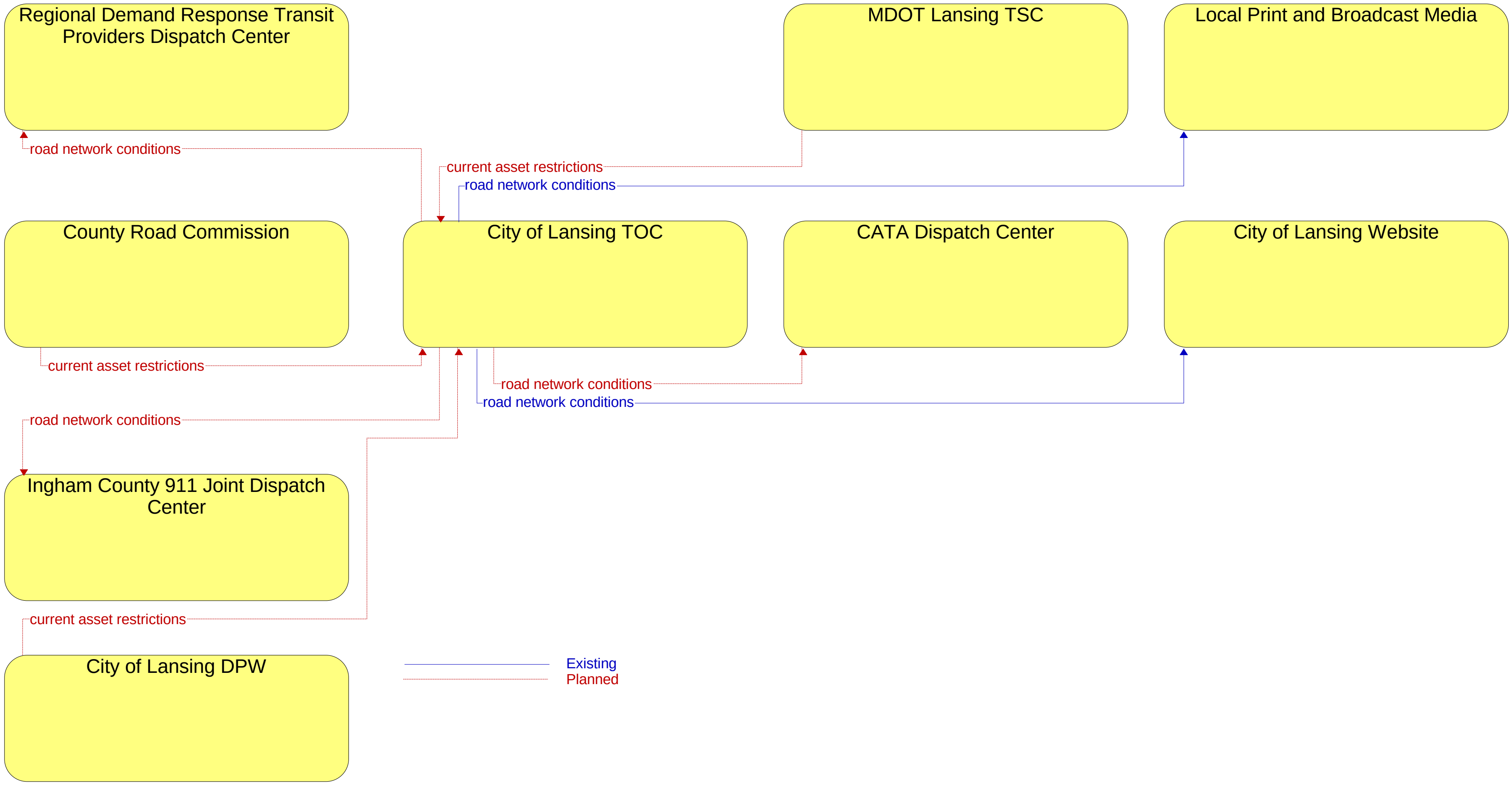


Figure 8 – Example Flow Diagram: ATMS06 – City of Lansing

In addition to market package style flow diagrams, Turbo Architecture has the ability to create flow diagrams that show only the connections between two or three specific elements or context diagrams that show all of the flows that involve an element. For example, **Figure 9** shows a simple flow between two elements, MDOT Mi Drive Website and MDOT STOC. While this is a portion of the planned interactions, it also could be useful to use a context diagram for the element, as shown in **Figure 10**, to view all of the other interactions with the MDOT STOC so that the project can be designed with the future in mind. However, context style flow diagrams can get very large and complicated for elements with a larger number of connections.

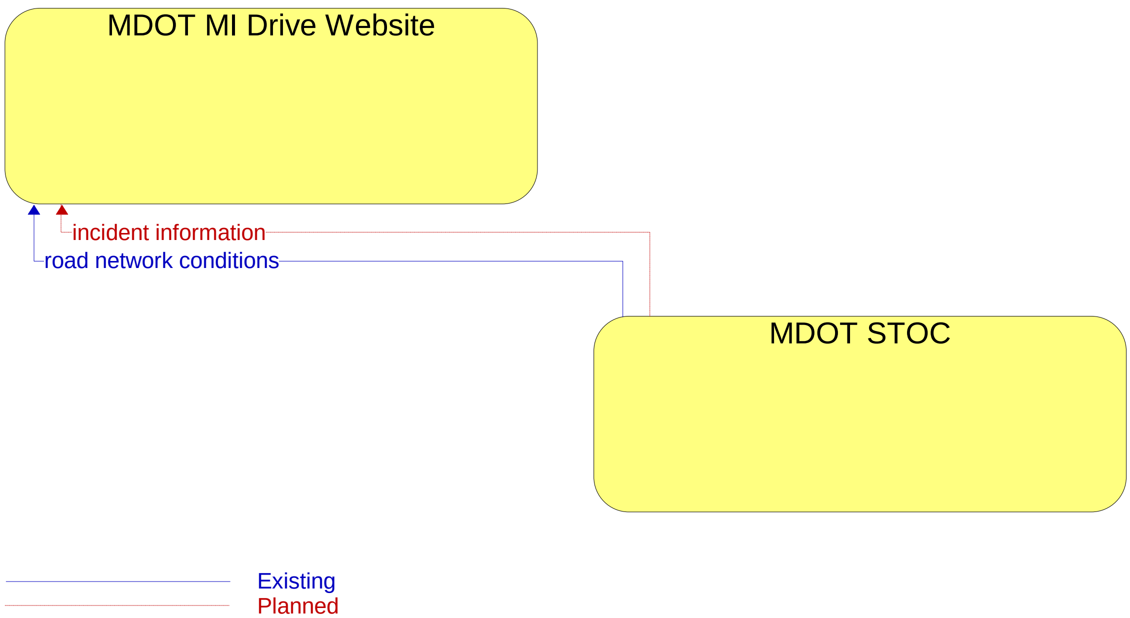


Figure 9 – Example Two Element Flow Diagram

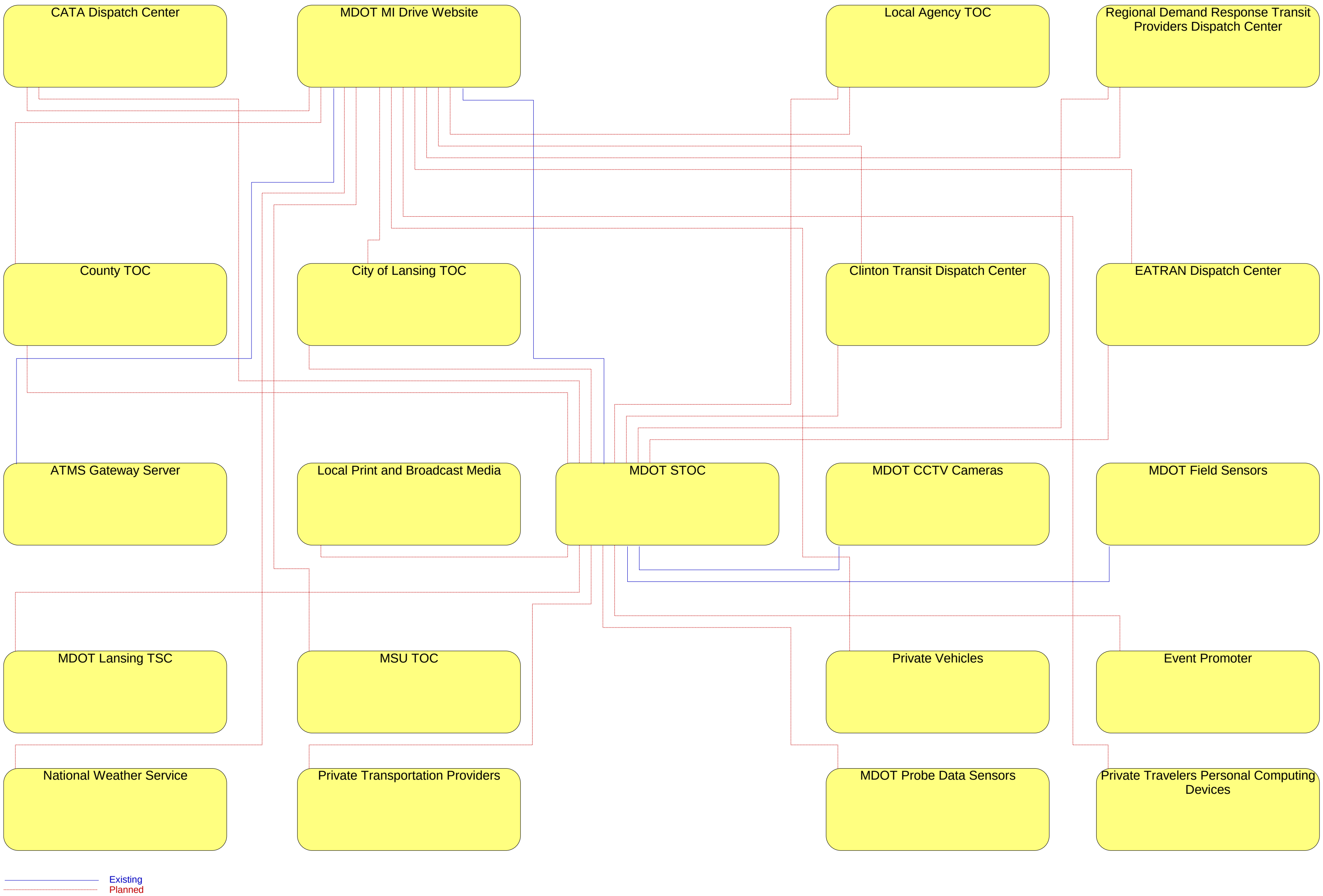


Figure 10 – Example Context Flow Diagram: MDOT STOC

4 Application of the Regional ITS Architecture

Detailed guidance for the stakeholders on the use and maintenance of the regional ITS architecture is provided in Section 5. This section presents some insight into some of the data that is available to support implementation of the services identified by the stakeholders. Some of the data that can be derived from the National ITS Architecture includes recommendations for standards and functional requirements for ITS elements. In addition, the operational concepts that define the roles and responsibilities of stakeholders were updated within the regional ITS architecture and document the stakeholders' concepts related to the services identified.

It is likely that the implementation of ITS in the TCRPC Region will require interagency agreements. Potential agreements are identified within this section based on the desired data flows identified in the regional ITS architecture. Additionally, an integration approach founded within the existing TCRPC planning processes is outlined within this section. The information provided in this section—combined with the application guidance in Section 5—should allow stakeholders to take projects identified in the architecture, document conformance to ensure the use of federal funds, and move forward with implementation of the identified ITS solutions.

4.1 Functional Requirements

Functions are a description of what the system has to do. In the National ITS Architecture, functions are defined at several different levels, ranging from general subsystem descriptions through somewhat more specific equipment package descriptions to process specifications that include substantial detail. Guidance from the USDOT on developing a regional ITS architecture recommends that each region determine their own level of detail for the functional requirements.

For the TCRPC Regional ITS Architecture, functional requirements have been identified at two levels. The customized market packages, discussed previously in Section 3.4.2, describe the services that ITS needs to provide in the Region and the architecture flows between the elements. These market packages and data flows describe what systems in the TCRPC Region have to do and the data that needs to be shared among elements.

At a more detailed level, functional requirements for the TCRPC Region are described in terms of functions that each element in the architecture performs or will perform in the future. **Appendix C** contains a table that summarizes the functions by element relative to the needs identified by the stakeholders. It is recommended that the development of detailed functional requirements, such as the "shall" statements included in a system's process specifications, be developed at the project level. These detailed "shall" statements identify all functions that a project or system needs to perform.

4.2 Standards

Standards are an important tool that will allow efficient implementation of the elements in the TCRPC Regional ITS Architecture over time. Standards facilitate deployment of interoperable systems at local, regional, and national levels without impeding innovation as technology advances, vendors change, and as new approaches evolve. The USDOT's ITS Joint Program Office is supporting Standards Development Organizations (SDOs) with an extensive, multi-year program of accelerated, consensus-based standards development to facilitate successful ITS deployment in the United States. **Table 8** identifies each of the ITS standards that apply to the TCRPC Regional ITS Architecture. These standards are based on the physical subsystem architecture flows previously identified in Section 3.5.2.

Table 8 – TCRPC Region Applicable ITS Standards

Standards Development Organization	Document ID	Title
AASHTO/ITE	ITE TMDD 2.1	Traffic Management Data Dictionary and Message Sets for External TMC Communication (TMDD and MS/ETMCC)
AASHTO/ITE/NEMA	NTCIP 1201	Global Object Definitions
	NTCIP 1202	Object Definitions for Actuated Traffic Signal Controller (ASC) Units
	NTCIP 1203	Object Definitions for Dynamic Message Signs (DMS)
	NTCIP 1204	Object Definitions for Environmental Sensor Stations (ESS)
	NTCIP 1205	Object Definitions for Closed Circuit Television (CCTV) Camera Control
	NTCIP 1206	Object Definitions for Data Collection and Monitoring (DCM) Devices
	NTCIP 1207	Object Definitions for Ramp Meter Control (RMC) Units
	NTCIP 1208	Object Definitions for Closed Circuit Television (CCTV) Switching
	NTCIP 1209	Data Element Definitions for Transportation Sensor Systems (TSS)
	NTCIP 1210	Field Management Stations (FMS) - Part 1: Object Definitions for Signal System Masters
	NTCIP 1211	Object Definitions for Signal Control and Prioritization (SCP)
	NTCIP 1214	Object Definitions for Conflict Monitor Units (CMU)
	NTCIP C2C	NTCIP Center-to-Center Standards Group
	NTCIP C2F	NTCIP Center-to-Field Standards Group
APTA	APTA TCIP-S-001 3.0.0	Standard for Transit Communications Interface Profiles
ASTM	ASTM E2468-05	Standard Practice for Metadata to Support Archived Data Management Systems
	ASTM E2665-08	Standard Specifications for Archiving ITS-Generated Traffic Monitoring Data
	DSRC 915MHz	Dedicated Short Range Communication at 915 MHz Standards Group
ASTM/IEEE/SAE	DSRC 5GHz	Dedicated Short Range Communication at 5.9 GHz Standards Group
IEEE	IEEE 1455-1999	Standard for Message Sets for Vehicle/Roadside Communications
	IEEE 1570-2002	Standard for the Interface Between the Rail Subsystem and the Highway Subsystem at a Highway Rail Intersection
	IEEE IM	Incident Management Standards Group
	IEEE P1609.11	Standard for Wireless Access in Vehicular Environments (WAVE) - Over-the-Air Data Exchange Protocol for Intelligent Transportation Systems (ITS)
SAE	ATIS General Use	Advanced Traveler Information Systems (ATIS) General Use Standards Group
	ATIS Low Bandwidth	Advanced Traveler Information Systems (ATIS) Bandwidth Limited Standards Group
	Mayday	On-board Vehicle Mayday Standards Group
	SAE J2395	ITS In-Vehicle Message Priority
	SAE J2396	Definitions and Experimental Measures Related to the Specification of Driver Visual Behavior Using Video Based Techniques
	SAE J2399	Adaptive Cruise Control (ACC) Operating Characteristics and User Interface
	SAE J2400	Human Factors in Forward Collision Warning Systems: Operating Characteristics and User Interface Requirements
	SAE J2735	Dedicated Short Range Communications (DSRC) Message Set Dictionary

4.3 Operational Concepts

An operational concept documents each stakeholder's current and future roles and responsibilities across a range of transportation services. Those services are grouped in the Operational Concepts section of Turbo Architecture. The services covered are:

- ***Surface Street Management*** – The development of signal systems that react to changing traffic conditions and provide coordinated intersection timing over a corridor, an area, or multiple jurisdictions.
- ***Freeway Management*** – The development of systems to monitor freeway (or tollway) traffic flow and roadway conditions, and to provide strategies such as ramp metering or lane access control to improve the flow of traffic on the freeway. Includes systems to provide information to travelers on the roadway.
- ***Incident Management*** – The development of systems to provide rapid and effective response to incidents. Includes systems to detect and verify incidents, along with coordinated agency response to the incidents.
- ***Emergency Management*** – The development of systems to provide emergency call taking, public safety dispatch, and emergency operations center operations.
- ***Maintenance and Construction Management*** – The development of systems to manage the maintenance of roadways in the Region, including winter weather maintenance operations. Includes the management of construction operations.
- ***Transit Services*** – The development of systems to more efficiently manage fleets of transit vehicles or transit rail. Includes systems to provide transit traveler information both before and during the trip.
- ***Parking Management*** – The development of systems to provide vehicle parking management for use by the driver, traveler, and other agencies.
- ***Commercial Vehicle Operations*** – The development of systems to facilitate the management of commercial vehicles (e.g., electronic clearance).
- ***Traveler Information*** – The development of systems to provide static and real-time transportation information to travelers.
- ***Archived Data Systems*** – The development of systems to collect transportation data for use in non-operational purposes (e.g., planning and research).

Table 9 identifies the roles and responsibilities of key stakeholders for a range of transportation services. The roles and responsibilities contained within the regional ITS architecture are focused at the regional level and do not include the level of detail associated with a project implementation. Once a project is identified for deployment, the stakeholders involved still must develop a more detailed Concept of Operations that is specific to technology and geographic boundaries of that deployment.

Table 9 – TCRPC Region Stakeholder Roles and Responsibilities

Transportation Service	Stakeholder	Roles/Responsibilities
Surface Street Management	City of Lansing	Operate and maintain traffic signal systems on City of Lansing routes as well as other local routes.
		Operate network surveillance equipment, including CCTV cameras and field sensors on local routes to facilitate traffic signal operations.
		Provide traffic information reports to regional information service providers.
		Provide traffic information to regional agencies, including transit, emergency management, maintenance and construction, and the media.
		Coordinate traffic information and control with City of Lansing TOC and MDOT STOC.
		Coordinate traffic information with other local agencies.
		Coordinate HRI signal adjustments with private rail operators.
		Provide traffic signal preemption for emergency vehicles.
	Local Agency	Operate traffic signal systems on local routes.
		Operate network surveillance equipment, including CCTV cameras and field sensors on local routes to facilitate traffic signal operations.
		Provide traffic information reports to regional information service providers.
		Provide traffic information to regional agencies, including transit, emergency management, maintenance and construction, and the media.
		Coordinate traffic information and control with MDOT STOC.
		Coordinate traffic information with other local agencies.
		Coordinate HRI signal adjustments with private rail operators.
		Provide traffic signal preemption for emergency vehicles.
	MDOT	Operate and maintain traffic signal systems on MDOT routes not managed by local agencies.
		Operate network surveillance equipment, including CCTV cameras and field sensors on MDOT routes not managed by local agencies to facilitate traffic signal operations.
		Provide traffic information to regional agencies, including transit, emergency management, maintenance and construction, and the media.
		Coordinate traffic information and control with local agency TOCs and other MDOT TMCs.
		Provide traffic signal preemption for emergency vehicles.
	MSU	Operate network surveillance equipment, including CCTV cameras and field sensors on local routes to facilitate traffic signal operations.
		Provide traffic information reports to regional information service providers.
		Provide traffic information to regional agencies, including transit, emergency management, maintenance and construction, and the media.
		Coordinate traffic information and control with MSU TOC.
		Coordinate traffic information with other local agencies.
Freeway Management	City of Lansing	Operate network surveillance equipment, including CCTV cameras and field sensors, as well as DMS, to convey traffic information on City routes.

Table 9 – TCRPC Region Stakeholder Roles and Responsibilities

Transportation Service	Stakeholder	Roles/Responsibilities
	City of Lansing (continued)	Provide traffic information to regional information service providers.
		Provide traffic information to regional transportation agencies and the general public through traffic information devices (primarily DMS).
		Coordinate traffic information and traffic control with City of Lansing and MDOT STOC.
	Local Agency	Operate network surveillance equipment, including CCTV cameras and field sensors, as well as DMS, to convey traffic information on county and local routes.
		Provide traffic information to regional information service providers.
		Provide traffic information to regional transportation agencies and the general public through traffic information devices (primarily DMS).
		Coordinate traffic information and traffic control with MDOT STOC.
	MDOT	Operate network surveillance equipment, including CCTV cameras and field sensors, as well as DMS, to convey traffic information on MDOT highway routes.
		Provide traffic information to regional information service providers.
		Provide traffic information to regional transportation agencies and the general public through traffic information devices (primarily DMS).
		Coordinate traffic information and traffic control with other MDOT TMCs.
		Provides video images to a large number of road and law enforcement agencies through secure web access.
	MSU	Operate network surveillance equipment, including CCTV cameras and field sensors to convey traffic information on local routes.
		Provide traffic information to regional information service providers.
		Provide traffic information to regional transportation agencies and the general public through traffic information devices (primarily website).
		Coordinate traffic information and traffic control with MSU TOC.
Incident Management (Traffic)	City of Lansing	Perform network surveillance for detection and verification of incidents on local routes.
		Provide incident information to regional emergency responders, including the MSP and MDOT.
		Coordinate maintenance resources for incident response with the MDOT Lansing TSC and local agencies.
	MDOT	Perform network surveillance for detection and verification of incidents on MDOT routes.
		Provide incident information to travelers via traffic information devices on highways (e.g. MDOT DMS).
		Responsible for coordination with other traffic operations centers and emergency management agencies for coordinated incident management.
		Coordinate maintenance resources for incident response with MDOT TSC Construction and Maintenance Operations.
		Responsible for the development, coordination, and execution of special traffic management strategies during an evacuation.
Incident Management (Emergency)	Local Agency	Receive emergency calls for incidents on local routes.
		Dispatch the local agency emergency vehicles to incidents, including the local agency police, fire, and EMS/rescue.

Table 9 – TCRPC Region Stakeholder Roles and Responsibilities

Transportation Service	Stakeholder	Roles/Responsibilities
Incident Management (Emergency) (continued)	Local Agency (continued)	Coordinate public safety resources for incident response on local routes.
		Coordinate incident response with other public safety agencies (fire, EMS, ambulance, etc.).
		Perform incident detection and verification on local routes and provide this information to the local agency TOC.
	MSP	Receive emergency calls for incidents on highways as well as local routes.
		Dispatch MSP vehicles for incidents on highways.
		Coordinate dispatch with local agency emergency vehicles to incidents, including the police, fire, and EMS/rescue.
		Coordinate incident response with other public safety agencies (local police, fire, EMS, sheriff) as well as MDOT.
		Coordinate public safety resources for incident response on highways as well as local routes.
		Perform incident detection and verification for the highways within the region and provide this information to traffic and other public safety agencies.
Emergency Management	City of Lansing	Participate in incident response, coordination, and reporting.
		Dispatch local agency fire/EMS/police vehicles.
		Receive AMBER Alert and other wide area alert information from MSP.
		Respond to transit emergencies/alarms on-board transit vehicles or at the transit facilities of local transit agencies.
	Local Agency (includes Ingham County 911 Joint Dispatch Center)	Participate in incident response, coordination, and reporting.
		Dispatch local agency fire/EMS/police vehicles.
		Receive AMBER Alert and other wide area alert information from MSP.
		Respond to transit emergencies/alarms on-board transit vehicles or at the transit facilities of local transit agencies.
	MSP	Participate in incident response, coordination, and reporting.
		Coordinate and dispatch MSP vehicles to incidents within their jurisdiction.
		Dispatch Local Agency emergency vehicles to incidents in areas where MSP has primary 911 call-taking responsibilities.
		Receive AMBER Alert and other wide area alert information from MSP Headquarters.
		Receive early warning information and threat information from the NWS and Local Agencies.
		Coordinate with regional emergency management providers, maintenance and construction providers, and regional traffic management providers for emergency plans and evacuation and reentry plans.

Table 9 – TCRPC Region Stakeholder Roles and Responsibilities

Transportation Service	Stakeholder	Roles/Responsibilities
Emergency Management (continued)	MSP (continued)	Provide regional traffic, transit, emergency management, and maintenance operations with disaster information to disseminate to the traveling public.
		Provide security monitoring of critical infrastructure for MDOT.
Maintenance and Construction	City of Lansing	Receive a request for maintenance resources for incident response from regional emergency management agencies.
		Coordinate maintenance resources for incidents with other regional maintenance providers.
		Receive vehicle location information from City of Lansing DPW vehicles.
		Dispatch City of Lansing maintenance vehicles.
		Provide maintenance of local routes and MDOT facilities (per contract), including pavement maintenance, construction activities, and winter maintenance.
	County Road Commission	Receive a request for maintenance resources for incident response from regional emergency management agencies.
		Coordinate maintenance resources for incidents with other regional maintenance providers.
		Receive vehicle location information from CRC maintenance vehicles.
		Dispatch CRC maintenance vehicles.
		Provide maintenance of local routes and MDOT facilities (per contract), including pavement maintenance, construction activities, and winter maintenance.
	Local Agency	Receive a request for maintenance resources for incident response from regional emergency management agencies.
		Coordinate maintenance resources for incidents with other regional maintenance providers.
		Receive vehicle location information from local agency DPW vehicles.
		Dispatch local agency maintenance vehicles.
		Provide maintenance of local routes and MDOT facilities (per contract), including pavement maintenance, construction activities, and winter maintenance.
	MDOT	Receive requests for maintenance resources for incident response from regional emergency management agencies.
		Support coordinated response to incidents.
		Responsible for the tracking and dispatch of MDOT maintenance vehicles.
		Collect road weather information with MDOT equipment and distribute it to regional traffic, maintenance, and transit agencies.
		Manage maintenance of state highways within the region, including pavement maintenance, winter maintenance, and construction activities.
		Manage work zones on all MDOT maintenance and construction activities, as well as monitor work zone safety with MDOT field devices and vehicles.
		Coordinate maintenance and construction activities with other regional maintenance and construction agencies.
		Distribute maintenance and construction plans and work zone information to regional information service providers, regional traffic operations, transit operations, emergency operations, rail operations, and the media.

Table 9 – TCRPC Region Stakeholder Roles and Responsibilities

Transportation Service	Stakeholder	Roles/Responsibilities
Maintenance and Construction (continued)	MDOT (continued)	Perform maintenance of ITS field equipment owned by MDOT.
		Coordinate snow removal resources with other regional maintenance providers.
	NOAA	Collect weather data from field devices.
Transit Services	Capital Area Transit Authority (CATA)	Provide fixed route bus service for CATA service area.
		Provide demand response transit service for the CATA service area.
		Track and evaluate schedule performance on all CATA fixed route and demand response vehicles.
		Provide transit schedule and fare information to private sector traveler information service providers via GTFS.
		Provide a demand response transit plan via the agency website.
		Provide transit passenger electronic fare payment on all CATA fixed route and demand response transit vehicles.
		Provide transit security on all transit vehicles and at transit terminals through silent alarms and surveillance systems.
		Provide automated transit maintenance scheduling through automated vehicle conditions reports on all CATA fixed route and demand response vehicles.
		Coordinate transit service with other regional transit providers as well as regional intermodal terminals and the regional airport.
		Provide transit traveler information to the agency website and local private sector traveler information services in addition to making it available on transit information kiosks.
		Collect and archive transit data from CATA transit operations.
	Clinton Transit	Provide fixed route bus service for Clinton Transit service area.
		Provide demand response transit service for the Clinton Transit service area.
		Track and evaluate schedule performance on all Clinton Transit fixed route and demand response vehicles.
		Provide transit schedule and fare information to the Clinton Transit website and private sector traveler information service providers.
		Provide a demand response transit plan via the agency website.
		Provide transit passenger electronic fare payment on all Clinton Transit fixed route and demand response transit vehicles.
		Provide transit security on all transit vehicles and at transit terminals through silent alarms and surveillance systems.
		Provide automated transit maintenance scheduling through automated vehicle conditions reports on all Clinton Transit fixed route and demand response vehicles.
		Coordinate transit service with other regional transit providers as well as regional intermodal terminals and the regional airport.
		Collect and archive transit data from Clinton Transit operations.
	EATRAN	Provide fixed route bus service for EATRAN service area.
		Provide demand response transit service for the EATRAN service area.
		Track and evaluate schedule performance on all EATRAN fixed route and demand response vehicles.

Table 9 – TCRPC Region Stakeholder Roles and Responsibilities

Transportation Service	Stakeholder	Roles/Responsibilities
Transit Services (continued)	EATRAN (continued)	Provide transit schedule and fare information to the EATRAN website and private sector traveler information service providers.
		Provide a demand response transit plan via the agency website.
		Provide transit passenger electronic fare payment on all EATRAN fixed route and demand response transit vehicles.
		Provide transit security on all transit vehicles and at transit terminals through silent alarms and surveillance systems.
		Provide automated transit maintenance scheduling through automated vehicle conditions reports on all EATRAN fixed route and demand response vehicles.
		Coordinate transit service with other regional transit providers as well as regional intermodal terminals and the regional airport.
		Collect and archive transit data from EATRAN operations.
	Regional Demand Response Transit Providers	Provide demand response transit service for the Regional Demand Response Transit Providers.
		Track and evaluate schedule performance on all Regional Demand Response Transit Providers' transit vehicles.
		Provide transit schedule and fare information to the Regional Demand Response Transit Providers website and private sector traveler information service providers.
		Provide transit passenger electronic fare payment on all Regional Demand Response Transit Providers' transit vehicles.
		Provide transit security on all transit vehicles and at transit terminals through silent alarms and surveillance systems.
		Provide automated transit maintenance scheduling through automated vehicle conditions reports on all Regional Demand Response Transit Providers' demand response vehicles.
		Collect and archive transit data from Regional Demand Response Transit Providers transit operations.
Parking Management	Capital Region Airport Authority	Manage airport DMS to display messages to travelers (number of spaces, entrance location, current charges, etc.).
		Maintain parking lot information (static and dynamic).
	City of Lansing	Manage City of Lansing DMS to display messages to travelers (number of spaces, entrance location, current charges, etc.).
		Maintain parking lot information (static and dynamic).
	East Lansing	Manage City of East Lansing DMS to display messages to travelers (number of spaces, entrance location, current charges, etc.).
		Maintain parking lot information (static and dynamic).
	Other Agencies	Manage local DMS to display messages to travelers (number of spaces, entrance location, current charges, etc.).
		Maintain parking lot information (static and dynamic).
Commercial Vehicle Operations	MDOT	Provide credential information, safety status information, driver records, and citations to roadside check facilities.
		Provide automated weigh-in-motion inspections for private fleet operations.
		Provide data concerning commercial vehicle safety and credentials into profiles.
Traveler Information	City of Lansing	Collect traffic information (road network conditions), work zone information, travel times, and weather information.

Table 9 – TCRPC Region Stakeholder Roles and Responsibilities

Transportation Service	Stakeholder	Roles/Responsibilities
Traveler Information (continued)	City of Lansing (continued)	Coordinate and share traveler information with all other traveler information providers within the region.
	Local Agency	Collect traffic information (road network conditions), work zone information, travel times, and weather information.
		Coordinate and share traveler information with all other traveler information providers within the region.
	MDOT	Collection, processing, storage, and broadcast dissemination of traffic, transit, maintenance and construction, and weather information to travelers via MI Drive website.
		Provide traveler information to private travelers through in vehicle and personal computing devices upon request.
		Provide traveler information to the media.
Archived Data Management	MDOT	Collect and archive asset status information from all MDOT maintenance offices and MDOT asset management systems.
		Collect and archive traffic information from regional traffic management providers and centers, emergency information from MSP and Local Agency Police, and transit information from regional transit agencies for planning purposes.
		Coordinate with MDOT Transportation Planning Division.
	TCRPC	Collect and archive traffic information from regional traffic management providers and centers, emergency information from MSP and Local Agency Police, and transit information from regional transit agencies for planning purposes.
		Coordinate with MDOT Transportation Planning Division.
		Collect and archive emergency and incident information from MSP and the region's emergency responders.

4.4 Potential Agreements

The TCRPC Regional ITS Architecture has identified many agency interfaces, information exchanges, and integration strategies that would be needed to provide the ITS services and systems identified by the stakeholders in the Region. Interfaces and data flows among public and private entities in the Region will require agreements among agencies that establish parameters for sharing agency information to support traffic management, incident management, provide traveler information, and perform other functions identified in the regional ITS architecture.

Integrating systems from two or more agencies combined with the anticipated level of information exchange identified in the architecture will require the implementation of ITS technologies along with subsequent formal agreements between agencies. These agreements, while perhaps not requiring a financial commitment from agencies in the Region, should outline specific roles, responsibilities, data exchanges, levels of authority, and other facets of regional operations. Some agreements also will outline specific funding responsibilities, where appropriate and applicable.

Agreements should avoid being specific with regards to technology when possible. Technology is likely to change rapidly and changes to technology could require an update of the agreement if the agreement was not technology neutral. The focus of the agreement should be on the responsibilities of the agencies and the high level information that needs to be exchanged. Depending on the type of agreement being used, agencies should be prepared for the process to complete an agreement to take several months or years. Agencies must first reach consensus on what should be in an agreement and then proceed through the approval process. The approval process for formal agreements varies by agency and can often be quite lengthy, so it is recommended that agencies plan ahead to ensure that the agreement does not delay the project.

When implementing an agreement for ITS, it is recommended that, as a first step, any existing agreements are reviewed to determine whether they can be amended or modified to include the additional requirements that will come with deploying a system. If there are no existing agreements that can be modified or used for ITS implementation, then a new agreement will need to be developed. The formality and type of agreement used is a key consideration. If the arrangement will be in effect for an extended duration or involve any sort of long term maintenance, then written agreements should be used. Often during long term operations, staff may change and a verbal agreement between agency representatives may be forgotten by new staff.

Common agreement types and potential applications include:

- **Handshake Agreement:** Handshake agreements are often used in the early stage of a project. This type of informal agreement depends very much on relationships between agencies and may not be appropriate for long term operations where staff is likely to change.

- **Memorandum of Understanding (MOU):** A MOU demonstrates general consensus or willingness to participate as part of a particular project, but is not typically very detailed.

- **Interagency and Intergovernmental Agreements:** These agreements between public agencies can be used for operation, maintenance, or funding of its projects and systems. They can include documentation on the responsibility of each agency, functions they will provide, and liability.

- **Funding Agreements:** Funding agreements document the funding arrangements for ITS projects. At a minimum, funding agreements include a detailed scope, services to be performed, and a detailed project budget.

- **Master Agreements:** Master agreements include standard contract language for an agency and serve as the main agreement between two entities which guides all business transactions. Use of a master agreement can allow an agency to do business with another agency or private entity without having to go through the often lengthy development of a formal agreement each time.

Table 10 provides a list of existing and potential agreements for the TCRPC Region based on the interfaces identified in the regional ITS architecture. It is important to note that as ITS services and systems are implemented in the Region, part of the planning and review process for those projects should include a review of potential agreements that would be needed for implementation or operations.

Table 10 – TCRPC Region Potential Agreements

Status	Agreement and Agencies	Agreement Description
Future	**Joint Operations/Shared Control Agreements (Public-Public or Public-Private)**	These agreements would allow joint operations or control of certain systems and equipment. The agreement should define such items as hours of operation and time of day/day of week when shared control would take effect, circumstances, or incidents when shared control would take effect, notification procedures between the agencies agreeing to share control arrangements, overriding capabilities of owning agency, etc. Private agencies, such as information service providers that provide traffic reports, could also be part of this agreement.
Future	**Data Sharing and Usage (Public-Public)**	These agreements would define the parameters, guidelines, and policies for inter- and intra-agency ITS data sharing. This data sharing would support regional activities related to traffic management, incident management, traveler information, and other functions. The terms of this agreement should generally address such items as types of data and information to be shared, how the information will be used (traffic incident information to be shared, displayed on web site for travel information, distributed to private media, etc.), and parameters for data format, quality, and security.
Future	**Data Sharing and Usage (Public-Private)**	These agreements would define the parameters, guidelines, and policies for private sector (such as the media or other information service providers) use of ITS data. This type of agreement is recommended to define terms of use for broadcasting public-agency information regarding traffic conditions, closures, restrictions, as well as video images. Agreements also can include requirements for the media to 'source' the information (i.e., using the providing agency's logo on all video images broadcast.
Future	**Mutual Aid Agreements (Public-Public)**	Mutual aid agreements often exist as either formal or informal arrangements. They are a routine practice among many public safety and emergency services agencies. Formal mutual aid agreements will become more important as agencies integrate systems and capabilities, particularly automated dispatch and notification. Formalized agreements should be considered as ITS or other electronic data sharing systems are implemented in the Region.

Table 11 presents a summary of existing and proposed agreements for the TCRPC region. These agreements either exist and are maintained by the partnering agencies or are identified as needed

agreements based on conversations during the architecture and deployment plan workshops. Proposed agreements should be developed through the participation of the partnering agencies to ensure consistency of operations as personnel turn-over occurs within each agency.

Table 11 – Existing and Proposed Agreements

Status	Agreement Name	Lead Agency	Partnering Agencies
Existing*	Traffic Signal Operations	City of Lansing	MDOT
Existing*	Ingham County 911 Joint Dispatch Center	City of Lansing	East Lansing, Meridian, Ingham County
Future	Maintenance and Construction	MDOT	Clinton County Road Commission
Existing*	Access to Camera Images	MDOT STOC	MSP, City of Lansing
Future	Sharing of Road Weather Data	MDOT	NWS, Clinton County Road Commission
Existing*	Video Surveillance	CATA	Lansing Police Department
Existing*	Emergency Management (plans)	CATA	MDOT, Ingham County, Eaton County, Clinton County, TCRPC, MSU
Future	Sharing Transit Information (GTFS)	CATA	MDOT, City of Lansing, Ingham County, Clinton County, Eaton County, TCRPC, other municipalities
Existing*	Interagency agreements	CATA	TCRPC
Future	AVL	CATA	Clinton Transit, EATRAN

**Note: These relationships have been identified in the region.*

4.5 Phases of Implementation

The TCRPC Regional ITS Architecture will be implemented over time through a series of projects led by both public sector and private sector agencies. Key foundational systems will need to be implemented to support other systems that have been identified in the regional ITS architecture. The deployment of all of the systems required to achieve the final regional ITS architecture build out will occur over many years.

A sequence of projects and their respective time frames are identified in the TCRPC Regional ITS Deployment Plan. These projects will be sequenced over a 10- to 15-year period, with projects identified for deployment in the short term (0 to 3 years), medium term (4 to 8 years), and long term (greater than 8 years).

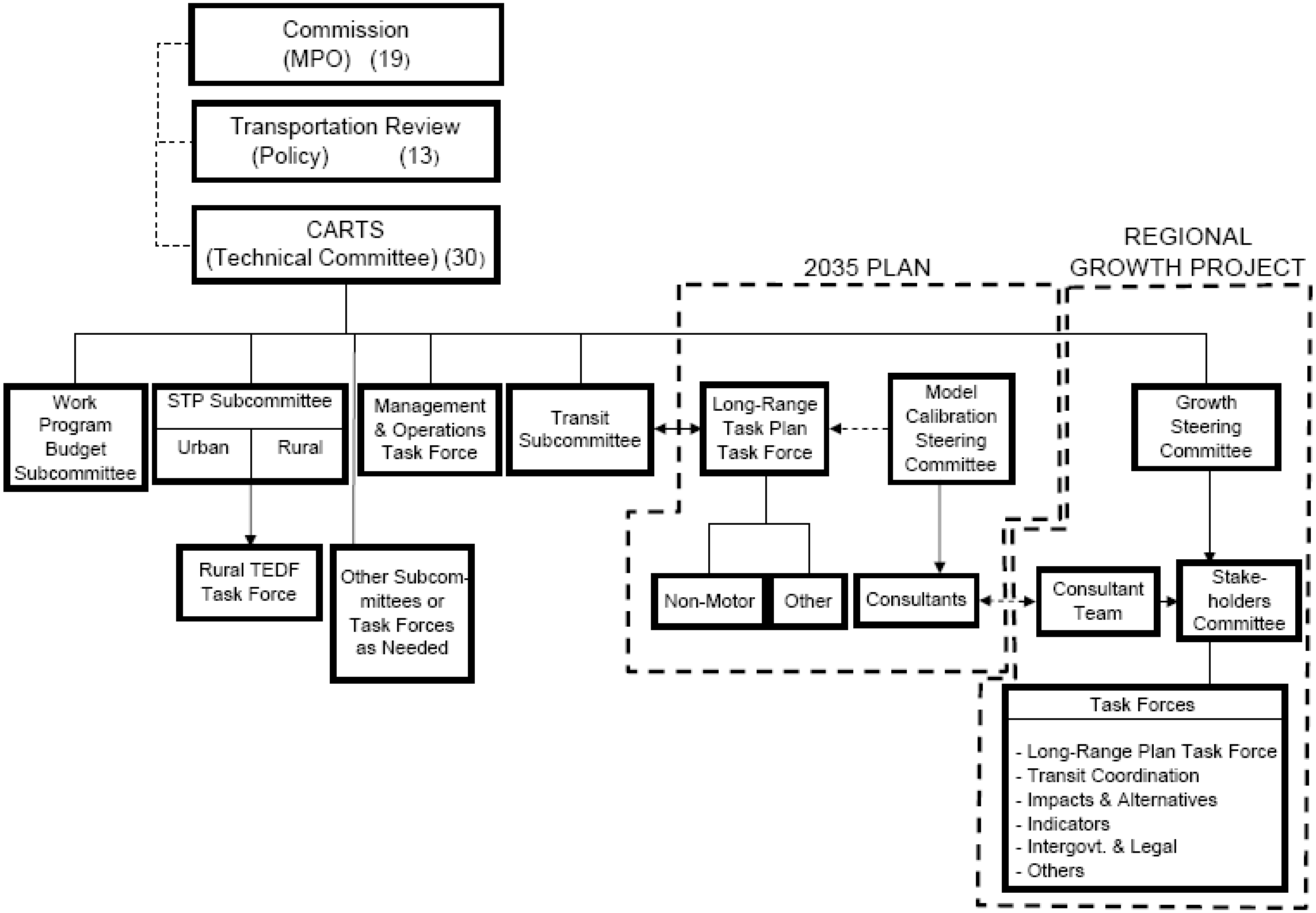
Some of the key market package areas that provide the functions for the foundational systems in the TCRPC Region are listed below. Projects associated with these and other market packages identified for the Region have been included in the TCRPC Regional ITS Deployment Plan.

- Network Surveillance
- Emergency Management
- Maintenance and Construction Vehicle Tracking
- Weather Information Processing and Distribution
- Surface Street Control
- ISP Based Trip Planning & Route Guidance
- Transit Fixed Route Operations

4.6 Incorporation into the Regional Planning Process

As an MPO, TCRPC is responsible for coordinating transportation planning and programming activities among the variety of transportation agencies and stakeholders involved in the Tri-county metropolitan area. To date, TCRPC has been active in the development and administration of the region's ITS Architecture and has been involved in ITS on a variety of levels. The TCRPC has established the Management and Operations Task Force to oversee the identification, selection, and implementation of ITS solutions in the region. This Task Force reviews project requests to ensure consistency with the TCRPC Regional ITS Architecture. **Figure 11** shows the task force within the overall TCRPC Committee structure.

The TCRPC adopted the Regional 2035 Transportation Plan on January 21, 2010. This plan has clearly outlined the process of strategic planning and implementation of ITS in the Tri-county region. In lieu of creating multiple locations that document the ITS Planning Process in place for the Tri-county stakeholders, the regional ITS architecture references Chapter 13 of the Plan. Beginning with page 13-219, the Plan provides a very in-depth overview of the process required to fund and implement a project in the Region.



Source: TCRPC Regional 2035 Transportation Plan, adopted January 21, 2010

Figure 11 – TCRPC Committee Structure

5 Use and Maintenance Plan for the Regional ITS Architecture

The update of the TCRPC Regional ITS Architecture addresses the Region's vision for ITS implementation at the time the document was completed. As the Region grows, needs will change, and, as technology progresses, new ITS opportunities will arise. Shifts in regional needs and focus, as well as changes in the National ITS Architecture, will necessitate that the regional ITS architecture be maintained and updated to remain a useful resource for the Region.

This section provides guidance for maintaining and using the regional ITS architecture for implementing projects; where appropriate, this section references the ITS deployment plan. Further detailed guidance on the maintenance of the ITS deployment plan is presented within that document. It is recommended that a comprehensive update to the regional ITS architecture occur concurrently with an update of the ITS deployment plan since the success of both of these documents relies on stakeholder involvement and regional ITS goals. However, it is important to note, that even though an ITS deployment plan provides great value to the ITS investment in the Region, only the ITS architecture is a federal requirement.

Updates to the TCRPC Regional ITS Architecture will occur on a regular basis as described in **Section 5.1** to maintain the regional ITS architecture as a useful planning tool. Between complete plan updates, smaller modifications likely will be required to accommodate ITS projects in the Region. **Section 5.2** provides a step-by-step process to guide stakeholders in determining whether or not a project requires regional ITS architecture modifications.

5.1 Maintenance Process

MDOT's ITS Program Office will work closely with TCRPC to maintain the TCRPC Regional ITS Architecture. Maintenance includes the oversight and management of modifications submitted by stakeholders as well as complete updates of the regional ITS architecture. Documenting modifications occurring between major updates will improve their efficiency. As element names or flows change due to the implementation of projects, simply documenting these impacts to the regional ITS architecture addresses the federal requirement for maintenance. It is recommended that complete updates to the regional ITS architecture occur in tandem with a complete update to the ITS Deployment Plan to capture the potential influences newly identified projects could introduce to the architecture. Additionally, concurrent updates of both documents help stakeholders to appropriately capture projects based on regional needs. **Table 12** summarizes the maintenance process for both the architecture and deployment plan.

Complete updates to the regional ITS architecture will occur approximately every five to seven years and will be led by the MDOT ITS Program Office with support from TCRPC and other regional stakeholders. The entire stakeholder group that was engaged to update this revision of the regional ITS architecture should be reconvened for the complete updates.

Table 12 – Regional ITS Architecture and Deployment Plan Maintenance Summary

Maintenance Details	Regional ITS Architecture		Regional ITS Deployment Plan	
	Modification	**Complete Update**	**Modification**	**Complete Update**
Timeframe for Updates	As needed	Every 5-7 years	As needed	Every 5-7 years
Scope of Update	Update market packages to satisfy architecture conformance requirements of projects or to document other changes that impact the Regional ITS Architecture	Entire Regional ITS Architecture	Update project status and add or remove projects as needed	Entire Regional ITS Deployment Plan
Lead Agency	MDOT ITS Program Office/TCRPC		MDOT ITS Program Office/TCRPC	
Participants	Stakeholders impacted by market package modifications	Entire stakeholder group	Stakeholders impacted by project modifications	Entire stakeholder group
Results	Market package or other change(s) documented for next complete update	Updated Regional ITS Architecture document, Appendices, and Turbo Architecture database	Updated project tables	Updated Regional ITS Deployment Plan document

** Transit related projects will be supported by MDOT's Bureau of Passenger Transportation*

5.1.1 ITS Architecture Changes between Scheduled Updates

For situations where a change is required, a Regional ITS Architecture Conformance and Maintenance Documentation Form was developed and is included in **Appendix E**. This form should be completed and submitted to the MDOT ITS Program Office and to the TCRPC Office whenever a change to the regional ITS architecture is proposed.

Noted on the form are additional agencies that need to be copied in specific instances. If the project is located within the TCRPC region, then TCRPC also should receive a copy of the form. If the project has a transit related component, MDOT's Bureau of Passenger Transportation also should be copied.

The Regional ITS Architecture Conformance and Maintenance Documentation Form identifies three levels of modifications.

- Level 1 – Basic changes that do not affect the structure of the architecture.

Examples include: Changes to the name or status of a stakeholder or element, or the status of a data flow.

- Level 2 – Structural changes that impact only one agency.

Examples include: Addition of a new market package or modifications to an existing market package that affects only one agency.

- Level 3 – Structural changes that have the potential to impact multiple agencies.

  Examples include: New market package additions or existing market package modifications that involve multiple agencies or incorporate a new stakeholder into the architecture.

MDOT's ITS Program Office and TCRPC will review and accept the proposed changes. All changes will be documented for incorporation during the next complete regional ITS architecture update performed by MDOT's ITS Program Office. **Figure 12** illustrates this process.

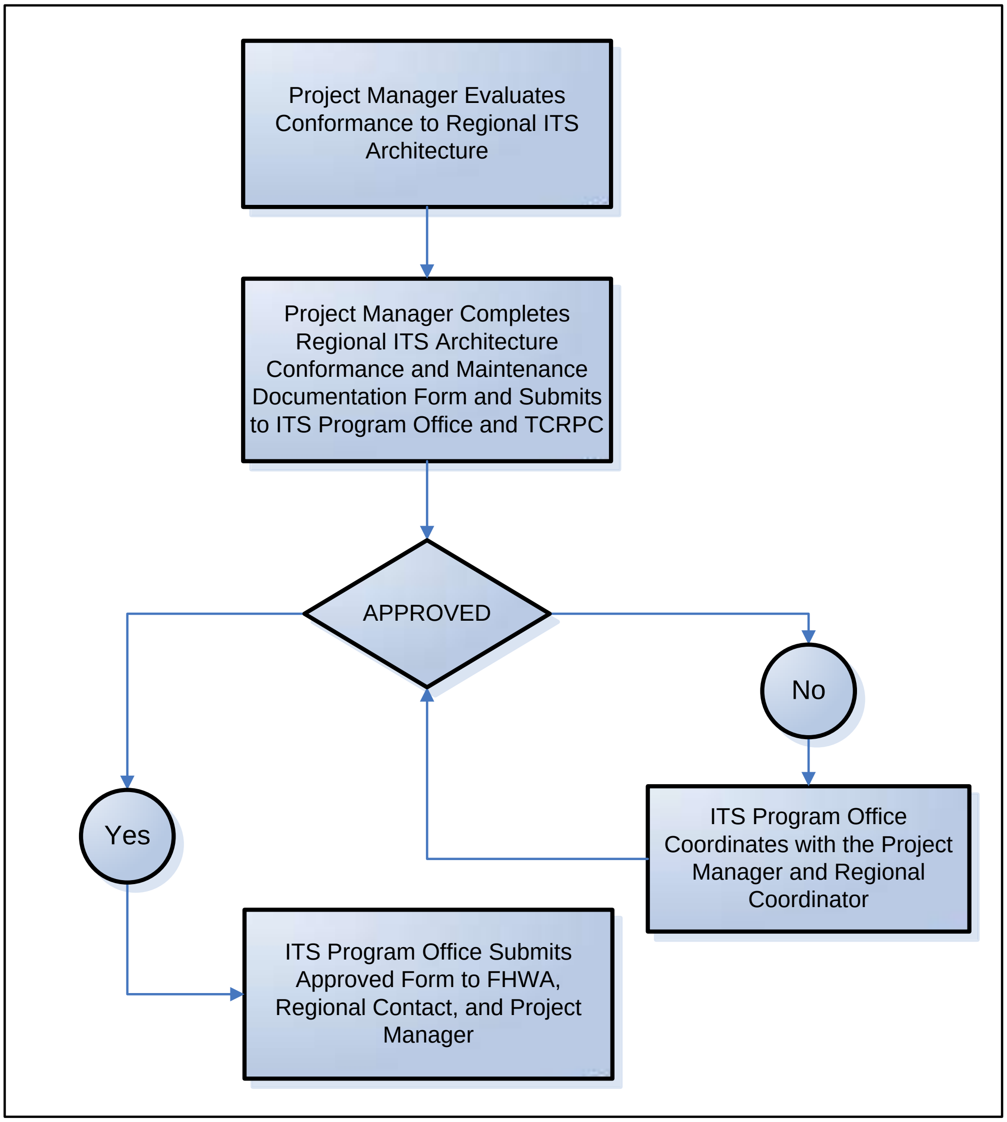


Figure 12 – Process for Documenting Architecture Performance

5.2 Process for Determining and Documenting Architecture Conformity

The life of an ITS project includes numerous steps from concept to reality. As the project moves from an idea to implementation following an MDOT process, it parallels the federally required systems engineering (SE) process. One of the first steps within the SE process is aligning the project with the architecture and identifying regional ITS architecture components. As **Figure 13** shows, these steps occur very early for both the MDOT and SE processes.

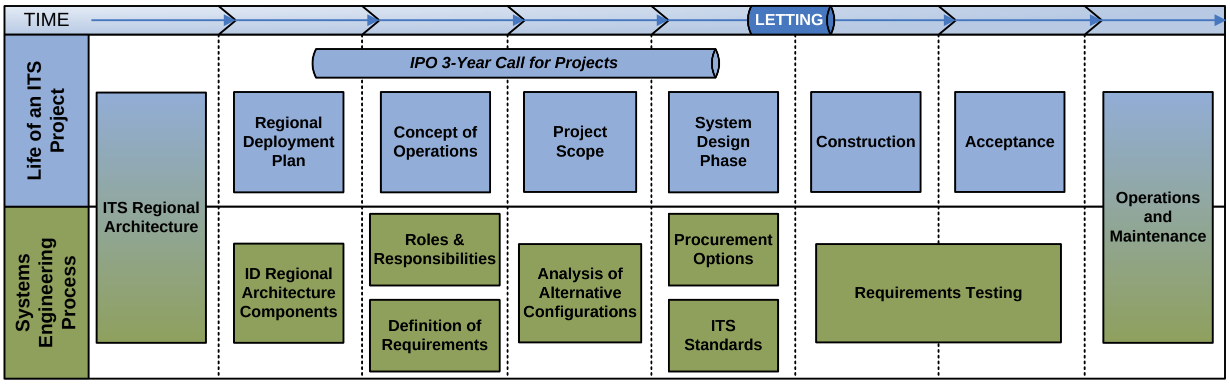


Figure 13 – Life of an ITS Project (excerpt from the Basis of Design Document (BODD)

This section provides stakeholders with step-by-step guidance through the development of a project to ensure it is in conformance with the regional ITS architecture. The stakeholders should work with the MDOT IPO, TCRPC, and any additional agencies involved in the project or its update.

Figure 14 illustrates steps the stakeholders will need to follow to determine the regional ITS architecture's conformity. For stakeholders that are less familiar with documenting the conformity, a checklist has been developed for guidance. The content for the Regional ITS Architecture Conformance and Maintenance Documentation Form can come directly from the checklist information. Both the checklist and form can be found in Appendix E.

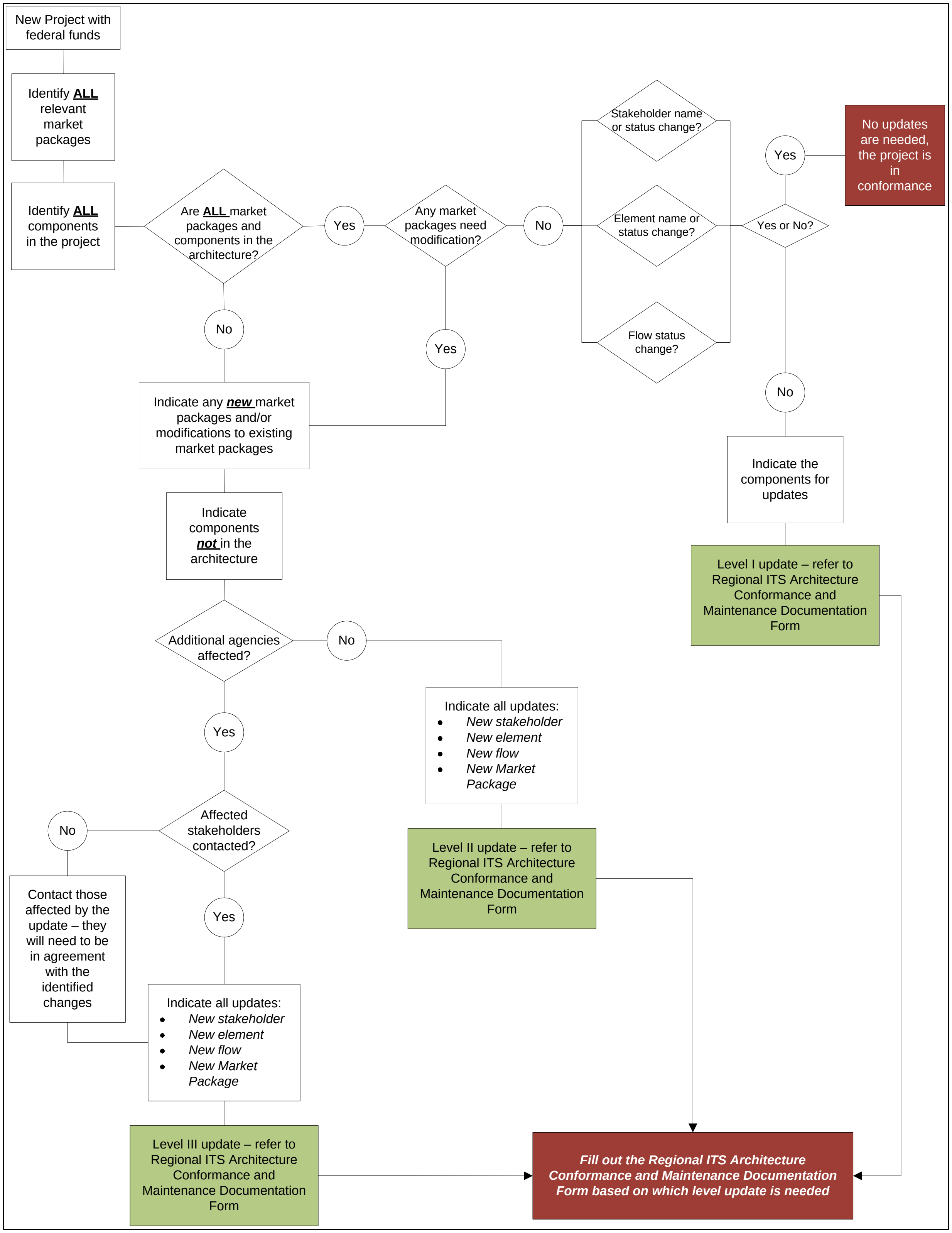


Figure 14 – Steps to Determine Architecture Conformity

The checklist is divided into four main categories that guide the stakeholder through evaluating and documenting conformance.

- Identify **ALL** market packages (MPs) and ITS components relevant to the project.
- Verify that **ALL** MPs and ITS components are contained within the architecture.
- Identify modifications or additions related to MPs or ITS components.
- Document the necessary changes to the regional ITS architecture to ensure conformance.

The checklist provides a set of questions and directions that should help the stakeholders establish the information needed to complete the Regional ITS Architecture Conformance and Maintenance Documentation Form. The following section provides additional detailed guidance on where to find the information needed for each step of the process.

Identify **ALL** relevant market packages and ITS components in the project

Referencing Appendix A and Appendix B of the regional ITS architecture document, the stakeholder will need to identify all market packages that are relevant to their project, regardless if they are existing or new. Secondly, the stakeholder should identify all of the components within the project, including the stakeholders, elements, and the flows between elements. Background regarding the elements in the regional ITS architecture is presented in Section 3.3. Table 4 and Table 5 provide information for reference regarding the stakeholders. These tables include all existing components and their status presented in the regional ITS architecture. They also demonstrate the information needed for any newly identified components.

Verify Whether **ALL** MPs and ITS components are in the Architecture

Once the stakeholder has identified all MPs and ITS components, they then will need to verify whether or not they are included in the regional ITS architecture. The verification can be done by comparing the result either with Turbo or by using Table 4, Table 5, or Table 6. The stakeholder should mark those that are not included in the architecture on the checklist for Question 1.

Identify Modifications/Updates to Market Packages or ITS Components

As a next step, the stakeholder should identify whether or not any of the MPs or ITS components require modification from their current form in the regional ITS architecture. A modification would include a name change, a flow change or a status change (from planned to existing). Table 5 provides the existing components, descriptions, and status. Projects sometimes introduce new elements or flows between elements or even new market packages within the architecture. The stakeholder can reference Appendix B while developing new MPs, elements, and/or flows.

Document Required Changes

If any changes are needed to accommodate the project under review, these changes need to be submitted using the Regional ITS Architecture Conformance and Maintenance Documentation Form, found in Appendix E. The checklist provides guidance on assembling information required for the form. Once the documentation of architecture changes are transferred to the form, it then is sent to MDOT IPO. The MDOT IPO will coordinate with TCRPC on implementing and maintaining records of changes to the regional ITS architecture. If there is a transit component to the update, then it needs to be sent to MDOT – Bureau of Passenger Transportation and the Federal Transit Authority (FTA). As a reminder for the stakeholder, if an existing MP is updated or a new market package is introduced, a sketch of the modification/update needs to be attached to the form when it is submitted.

5.3 Relevant Standard Use

The regional ITS architecture identifies National Standards that are applicable at a regional level based on the market packages and flows identified by the stakeholders. These standards provide a starting point for the implementation of integrated solutions, but do not always provide an adequate level of guidance for the individual stakeholder agency. As each market package or solution is implemented in the region, it is important for all of the identified and potential stakeholders to be involved. Even though some stakeholders may not be funding or implementing current components of the project, their buy-in and support of the selected solution is integral to the success of the project on a regional level. When those stakeholders decide to implement expansions of a system or systems of their own that should integrate, they need to agree to the standards identified during the initial phase.

The National Architecture does not provide specific guidance on conformance to local standards, but this can be achieved through mutual agreements between the involved agencies. Additionally, continuous conversations between the stakeholders through standing ITS committees provide support and guidance to stakeholders new to ITS. The committee meetings also include newer stakeholders in conversations around the established local standards that may already exist. As the MDOT IPO and TCRPC review architecture and maintenance forms for the TCRPC Region, it is important that consideration be given to the solutions identified for the project and the standards that are selected. Close management of these standards can improve operations costs on systems and improve the interoperability of the regional deployment of ITS, which is the goal of the regional ITS architecture.

6 Deployment Plan

The last ITS plan developed for the Tri-County Regional Planning Commission (TCRPC) are was developed as part of a larger MDOT Deployment Plan effort that was completed in 2002. The report documented a wide range of ITS concepts including freeway management, arterial management and transit ITS deployment. Since that time there have been several deployments in the region and a number currently in the planning stage, including:

- Deployment of extensive ITS technology on the Capital Area Transit Authority (CATA) system;
- Development of a Traffic Management Center for the Lansing arterial system;
- Deployment of a freeway management system on I-496 and I-96 east of Lansing
- Ongoing deployment of a Statewide Traffic Operations Center that will serve Lansing and all ITS deployments in Michigan outside of the Detroit and Grand Rapids regions; and
- A temporary ITS system that was deployed as part of the reconstruction of I-496 through Lansing in 2001.

These active deployment activities were discussed in more detail in Chapter 1 of this report. Chapter 1 also documents the stakeholder process that was used to generate proposed deployments for this study. The first stakeholder meeting focused on the ITS architecture and general summary of need, while the second focused on specific projects. **Table 13** through **Table 16** show the final list of projects that were agreed upon after the second stakeholder meeting. The final set of projects were evaluated using the ITS Deployment Analysis (IDAS) system, a package developed for FHWA for evaluating benefits and costs of a wide range of ITS deployments. IDAS incorporates travel demand models from regional and State agencies, which means that basic assumptions regarding the transportation network, trip generation and trip distribution as those used by the regional and State agencies for their planning projects. A more detailed description of the IDAS model is found later in this section. In this update, the TCRPC regional model was incorporated into IDAS and analysis conducted year the base year of 2010 and the future year 2020. TCRPC models were not available for year 2020 so 2025 forecast models were used and the results interpolated back to 2020. ITS analysis is generally done over a shorter timeframe than capital planning due to several factors:

- Projects usually require less lead time
- The life of key ITS equipment such as CCTV and DMS is generally in the 8-15 year timeframe, much less than that of major capital investments; and
- Rapid changes in technology make any forecast beyond 10 years potentially obsolete, Connected Vehicle technology, for example, has the potential to replace much of the current ITS technology within in the next 10-20 years.

An important caveat on the modeling effort is that the TCRPC is a national leader in the integration of transportation and land use planning. Their long-range planning models (2030 and 2035) include alternatives that concentrate growth closer to urban and town centers, thus reducing trip lengths and VMT. TCRPC has a number of initiatives ongoing with local communities in its service regions to implement these policies. The IDAS analysis conducted for this project is only using a 10-year horizon the model assumptions do not reflect these policy initiatives or their impacts. Because these policies would reduce travel times and probably lead to more use of transit and non-motorized modes, they would result in a lower level of benefits than those estimated in this study for highway ITS alternatives.

Since most of the projects listed below are only conceptual at this point, with no design has been completed. Therefore, where precise information was not available, general assumptions were made regarding the deployments. These include:

- Freeway Management Systems – Full CCTV coverage was assumed for urban segments with spacing of roughly one mile. In rural sections CCTV were assumed at interchange locations. Detectors were assumed to be in place between all interchanges in both urban and rural segments. Specific locations were selected for DMS
- Freeway Service Patrol – Freeway Service Patrol operation was assumed on weekdays during peak periods.
- Arterial Improvements – Arterial improvements generally assumed a density of three signal improvements per mile in rural and outlying suburban areas, and six signals per mile in urban areas. Google Earth was utilized to estimate the proper density.
- Road Weather Information System (RWIS) deployments, Environmental Sensor Stations, were located as part of the RWIS Concept of Operations Project completed in 2008.
- For some deployments, including Central Software and Emergency Management, benefits could be estimated with any confidence; therefore these alternatives were not included in the IDAS analysis.

Table 13 – Deployment Plan Projects – Freeway Management System

PROJECT NUMBER	*PROJECT DESCRIPTION*	*AGENCY*	*COMMENT*
	Freeway Management System Expansion (Urban)		
URITS-101	I-96 from I-69/I-96 Business to US-127	MDOT	
URITS-102	I-69 from I-96 Business to east of I-69 Business	MDOT	
URITS-103	I-496 from I-69/I-96 Business to US-127/I-496	MDOT	
	Freeway Management System Expansion (Rural)		
URITS-104	US-127 from E. Colony Road to I-69	MDOT	
URITS-105	US-127 from I-96 to Bellevue Road	MDOT	
URITS-106	I-69 from I-69/I-96 Business to M78	MDOT	
URITS-107	I-96 from S. Grange Road to I-69/I-96 Business	MDOT	
	Freeway Service Patrol		
URITS-108	I-96 from Okemos Road to US-127 and US 127 from Holt Road (south of I-96) to I-69 and I-496 from I-69/I-96 Business to US-127/I-496 and I-96 from I-469 to I-69/I-96 Business	MDOT	*Priority 1*
URITS-109	I-96 from US-127 to I-496 and I-69 from I-96 Business to US-127	MDOT	*Priority 2*
URITS-110	I-96 from S. Grange Road to I-69/I-96 Business and US-127 from E. Colony Road to I-69 and I-69 from US-127 to east of I-69 Business and I-96 from Okemos Road to Wallace Road	MDOT	*Priority 3*
URITS-111	US-127 from I-96 to Bellevue Road and I-69 from I-69/I-69 Business to M78	MDOT	*Priority 4*

Table 14 – Deployment Plan Projects – Arterial Management System

PROJECT NUMBER	*PROJECT DESCRIPTION*	*AGENCY*	*COMMENT*
	Lansing – Intersection Priority List		
URITS-112	Southeast Area	Lansing	*Intersection Priority List*
URITS-113	Pennsylvania Avenue	Lansing	*Intersection Priority List*
URITS-114	Grand River / Saginaw	Lansing	*Intersection Priority List*
URITS-115	Southwest Area	Lansing	*Intersection Priority List*

Table 15 – Deployment Plan Projects – Maintenance and Construction

PROJECT NUMBER	*PROJECT DESCRIPTION*	*AGENCY*	*COMMENT*
	Road Weather Information Systems		
URITS-116	Phase I – City of Lansing Locations	Lansing	*Design funded*
URITS-117	Phase II		
URITS-118	Phase III		

PROJECT DESCRIPTION	*Clinton County*	*Eaton County*	*Ingham County*	*City of Lansing*
AVL for Winter Operations	Proposed	Proposed	Proposed	Proposed
PROJECT NUMBER	URITS-119	URITS-120	URITS-121	URITS-122

Table 16 – Deployment Plan Projects – Transit Projects

PROJECT NUMBER	*PROJECT DESCRIPTION*	*CATA*	*EATRAN*
URITS-123	AVL for Demand Response Operations		*Programmed (2012)*
URITS-124	Automatic Passenger Counters		*Programmed (2011)*
URITS-125	Security Cameras on Vehicles	*Proposed*	
URITS-126	Real-time Paratransit Information	*Programmed*	
URITS-127	CCTV on transit vehicles	*Proposed*	
URITS-128	Vehicle surveillance	*Proposed (with Lansing 911)*	
URITS-129	Fiber link with City of Lansing	*Proposed*	

The maps shown in **Figure 15** and **Figure 16** show the location of the geographically-based alternatives shown in the Tables above with **Figure 15** covering the TCRPC Region and **Figure 16** focusing on the Lansing region. **Figure 15** includes all freeway deployments, while **Figure 16** highlights the arterial deployments that are primarily located within the City of Lansing.

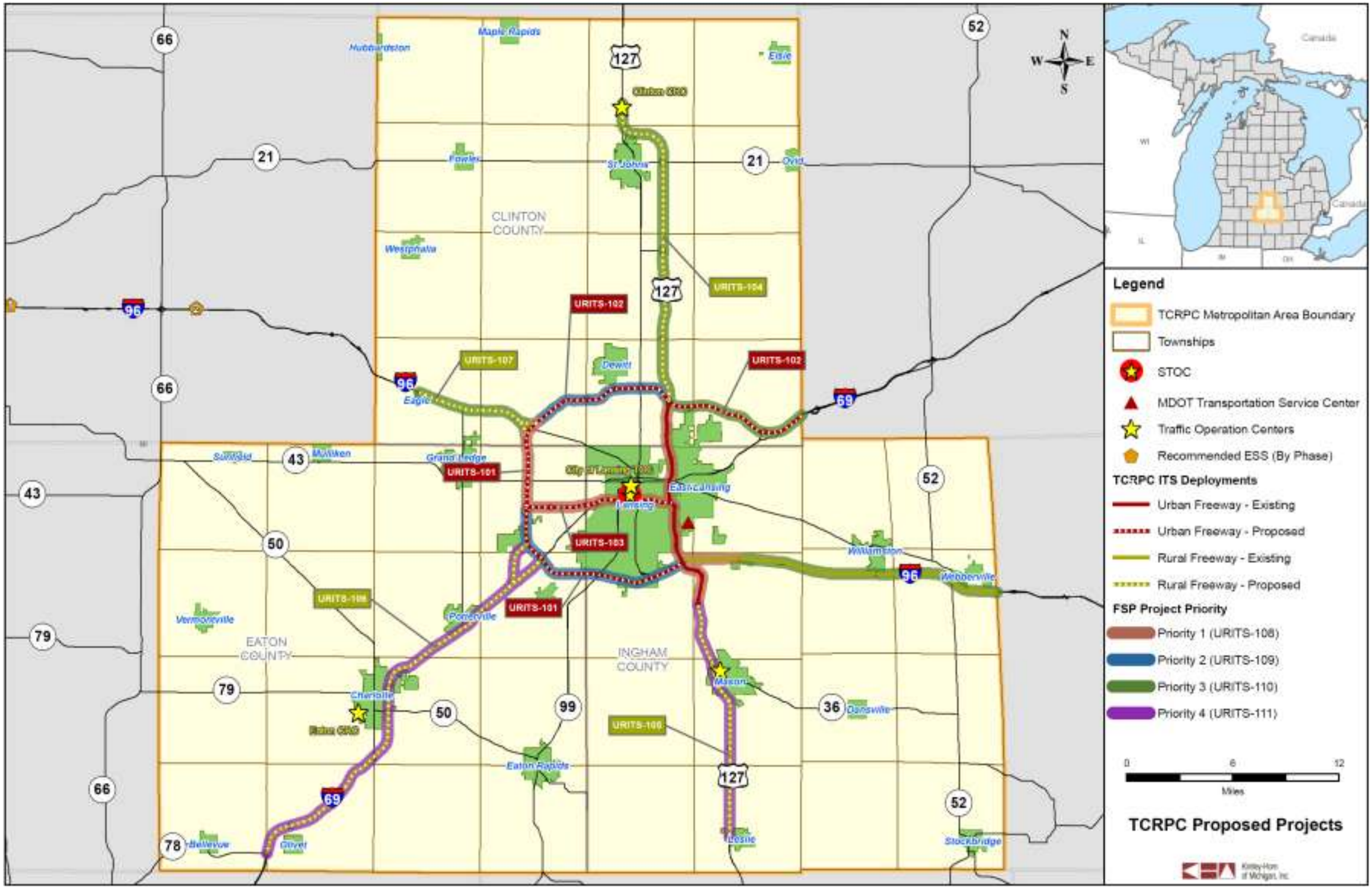


Figure 15 – TCRPC Regional Deployments

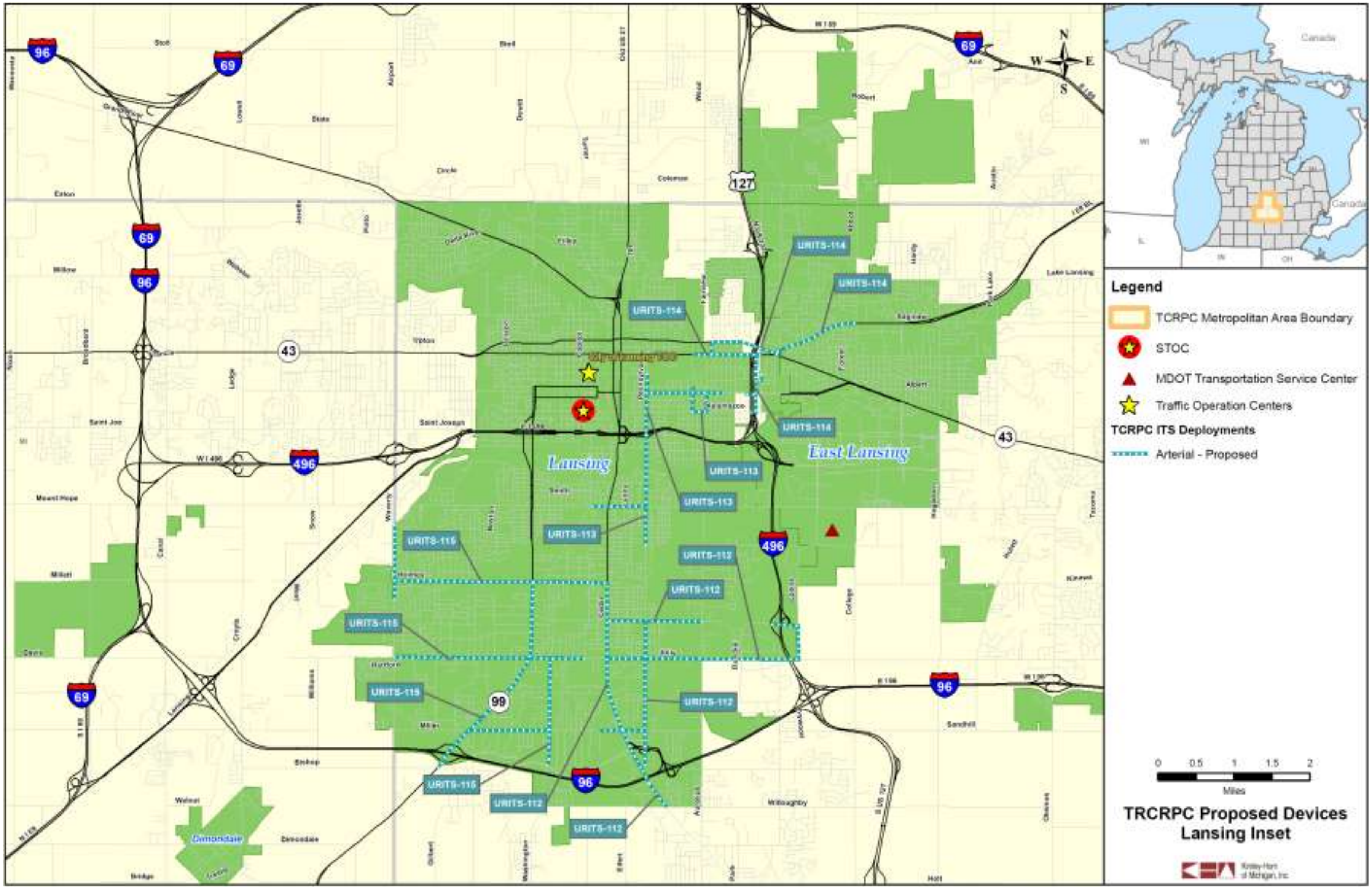


Figure 16 – TCRPC Region ITS Deployments – Lansing Area Blowup

6.1 Benefit/Cost Analysis Methodology

6.1.1 IDAS Description

The most important quantitative tool used in the evaluation was the ITS Deployment Analysis System (IDAS). This software package was used to conduct the benefit-cost analysis of identified ITS improvements. IDAS is a sketch-planning software and analysis methodology developed by Cambridge Systematics for the Federal Highway Administration (FHWA).

IDAS was developed to assist state, regional, and local agencies in integrating ITS into the transportation planning process. Planners and others can use IDAS to calculate relative costs and benefits of ITS investments. IDAS currently predicts costs, benefits, and impacts for more than 60 types of ITS investments.

In order to be consistent with current transportation planning processes, IDAS operates as a post-processor to travel demand models used by Metropolitan Planning Organizations (MPO) and by state DOTs. IDAS, although a sketch-planning tool, can implement the modal split and/or traffic assignment steps associated with a traditional planning model. These are key steps in estimating the changes in modal, route, and temporal decisions of travelers resulting from ITS technologies.

The set of impacts evaluated by IDAS included changes in user mobility, travel time/speed, travel time reliability, fuel costs, operating costs, accident costs, emissions, and noise. The performance of selected ITS options can be viewed by market sector, facility type, and district. Given the diverse types of performance measures that may be impacted by ITS and the desirability of providing a comprehensive analysis tool, IDAS is comprised of five different analysis modules as shown in **Figure 17**.

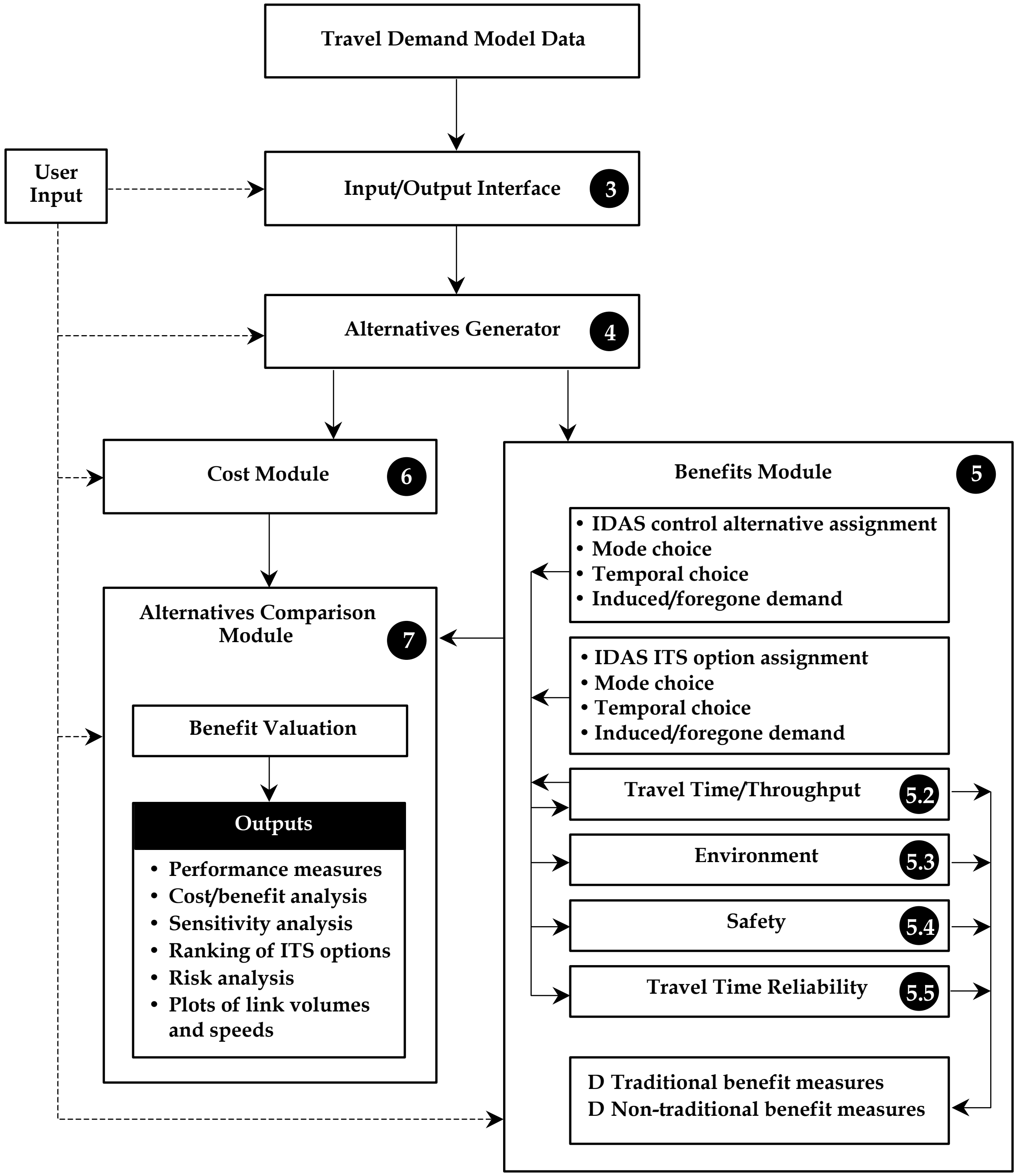


Figure 17 – IDAS Model Structure

6.1.2 IDAS Inputs and Default Values

For this evaluation, data outputs were obtained from the TCRPC model to use as inputs into the IDAS model. The model data included both network files and travel demand files (trip tables) representing daily volumes for 2010 and the forecast year 2020. As discussed in the introduction, the TCRPC network files used for 2025, and the results interpolated back to 2020. Only highway facilities, including automobile and truck trips, were evaluated using the models.

Other parameters, such as baseline travel time skims (zone to zone), turn prohibitors, volume-delay curves, in- and out-of-vehicle travel times, and vehicle occupancies from the model were incorporated into IDAS.

IDAS estimates the impacts of the various ITS deployments by drawing on a database of default impacts for each separate ITS component. These defaults were developed by assembling and analyzing observed impacts and evaluation results for similar deployments across the United States.

The default impacts form the basis for the estimation of impacts on traffic, such as travel time and speed, in the IDAS software. Impact values are applied to the model runs to estimate the changes that occur as a result of ITS deployments. These are generally applied to travel times or volumes in the model. For example, DMS sign parameters contain three components:

- The percentage of time that the sign is active regarding an event that impacts downstream traffic;
- The percentage of motorists who react to the information on the sign and change their route; and
- The estimated number of minutes saved by the diversion.

Parameters were derived primarily from surveys taken of commuters in the Detroit and Lansing regions. Detroit commuters did have permanent signs available at the time of the survey while Lansing commuters did not. Lansing commuters did have temporary signs associated with construction however and thus were familiar with the concept. Adjustments are made in different regions to the travel time savings estimate based on the availability of alternative routes.

Implementation of the impacts parameters occurs in the model. Links that have a DMS are designated and the parameters are applied to the total travel time that is experienced on the link (number of vehicle x average travel time). The time savings calculated are then monetized using the values shown in Table 18. IDAS incorporated delay functions into the model which is incorporated into some deployments such as freeway service patrols. Other impacts values are used as follows:

- Crash rates are calculated by link based on volume and type of facility, and then crash reduction rates are applied depending on the deployment;
- Fuel consumption is calculated in the model based on volume and speed and then benefit parameters applied; and
- Emissions are calculated using the MOBILE 5 model, which has is utilized in many travel demand models.

The project team used a combination of default values and values developed for a series MDOT ITS deployment studies conducted between 2006 and 2009 in the Superior, North, Bay, Southwest and Grand (excluding GVMC) regions, as well as the SEMCOG region which included Metro and part of the University region. Some of the benefit parameters were derived from a commuter survey of both the Detroit and Lansing regions in an earlier deployment study (2002). In general, a conservative approach to estimation of benefits was taken. In some cases, the national default values were used for this analysis, while in others, default values produced very high impact estimates. Modifications were made based on Michigan specific data. **Table 17** presents the adjusted impact values used for this study and the recent series of MDOT deployment studies.

Table 17 – Comparison of Impact Values Used for IDAS Analysis (IDAS Model Default Parameter in Parentheses)

Deployment	Benefit	Parameter
Freeway Service Patrols	Reduction in incident duration	20% (55%)
	Reduction in fuel consumption	1% (42%)
	Reduction in fatality rate	1% (10%)
Traffic Signal Progression	Capacity improvement on impacted links	6% (8%)
DMS Signs	Percent of time significant events occur	10% (10%)
	Percent of drivers saving time	20% (20%)
	Time saved	5 minutes (3 min)
Freeway and Arterial Management Systems (CCTV and Detection) – Benefits from improved incident response	Reduction in incident duration	5% (ND)
	Reduction in crashes	1% (ND)
	Reduction in operating cost	1% (ND)
	Reduction in emissions	1% (ND)
Freeway and Arterial Management Systems (CCTV and Detection) – Benefits from Improved Traveler Information	Percent of time significant events occur	10% (10%)
	Percent of drivers saving time	10% (20%)
	Time saved per traveler	5 minutes (3 min)
APTS CAD and AVL	Operating Cost Savings	5% (5%)
Winter Maintenance AVL	Operating Cost Savings	5% (5%)

Table 18 includes the monetized values of the benefit parameters used in this analysis. The parameters were developed by FHWA in 1995 and have been inflated to 2010 using a 3% annual inflation rate. The one exception was the price of fuel, which significantly exceeded the 3% inflation rate. This cost was raised to $3/gallon. Gasoline prices have jumped to nearly $4/gallon between the time the analysis was conducted and the writing of this report. It can therefore be assumed the fuel consumption benefits of ITS will be higher. However, the increase will not necessarily be proportional to the increase in prices. Traffic levels may be reduced as result and the elasticity of demand in relation to price is uncertain given economic conditions and ongoing changes in the vehicle fleet.

Table 18 – Monetary Values of IDAS Default Parameters

Benefit Parameters		Parameter Values
	Number of travel days in a year	247
	Year of $ values	2010
	Inflation Rate	3%
	Value of In-vehicle time	$15.00
	Value of In-vehicle time (commercial)	$26.42
	Value of Out-of-vehicle time (commercial)	$26.49
	Value of time multiplier for Emergency Vehicle	30.0
	Value of Out-of-vehicle time	$26.49
	Value of reduced delay time	$45.03
	Fuel Costs (gallon)	$3.00
Emissions Costs ($/ton)		
	HC/ROG	$2,763.83
	NOX	$5,812.78
	CO	$6,058.94
	PM10	$17,240.47
	CO2	$5.55
	SO2	$5.55
	GW	$0.00
Accident Costs	***Internal***	
	Fatality	$3,610,430.58
	Injury	$79,082.43
	Property damage	$4,399.70
	External	
	Fatality	$637,133.89
	Injury	$13,956.27
	Property damage	$775.87
	Non-Fuel operating costs ($/mile)	$0.10
	Noise Damage Costs ($/mile)	$0.0011
	Other mileage based ($/mile)	$0.00
	Other non-mileage based ($/mile)	$0.00
	Cost of winter Maintenance ($/mile)	$2,000.00

Figure 18 shows how individual elements of the ITS systems are deployed on links of the network in IDAS. In this case, proposed RWIS stations for the Lower Peninsula regions are shown. It should be noted that these are conceptual only since planning studies to select locations have not yet been initiated. Other ITS deployments are added to the transportation network in this fashion in order to create an alternative that can be modeled in IDAS.

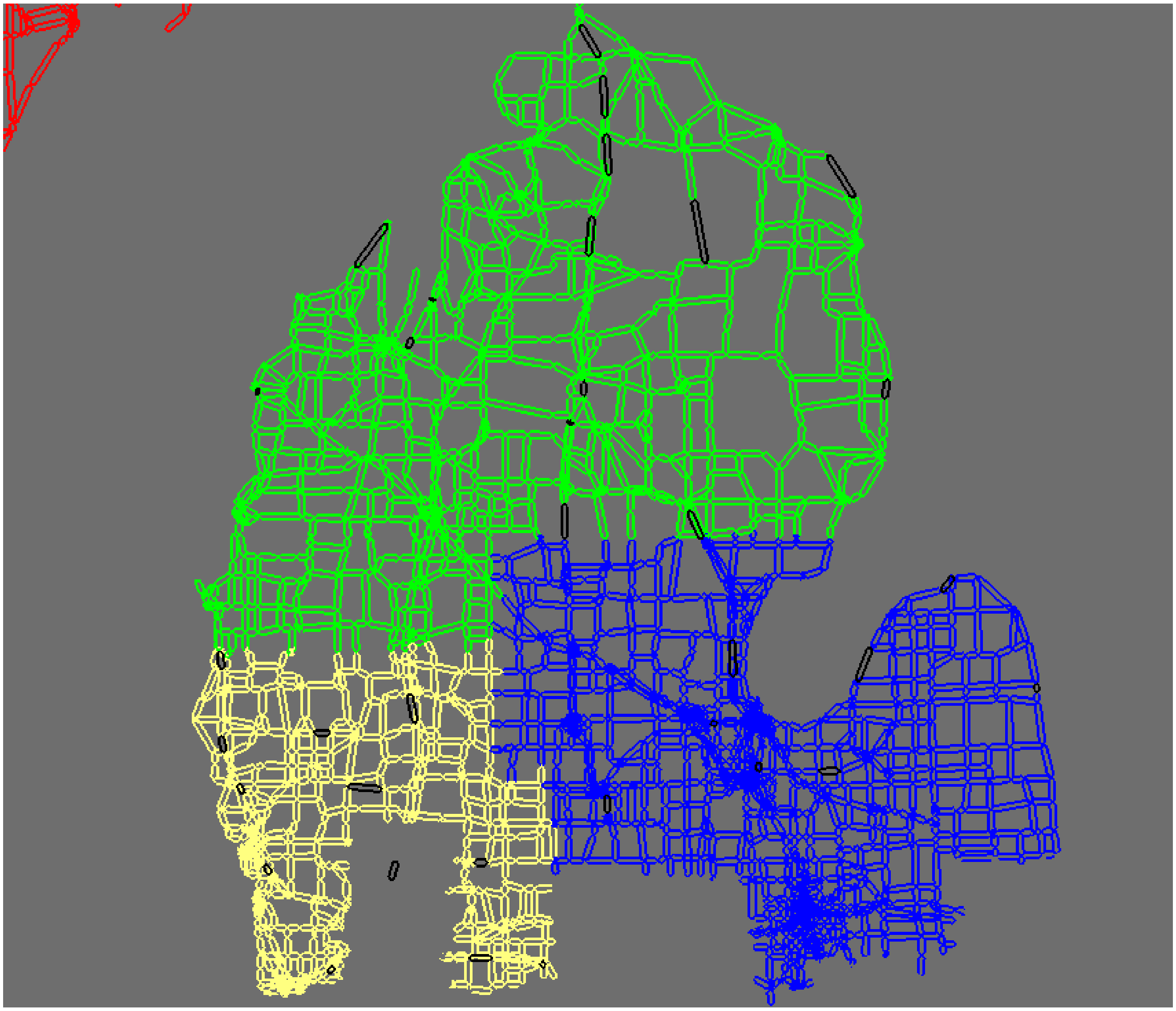


Figure 18 – IDAS Representation of RWIS Deployment in the Lower Peninsula

Once an alternative is defined, the analysis procedures are initiated to estimate the incremental costs and benefits of ITS improvements. These benefit-cost results can then be compared with other alternatives defined and analyzed in the IDAS software. Summaries of project benefits and costs for each deployment package are shown in Section 4. In order to simplify the results, impacts were collapsed into four categories for purposes of presentation. These are shown below in **Table 19.**

Table 19 – Summary Categories for IDAS Benefits

Summary Category	IDAS Subcategories Included
Travel Time Savings	Change in User Mobility Change in User Travel Time ▪ In-vehicle travel time ▪ Out-of-vehicle travel time ▪ Travel time reliability
Fuel/Operating Cost Savings	Change in Costs Paid by Users ▪ Fuel Costs ▪ Non-fuel operating costs
Accident Reduction	Change in Costs Paid by Users ▪ Accident Costs (Internal Only) Change in External Costs ▪ Accident Costs (External Only)
Air Quality/Environmental	Change in External Costs ▪ Emissions – HC/ROG – NOx – CO – PM10 – CO_2 – Global Warming ▪ Noise ▪ Other Mileage-based External Costs ▪ Other Trip-Based External Costs

6.1.3 Estimation of ITS Alternative Costs

Development of cost estimates for the various ITS alternatives required full consideration of the unique characteristics and requirements of ITS strategies that impact the costs, funding, and implementation of improvements. Planning of ITS improvements requires an increased effort on operational planning that is not generally considered in planning for traditional transportation infrastructure projects. ITS strategies typically require that a greater proportion of resources be expended for ongoing O&M activities than do traditional improvements. A "rule of thumb" based on general experience is that annual operations and maintenance expenditures are about 15-20 percent of the original capital cost. However, this figure can vary depending on the size and complexity of the operation. A lower percentage may indicate that there is a lack of investment that will require premature replacement of equipment. The replacement cycles of equipment also must be carefully considered as ITS equipment does not have as long a life cycle as traditional transportation agency assets. Failure to account for these continuing costs and funding responsibilities may result in future shortfalls in funding, personnel, or resources.

IDAS software can generate default values for a wide range of cost elements, in a manner similar to that used to calculate benefits. For this project, however, two separate efforts were undertaken in order to develop costs that better reflect the operating conditions in northern Michigan. MDOT cost data for operations and maintenance of the Detroit and Grand Rapids systems were reviewed, as well as costs for recent ITS capital purchases.

These sources were used to develop data for input into the IDAS cost module. IDAS provides information, such as assumed equipment life, that is used to develop life-cycle costs for the identified projects. Preliminary estimates of life-cycle costs and resource requirements were developed for the initial IDAS runs and then modified based on a review of the results. While preliminary design work is essential to refine cost estimates, the results of this study provide a reasonable initial estimate for up-front capital and ongoing O&M costs required for successful deployment of identified alternatives.

Table 20 shows the unit costs assumed for the deployments analyzed for the TCRPC region and a parallel study for the Grand Valley Metropolitan Commission (GVMC) serving the Grand Rapids area. These are based primarily on procurements in Michigan but supplemented with information from the IDAS database and anecdotal information from the project team. This includes both capital items, which were amortized based on the number of years and a 3% interest rate and operations and maintenance costs. As discussed earlier, costs were allocated to projects primarily on a per mile basis.

Table 20 – TCRPC – Estimated ITS Cost per Corridor Mile

Device	Density	Cost Unit	Per Unit	Lifespan (years)	O&M	Total cost
Urban Freeway						
Communication fiber for devices	1	per mile	$140,800	30	$14,080	$140,800
CCTV cameras	1	per mile	$35,000	10	$3,500	$35,000
DMS units			$225,000	20	$22,500	$0
Freeway Service Patrol Personnel	2	people per day	$72,800	1	$0	$145,600
DMS - Side Mount			$175,000	20	$17,500	
ESS Station			$78,000	15	$9,200	
Rural Freeway						
Wireless infrastructure for devices	0.5	per mile	$46,200	30	$4,620	$23,100
CCTV cameras	0.5	per mile	$35,000	10	$3,500	$17,500
DMS units			$225,000	20	$22,500	$0
Freeway Service Patrol Personnel	2	people per day	$72,800	1	$0	$145,600
DMS - Side Mount			$175,000	20	$17,500	
ESS Station			$78,000	15	$9,200	
Arterial - Downtown/Heavy Commercial						
Communication fiber for devices	1	Mile	$140,800	30	$14,080	$140,800
Signal improvements	3	per mile	5000	10	$500	$15,000
CCTV cameras	1	per mile	$35,000	10	$3,500	$35,000
Arterial - Less Dense						
Communication fiber for devices	1	Mile	$140,800	30	$14,080	$140,800
Signal improvements	6	per mile	5000	10	$500	$30,000
CCTV cameras	1	per mile	$34,100	10	$3,410	$34,100
Freeway Courtesy Patrol	1	Truck	$125,000	5	$145,000	

6.2 Deployment Plan Results

This section summarizes the benefit/cost analysis results for the deployment plan. Due to the large number of projects and the fact that most of them are conceptual at this stage, the quantitative results were aggregated by type of deployment. All transit projects identified are either in the deployment stage or programmed and moving toward implementation, therefore benefits were not calculated for them. Individual results were then evaluated for the base 2010 and future year 2020, and placed into three categories based primarily on benefit/cost ratio, with some consideration of net benefits. It is important to look at both these results to accurately understand project impacts. Some projects may have high benefit/cost ratio but a relatively low amount of net benefit, or benefits limited to a very small portion of the public. Other projects may have high net benefits, but also high capital and/or operating costs that would use a disproportionate amount of overall resources. **Figure 19** summarizes the projects by priority category with green projects showing a high level of priority, yellow are projects that of medium priority and red are those of lowest priority. It is important to emphasize that these priorities are based solely on net benefits and benefit/cost ratios and may not reflect all factors in the decision-making process. The existence of crash hotspots or need for system connectivity may result in some yellow or red projects being moved up. It should also be noted that in spite of relatively modest growth project for the TCRPC region over the next 10 years, there is adequate growth projected in some areas to move projects up one category.

Project Category	**Project Number**	**B/C Ratio 2010**	**B/C Ratio 2020**
Freeway Management System Expansion (Urban)	URITS-101	🟡	🟡
Freeway Management System Expansion (Urban)	URITS-102	🟡	🟡
Freeway Management System Expansion (Urban)	URITS-103	🟡	🟡
Freeway Management System Expansion (Rural)	URITS-104	🟡	🟡
Freeway Management System Expansion (Rural)	URITS-105	🟡	🟡
Freeway Management System Expansion (Rural)	URITS-107	🟡	🟡
Freeway Service Patrol	URITS-108	🟢	🟢
Freeway Service Patrol	URITS-109	🟡	🟡
Freeway Service Patrol	URITS-110	🟢	🟢
Lansing – Intersection Priority List	URITS-111	🔴	🟡
Lansing – Intersection Priority List	URITS-112	🔴	🔴
Lansing – Intersection Priority List	URITS-113	🟢	🟢
Lansing – Intersection Priority List	URITS-114	🟡	🟡
Road Weather Information Systems	URITS-115	🟡	🟡
Road Weather Information Systems	URITS-116	🟡	🟡
Road Weather Information Systems	URITS-117	🟡	🟡

Figure 19 – Ranking Categories for TCRPC Projects

Most of the projects proposed for the Lansing region fall in the medium priority range indicating positive but moderate benefit/cost ratios. Freeway Courtesy Patrol tend to have the highest rankings while freeway management systems, arterial systems and RWIS all fall generally within the medium range. Thus the overall program will be beneficial for the region's transportation system, but costs should be minimized where possible to maintain a positive benefit/cost ratio. The results for arterial deployments are more mixed. This is mainly a function of the relative lack of congestion on the freeway system and modest growth projected for the overall region. Another important factor to consider when evaluating arterial alternatives is that the IDAS model, like all similar models, optimizes the entire network. Improvements that increase arterial capacity and throughput will attract more traffic from other, less efficient, facilities. In addition improved arterials may draw short trips away from freeways. Since freeways have lower crash rates and higher speeds, crash rates and fuel consumption may increase slightly. As a result, the benefit/cost ratio of the improvement on the arterial itself may be around 1.0 or possibly lower. However, these improvements are still desirable since they have a positive impact on the overall network. Since this is a network analysis, benefits and costs are summarized for three categories of improvement:

- Freeway Management System and Freeway Service Patrol – The IDAS model shows most of the largest amount of benefit accruing from the Freeway Service Patrol. However, the FSP cannot work effectively without detection, surveillance and traveler information systems, supported by the Traffic Management Center, that locate incidents and let the traveling public know about them. Therefore the most realistic summary combines both when looking at benefits.

- Road Weather Information Systems
- Arterial Improvement Systems – As discussed above, the model can show negative impacts for arterial projects in the area of safety and fuel consumption. This was not the case in the Lansing analysis although benefits in these areas were minimal.

Table 21 through **Table 28** show the benefits and costs by project grouping with urban freeway and freeway courtesy patrol combined for 2010 and 2020. The highest levels of net benefit and benefit/cost ratio are realized for the Urban Freeway Management and Freeway Courtesy Patrols option although all the categories show a positive benefit. Travel time savings constitute by far the majority of the benefits. Total benefits for the Urban Freeway Management System and Freeway Courtesy Patrol are projected to increase by over 15% during the 10-year forecast period, but due to low projected growth rates increases in the other categories are somewhat lower. Future success of TCRPC's land use initiative would result in a lower level of benefit for the freeway alternatives. If future growth is concentrated more in the urban portions of the region, the arterial and transit ITS alternatives would gain a greater share of the benefits.

In looking at the costs for the TCRPC plan it is important to note that the freeway management system elements will be operated by the MDOT Statewide Traffic Operations Center (STOC) while the arterial system will be operated by the City of Lansing. Approximately 80% of the operating cost estimated for this program ($1.3 million out of $1.5 million) would be allocated to the rural and urban freeway management systems and the freeway courtesy patrol. Since the full scope of the STOC is still in development it is not clear what resources would be allocated to Lansing as opposed to other systems across the State. It is likely that economies of scale can be gained as new systems are brought on line in the STOC. Therefore estimation of O&M costs is difficult.

Table 21 – Year 2010 – Urban Freeway Management System and Freeway Courtesy Patrol Benefit/Cost Summary

Benefits and Costs	Monetary Values
Travel Time Savings	$9,493,207
Crash Reduction	$166,314
Operating Costs	$698,106
Environmental	$142,993
Total Annual Benefits	$10,500,620
Annualized Cost	$1,847,713
Net Benefits	$8,652,907
Benefit/Cost Ratio	5.7
Capital Cost	$8,903,839
Annual O & M Cost	$1,018,956

Table 22 – Year 2020 – Urban Freeway Management System and Freeway Courtesy Patrol Benefit/Cost Summary

Benefits and Costs	Monetary Values
Travel Time Savings	$10,834,738
Crash Reduction	$169,627
Operating Costs	$709,455
Environmental	$151,239
Total Annual Benefits	$11,865,059
Annualized Cost	$1,847,713
Net Benefits	$10,017,346
Benefit/Cost Ratio	6.4
Capital Cost	$8,903,839
Annual O & M Cost	$1,018,956

Table 23 – Year 2010 – Freeway Management System (rural) Benefit/Cost Summary

Benefits and Costs	Monetary Values
Travel Time Savings	$1,549,891
Crash Reduction	$40,906
Operating Costs	$185,038
Environmental	$111,595
Total Annual Benefits	$1,887,430
Annualized Cost	$628,252
Net Benefits	$1,259,178
Benefit/Cost Ratio	3.0
Capital Cost	$3,102,994
Annual O & M Cost	$310,298

Table 24 – Year 2020 – Freeway Management System (rural) Cost Savings Benefit/Cost Summary

Benefits and Costs	Monetary Values
Travel Time Savings	$1,593,434
Crash Reduction	$41,931
Operating Costs	$189,214
Environmental	$118,906
Total Annual Benefits	$1,943,485
Annualized Cost	$628,252
Net Benefits	$1,315,233
Benefit/Cost Ratio	3.1
Capital Cost	$3,102,994
Annual O & M Cost	$310,298

Table 25 – Year 2010 – Road Weather Information Systems (RWIS) Benefit/Cost Summary

Benefits and Costs	Monetary Values
Travel Time Savings	$130,691
Crash Reduction	$374,304
Operating Costs	$221,822
Environmental	$0
Total Annual Benefits	$726,817
Annualized Cost	$230,929
Net Benefits	$349,480
Benefit/Cost Ratio	2.5
Capital Cost	$1,014,000
Annual O & M Cost	$119,600

Table 26 – Year 2020 – Road Weather Information Systems (RWIS) Benefit/Cost Summary

Benefits and Costs	Monetary Values
Travel Time Savings	$109,788
Crash Reduction	$361,723
Operating Costs	$311,361
Environmental	$0
Total Annual Benefits	$782,872
Annualized Cost	$230,929
Net Benefits	$390,003
Benefit/Cost Ratio	2.7
Capital Cost	$1,014,000
Annual O & M Cost	$119,600

Table 27 – Year 2010 – Arterial Management System Benefit/Cost Summary

Benefits and Costs	Monetary Values
Travel Time Savings	$252,452
Crash Reduction	$102,025
Operating Costs	$31,976
Environmental	$26,224
Total Annual Benefits	$412,677
Annualized Cost	$191,000
Net Benefits	$221,677
Benefit/Cost Ratio	2.2
Capital Cost	$824,000
Annual O & M Cost	$103,000

Table 28 – Year 2020 – Arterial Management System Benefit/Cost Summary

Benefits and Costs	Monetary Values
Travel Time Savings	$257,293
Crash Reduction	$103,982
Operating Costs	$32,589
Environmental	$26,727
Total Annual Benefits	$420,591
Annualized Cost	$191,000
Net Benefits	$229,591
Benefit/Cost Ratio	2.2
Capital Cost	$824,000
Annual O & M Cost	$103,000

The tables below summarize the benefits and costs for the entire deployment plan program. This analysis is summarized in **Table 29** through **Table 32**. Travel time improvement is clearly the most significant benefit from a dollar value point of view; however significant benefits are realized in all categories.

Table 29 – Estimate of Total Benefits

	2010	2020
Deployment Type	**Total Benefits**	**Total Benefits**
Freeway Management System (rural)	$1,887,430	$ 1,943,485
FMS urban and Freeway Courtesy Patrol	$10,500,620	$ 11,865,059
RWIS	$ 726,817	$ 782,872
Arterial Management Systems	$ 412,677	$ 420,591

Table 30 – Estimate of Net Benefits

	2010	2020
Deployment Type	**Net Benefits**	**Net Benefits**
Freeway Management System (rural)	$ 1,259,178	$ 1,315,233
FMS urban and Freeway Courtesy Patrol	$ 8,652,907	$10,017,346
RWIS	$ 349,480	$ 390,003
Arterial Management Systems	$ 221,677	$ 229,591

Table 31 – Estimate of Annualized Costs

Deployment Type	2010 Annualized Costs	2020 Annualized Costs
Freeway Management System (rural)	$ 628,252	$ 628,252
FMS urban and Freeway Courtesy Patrol	$1,847,713	$1,847,713
RWIS	$ 230,929	$ 230,929
Arterial Management Systems	$ 191,000	$ 191,000

Table 32 – Estimate of Benefit/Cost Ratio

Deployment Type	2010 Benefit/Cost Ratio	2020 Benefit/Cost Ratio
Freeway Management System (rural)	3.0	3.1
FMS urban and Freeway Courtesy Patrol	5.7	6.4
RWIS	2.5	2.7
Arterial Management Systems	2.2	2.2

It should be noted that much of the capital cost is in fiber, which can serve all of the deployment categories. The initial capital cost for the full program is approximately $13 million with an annualized cost of about $3 million. Of the $13 million estimated capital cost about $9 million is for the urban freeway management system and freeway courtesy patrol. This amount is split roughly evenly between annualized capital costs and operations and maintenance cost, each of which is approximately $1.5 million.