SYSTEMS ENGINEERING ANALYSIS

Baton Rouge to New Orleans ITS-TIM Phase 3
Routes: I-10, I-110, I-12, & US 61
East Baton Rouge and Ascension Parishes
S.P. No. 737-96-0058
F.A.P. No. ITS-9606(500)

FINAL

JANUARY 2010

Presented to:

Louisiana Department of Transportation
and Development

ABMB ENGINEERS, INC.

Wilbur Smith Associates
ENGINEERS PLANNERS ECONOMISTS

ABMB ENGINEERS, INC.

January 21, 2010

Louisiana Department of Transportation and Development
ATTN: Stephen Glascock, P.E., PTOE
ITS Director
1212 East Highway Drive
Baton Rouge, Louisiana 70802-4438

Re: S.P. No. 737-96-0058
F.A.P. No. ITS-9606(500)
Baton Rouge to New Orleans ITS-TIM Phase 3

Dear Mr. Glascock:

Please find the attached final submittal of the Systems Engineering Analysis (SE) for the Baton Rouge to New Orleans ITS-TIM Phase 3 Project.

This SE has been created to satisfy FHWA Final Rule CFR 940 part 11 for ITS Projects. The Intelligent Transportation Project (ITS) project covered by this SE consists of possible ITS field devices including closed circuit television (CCTV) cameras, dynamic message signs, vehicle detector, highway advisory radios, and communications. Since the Baton Rouge area has an existing ITS, this project will be a continuation of the deployed system.

This project will use the Design-Build procurement process. The procurement documents are envisioned to allow the Design-Builders to provide the best solution based on DOTD's constrained budget. This SE document supports this procurement methodology.

Sincerely,

ABMB ENGINEERS, INCORPORATED

Jonathan Fox, P.E., PTOE
Director of ITS Services

Cc:
Mary Stringfellow, FHWA

STATE PROJECT NUMBER: 737-96-0058
FEDERAL AID PROJECT NUMBER: ITS-9606(500)
BATON ROUGE TO NEW ORLEANS
INTELLIGENT TRANSPORTATION SYSTEMS (ITS)–
TRAFFIC INCIDENT MANAGEMENT (TIM) PHASE 3
ROUTES: I-10, I-110, I-12, & US-61 (Airline Hwy)
EAST BATON ROUGE AND ASCENSION PARISHES

Systems Engineering Analysis

FINAL

Presented to:

Prepared by:

January 2010

TABLE OF CONTENTS

1 INTRODUCTION 1
2 ACRONYMS AND ABBREVIATIONS 3
3 PROJECT PHYSICAL ARCHITECTURE 5
3.1 Stakeholders 5
3.2 Project Architecture 5
4 CONCEPT OF OPERATIONS 7
4.1 Needs 7
4.2 Scope 7
4.3 Justification for the ITS Project 8
4.4 Existing Operations 8
4.5 System Overview 13
4.6 Operational Environment 13
4.7 Operational Scenarios 13
4.7.1 Traffic Incident Management Operations (TIM) 14
4.7.2 Other Event Management 15
4.8 Summary of Impacts 15
5 REQUIREMENTS 17
5.1 ITS Field Equipment Roadside Devices 17
5.1.1 Dynamic Message Signs 17
5.1.2 Video Surveillance – closed circuit television cameras 18
5.1.3 Vehicle Detection 19
5.1.4 Highway Advisory Radio – HAR 20
5.2 Requirements Traceability Matrix 22
6 SYSTEM DESIGN 23
6.1 High-Level Design 23
6.1.1 Hardware and Software Components 24
6.2 Detailed Design 24
7 ALTERNATIVE CONFIGURATIONS 25
7.1 Project Communications 25
7.2 Power Configuration 26
7.3 Software Alternative Configurations 27
7.4 Life Cycle Funding 27
7.5 Conclusion 28
8 TESTING 30
9 OPERATIONS AND MAINTENANCE 31
10 ITS STANDARDS 32
10.1 Project Standards 32
10.1.1 Center-to-Field Standards 33
10.2 Standards Applicable to the Project 33

APPENDIX A – Communication Technologies
APPENDIX B – Traceability Matrix

1 Introduction

The Louisiana Department of Transportation and Development (DOTD), supported by Federal Highway Administration (FHWA), has analyzed the feasibility of implementing the Baton Rouge to New Orleans ITS-TIM Phase 3 Project. This project is the third of four total, design-build, projects between Lafayette and New Orleans. There are four major highway facilities included in the study area which are the focus of the project.

The first highway facility is I-10 extending from the I-10/I-110 interchange to the US-61 Intersection (I-10 Exit 187), a distance of approximately 31 miles. I-10 is the primary travel corridor for the study area between Baton Rouge and New Orleans. This freeway facility is typically a four-lane divided facility (two lanes per east and west directions) with 12- foot travel lanes and 10- foot inside and outside shoulders. I-10 is the principle interstate system for east-west movement in the southern U.S. In the major urban area of Baton Rouge, the freeway facility varies between four to six travel lanes. The speed limit is posted at 60 miles per hour for the majority of the facility. Daily traffic volume along I-10 through the Baton Rouge urban area ranges from 130,000 to 170,000.

The second highway facility is US-61, the primary incident alternate route, extending from I-110 to I-10, a distance of approximately 33 miles. Daily traffic volume for US-61 through the Baton Rouge urban area ranges from 34,000 to 57,000. US-61 will be used as the detour route in the event that traffic should need to be redirected from I-10 due to a prolonged traffic incident.

The third highway facility in this study area is Interstate 110 (I-110) extending from Harding Blvd. to the I-110/I-10 interchange, a distance of approximately 6.5 miles. I-110 within the project limits has a daily traffic count that ranges from 22,000 to 87,000.

The fourth highway facility is I-12 extending from the I-10/I-12 interchange to O'Neal Rd., a distance of approximately 6.5 miles. I-12 within the project limits has a daily traffic count that ranges from 85,000 to 133,000.

Note that the project limits also include a 3.5 mile approach to the boundaries defined above for power deployments, traffic control, etc.

The occurrence of unplanned incidents that increase or disrupt the normal flow of traffic places a premium on the optimal use of existing facilities. Any response to traffic incidents may require the use of the numerous streets between I-10 and US-61 identified as potential secondary alternate routes during emergency traffic situations. Included as part of traffic incident management, these secondary alternate routes include: LA-3064 (Essen Ln), Blue Bonnet Blvd (city route), Siegen Ln (city route), LA-42 (Highland Rd.), LA-73, LA-30, LA-44 (S. Burnside Ave.), and LA-22 (John LeBlanc Blvd).

Also within the project limits are the DOTD ITS Statewide Traffic Management Center (TMC) located at 1212 East Highway Drive, Baton Rouge, LA. as well as the Baton Rouge TMC within the City of Baton Rouge Advanced Traffic Management and Emergency Operations Center

(ATM/EOC) located at 3773 Harding Blvd., Baton Rouge, LA. **Figure 1** shows the limits of the project and study area.

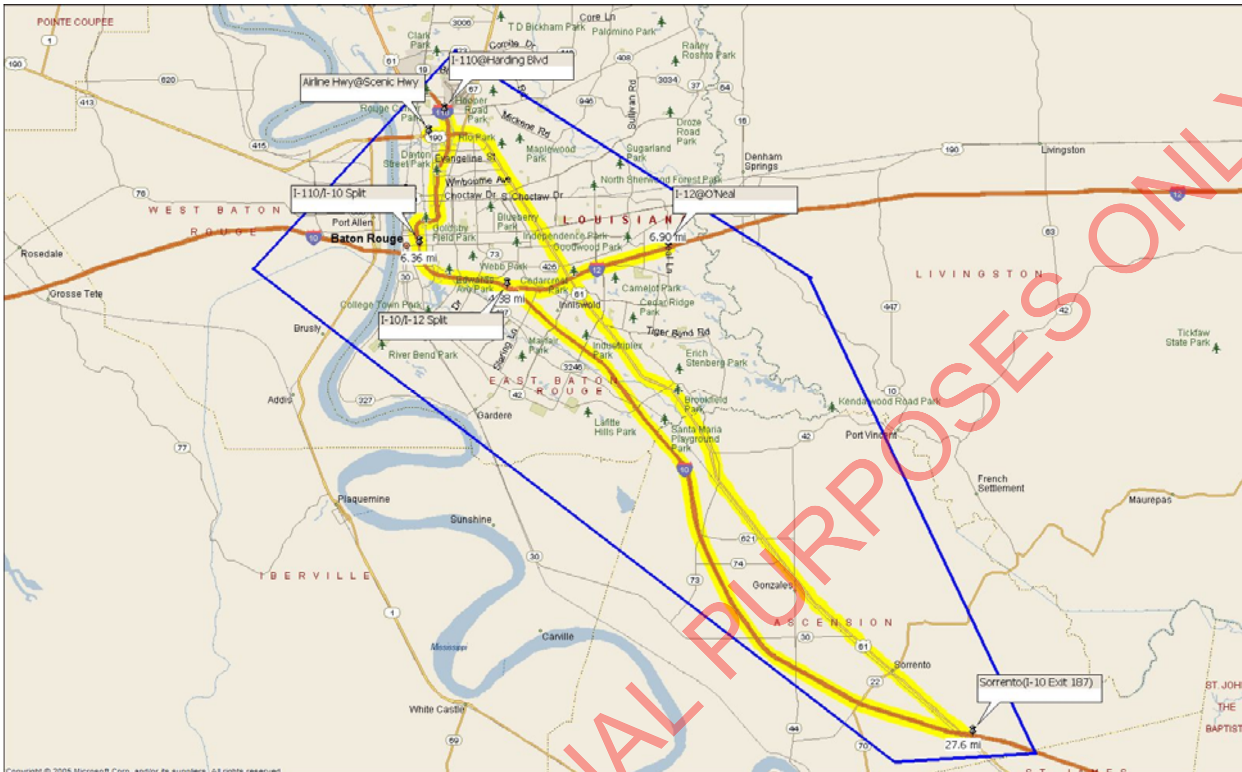


Figure 1: Project Area and Physical Limits

2 Acronyms and Abbreviations

Wherever the following abbreviations or acronyms are used in this SE document, they are interpreted as follows:

AASHTO	American Association of State Highway and Transportation Officials
ADC	Analog-to-Digital Conversion
ADSL	Asymmetric Digital Subscriber
ARN	Area Radio Network
ATIS	Advanced Traveler Information Systems
ATM	Advanced Traffic Management
C2C	Center-to-center
C2F	Center-to-field
CDMA	Code Division Multiple Access
CDPD	Cellular Digital Packet Data
CONOPS	Concept of Operations
CMS	Changeable Message Sign
DCM	Data Collection and Monitoring
DATEX-ASN	Data Exchange ASN.1
DARC	Data Radio Channel System
DOTD	Department of Transportation and Development
DB	Design-build
DMS	Dynamic Message Sign
E9-1-1	Enhanced 9-1-1
EDGE	Enhanced Data for Global Evolution
EM	Emergency Management
EOC	Emergency Operations Center
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FR	Functional Requirement
GHz	Gigahertz
GSM	Global System for Mobile Communication
HAR	Highway Advisory Radio
IEEE	Institute of Electrical and Electronic Engineers
IM	Incident Management
ISO	International Standards Organization
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
Kbps	Kilobits per Second
MHz	Megahertz
MOU	Memorandum of Understanding
NEC	National Electric Code
NEMA	National Electrical Manufactures Association
NTCIP	National Communications for ITS Protocol
NS	Network Surveillance
O&M	Operations and Maintenance
OER	Octet Encoding Rules
OFDM	Orthogonal Frequency Division Multiplexing
PAR	Peak-to-Average Ratio
PCS	Personal Communications Services
POTS	Plain Old Telephone Service

PR	Performance Requirement
RVD	Radar Vehicle Detector
RFP	Request for Proposals
SCP	Signal Control and Prioritization
SDO	Standard Development Organizations
SE	Systems Engineering
SNMP	Simple Network Management Protocol
STIC	Sub carrier Traffic Information Channel System
STMF	Simple Transportation Management Framework
STMP	Simple Transportation Management Protocol
SSC	Surface Street Control
TCP/IP	Transmission Control Protocol/Internet Protocol
TIS	Traveler Information System
TIM	Traffic Incident Management
TMC	Traffic Management Center
TMP	Transportation Management Protocols
TOC	Traffic Operations Center
TSS	Transportation Sensor Systems
UDP/IP	User Datagram Protocol/Internet Protocol
US	United States
USDOT	United States Department of Transportation
VD	Vehicle Detector
WAN	Wide Area Network
WLAN	Wireless Local Area Network

3 Project Physical Architecture

3.1 Stakeholders

The project will involve the interaction of multiple agencies located within the region. It is anticipated that project deployment will provide the tools that will allow these stakeholders to facilitate their traffic and transportation management roles. Project stakeholders within the project boundaries include:

- DOTD ITS Section
- DOTD ITS Statewide TMC
- DOTD Baton Rouge (BR) TMC (i.e., DOTD ITS Operations at the ATM/EOC)

3.2 Project Architecture

It is essential that a project physical architecture be developed to illustrate the important ITS interfaces and the major system elements. The project physical architecture assigns processes from the logical architecture to subsystems, and it groups data flows from the logical architecture into architecture flows. These flows and corresponding communication requirements define the interfaces which are a main focus of the project ITS standards. The elements identified for this project are listed below. **Figure 2** illustrates the project physical architecture under consideration. It graphically depicts the overall understanding of the physical architecture elements and architecture flows associated with the project. Note the project to be deployed is a continuation of the existing system within Baton Rouge, so no planned elements are indicated within **Figure 2**. Illustrated project architecture elements are as follows:

- DOTD ITS Statewide TMC
- DOTD ITS Section
- DOTD Baton Rouge TMC
- DOTD Baton Rouge CCTV
- DOTD Baton Rouge DMS
- DOTD Baton Rouge VD

Note the DOTD ITS Statewide TMC and DOTD ITS Section elements are in accordance with the *Baton Rouge Regional ITS Deployment Plan, Regional ITS Architecture* (i.e., regional architecture) dated 2006. The DOTD BR TMC is an instance of the regional architecture element "DOTD District 61 Traffic Operations Center." Similarly, the DOTD Baton Rouge CCTV, DMS and VD are instances of "DOTD Baton Rouge ITS Field Devices."

The Capital Region Planning Commission (CRPC) is the Baton Rouge area's designated Metropolitan Planning Organization (MPO). Each metropolitan area must have an MPO in order to carry out regional transportation planning efforts and receive federal highway funds. The Baton Rouge Region includes a large part of East Baton Rouge Parish, the northern portion of Ascension Parish, the eastern portion of West Baton Rouge Parish, the northeast portion of Iberville Parish and the western portion of Livingston Parish. The ITS Statewide TMC and DOTD BR TMC are located in East Baton Rouge Parish.

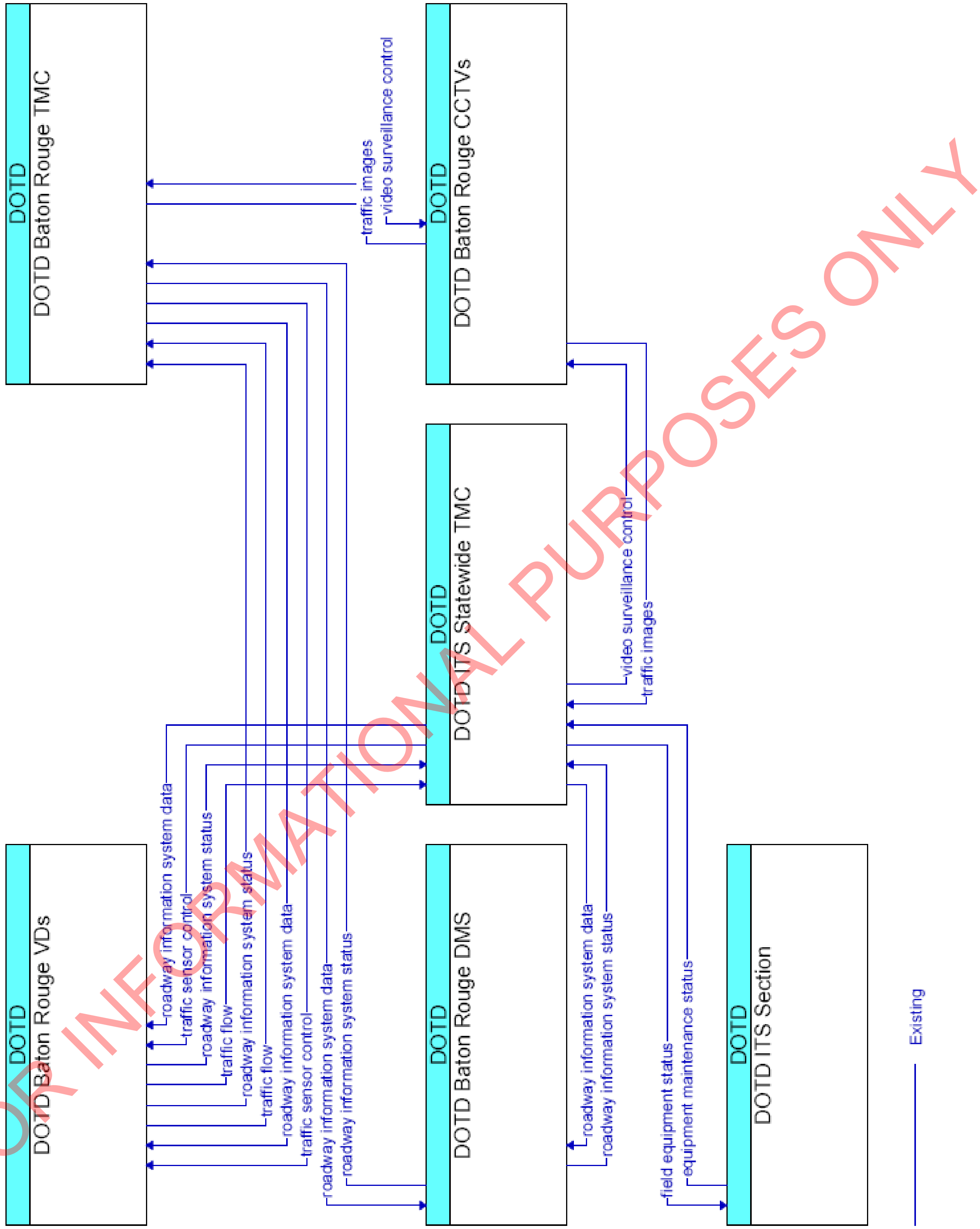


Figure 2: Existing Project Physical Architecture and Data Flows

Note this project deploys new instances of existing elements and architecture flows.

4 Concept of Operations

Concept of Operations (ConOps) describes how the proposed system will function, the environment in which it will operate, and the people who will use and support the system. ConOps identifies the stakeholders involved in the project and their responsibilities. It also describes the roles and responsibilities for operations and maintenance of the various system users.

The ConOps is a non-technical discussion of the ITS system that should be understood by all project stakeholders. The ConOps presents a view of the operational system once the project is completed, the intended benefits of the system, and the impact on the region in which it is deployed.

4.1 Needs

The purpose of the Baton Rouge to New Orleans ITS-TIM Phase 3 Project is to reduce the negative impacts of traffic congestion and incidents within the Baton Rouge area. **Figure 3** is a map of the project limits with specific areas highlighted, based on the indicated project needs.

The project needs have been identified as:

- To detect, verify, and assess traffic congestion and incidents
- To distribute information to motorists in a timely manner
- To provide system monitoring and coordinated operations between the DOTD ITS Statewide TMC and DOTD Baton Rouge TMC.

4.2 Scope

The Baton Rouge to New Orleans ITS-TIM Phase 3 Project provides for the interaction of six elements as previously identified in the Project Physical Architecture **Figure 2**. The scope of this project includes the deployment of the ITS equipment components, communications, and integration.

The goal of the project is to expand the existing ITS system that will provide DOTD with traffic surveillance and management tools to more effectively facilitate traffic and incident management activities through the Baton Rouge area. Additional ITS field equipment will improve the ability of DOTD to detect, verify, advise affected motorists, respond, manage traffic, and clear traffic incidents within the project limits. The project goal is improve mobility and safety for all motorists.

The design-build (DB) contracting method is to be used by DOTD to implement a fully operational ITS project. There are a number of advantages for DOTD when using the design-build contracting technique. First, it allows the design-builder the flexibility of implementing an ITS system with the most recently tested and effective technologies. Second, the overall risk for designing, constructing, testing and implementing the ITS system falls to the design-builder. Third, this process should reduce project implementation time.

It is intended that TMC operations staff in the DOTD ITS Statewide and DOTD Baton Rouge TMC will operate the ITS field equipment to be deployed by this project.

4.3 Justification for the ITS Project

The section of I-10 within the project limits has only one alternative route suitable for interstate traffic, US-61 (Airline Highway). The recommended route for access to the alternate route is I-10/I-12 interchange in Baton Rouge eastbound on I-12 to US-61. The distance from the I-10/I-12 interchange to US-61 (Sorrento) is approximately 28 miles. Over the 28 miles there are numerous rural roads which are not suited for interstate traffic of which eight have been identified as secondary alternate routes. Due to the numerous routes and limited access, immediate detection, response, site management, and motorist notification of incidents is critical to travel.

There are currently a limited quantity of deployed ITS field devices to monitor and direct traffic along the primary alternate route. In the event of a major traffic incident on I-10 that blocks travel lanes for a prolonged duration, it is essential that conditions on the primary alternate route be known and that traffic on that route be actively managed. ITS improvements are essential to address these needs.

4.4 Existing Operations

Within the project limits, DOTD BR TMC actively monitors the existing closed circuit television cameras (CCTV) along I-10, I-12 and I-110, within the project limits. Also, the DOTD BR TMC operates dynamic message signs (DMS) and radar vehicle detectors (RVD) within the project limits with oversight provided by the DOTD ITS Statewide TMC.

The DOTD BR TMC currently uses the Management Information System for Transportation (MIST™) for the monitoring and control of DMS and vehicle detectors (VD) plus software provided by 360 Surveillance for monitoring CCTV cameras. The DOTD ITS Statewide TMC similarly uses a MIST™ client for the monitoring and control of DMS and VD within the region, and also uses software provided by 360 Surveillance for CCTV camera monitoring and control. Vendor software is commonly used by both TMCs for some of the DMS manufactured by 3M. These specific DMS have not been integrated into MIST™ due to their operations being via dial-in phone communications. Vendor software for other devices is used when the normal operating system is out of service.

ITS Operations at the Traffic Management Centers are as indicated below. Note DOTD ITS Statewide TMC operates for DOTD BR TMC after hours.

DOTD BR TMC
hours: 6 AM -10 PM, M -F
1 – TMC Operations Supervisor 8hr M-F
2 – TMC Operator 8hr/ea. M-F

DOTD ITS Statewide TMC
hours: 24/7, 7-Days/Wk
1 – Statewide TMC Operations Manager 8hr M-F
3 – TMC Operators 8hr/ea., 7-Days/Wk
1 – TMC Operator (Construction Coord.) 8hr M-F

Communication hub buildings within the project boundaries are located at the I-10/I-110 Split, I-10/I-12 Split and I-10 at Siegen Ln. Fiber optic cabling extends from the ATM/EOC, 3773 Harding Blvd, along I-110 to the hub building located at the I-10/I-110 split. From the West side, fiber cabling extends from LA-415 (Lobdell Hwy.), to the hub building located at the I-10/I-110 split. From the I-10/I-110 split, fiber optic cabling also extends along I-10 to the hub building located at the I-10/I-12 split and continues along I-12 to Airline Hwy. At the hub building located at the I-10/I-12 split, fiber optic cabling extends south along I-10 just passing Siegen Ln.

Figure 4 shows the locations of the previously mentioned ITS field devices existing within the project limits.

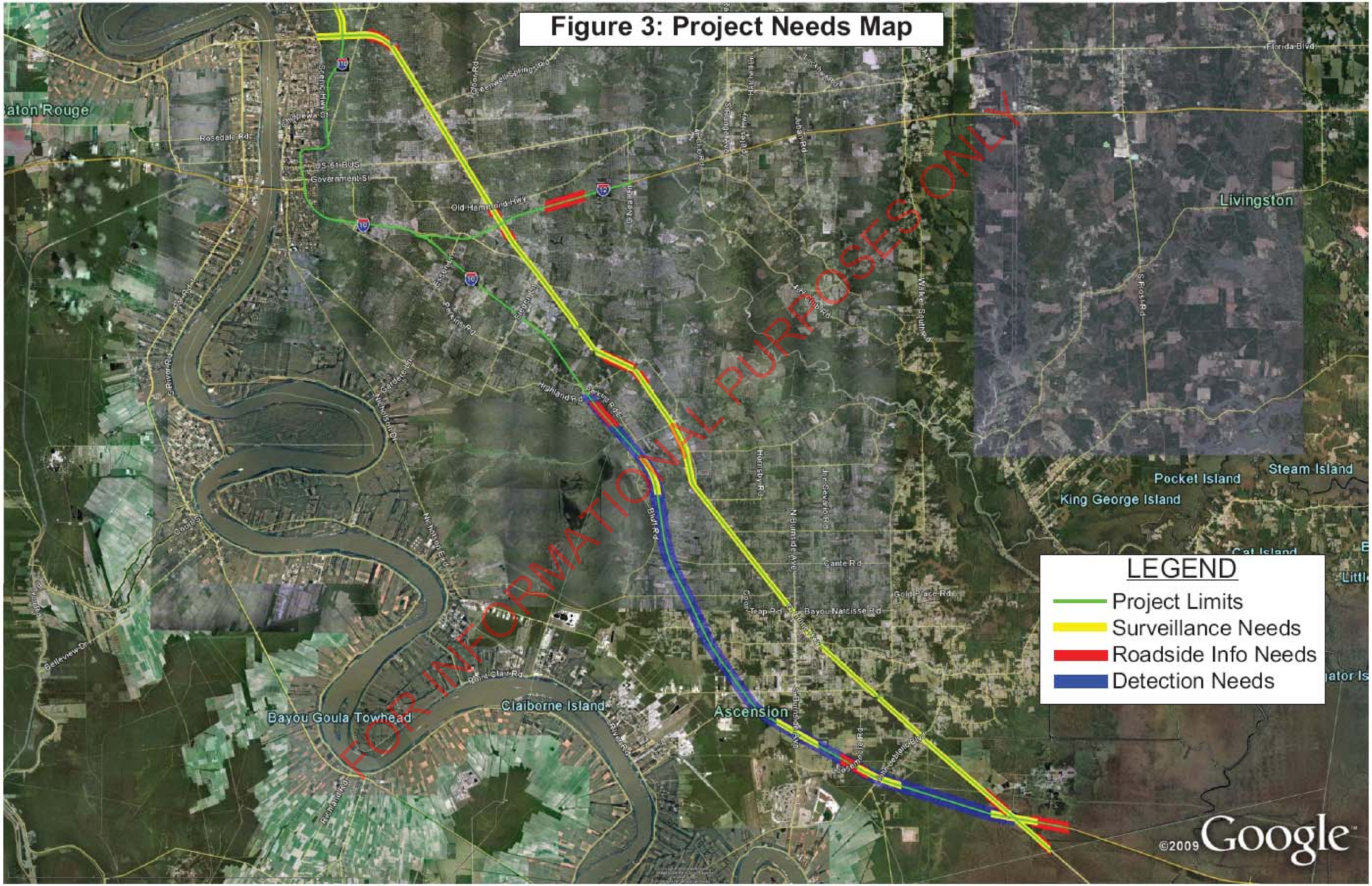


Figure 3: Project Needs Map
LEGEND
Project Limits
Surveillance Needs
Roadside Info Needs
Detection Needs
FOR INFORMATIONAL PURPOSES ONLY
Baton Rouge
Livingston
Pocket Island
Steam Island
King George Island
Ascension
Claiborne Island
Bayou Goula Towhead
©2009 Google

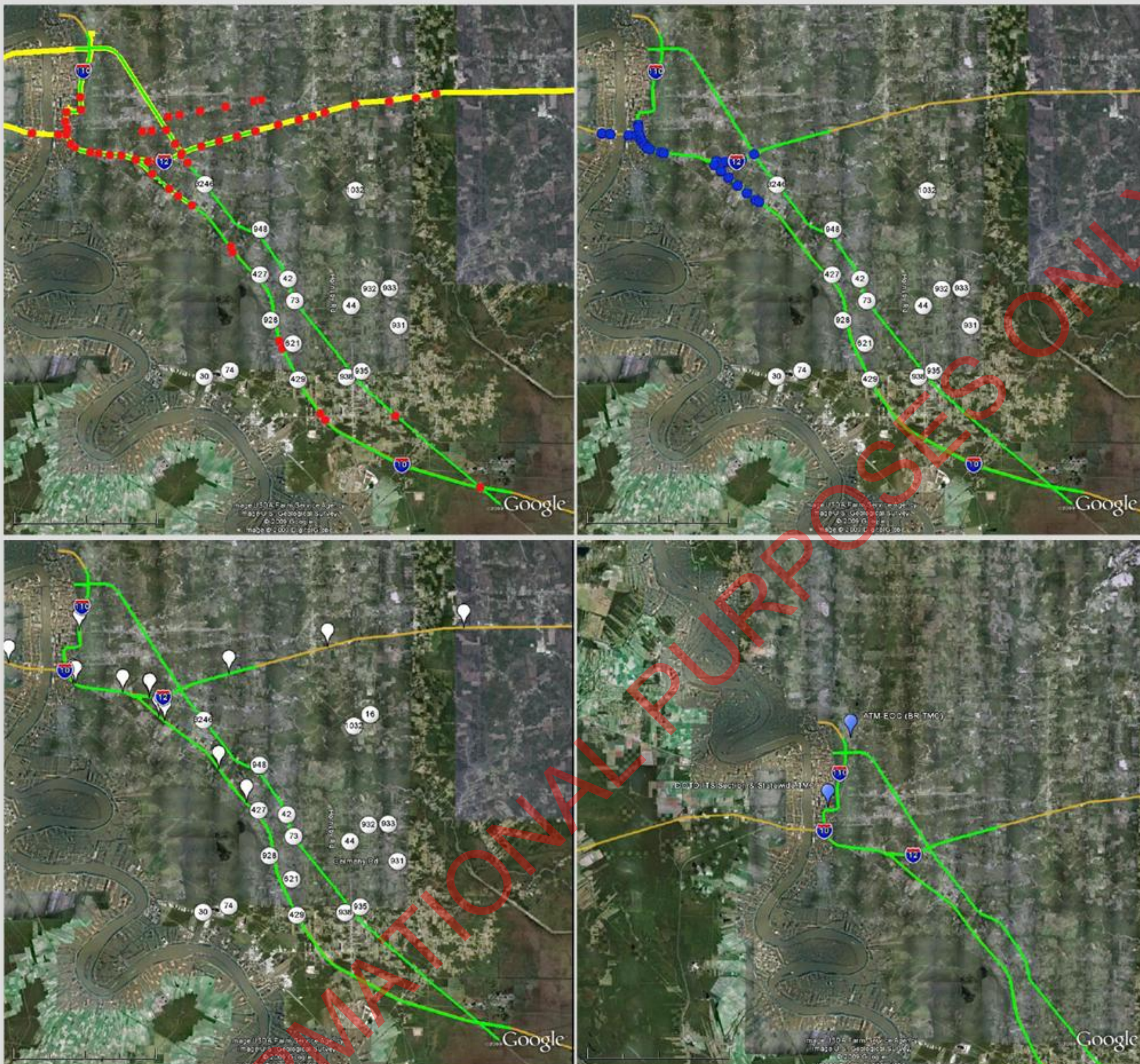
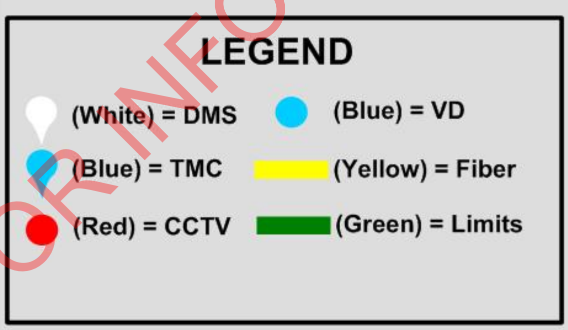


Figure 4: Existing ITS Devices



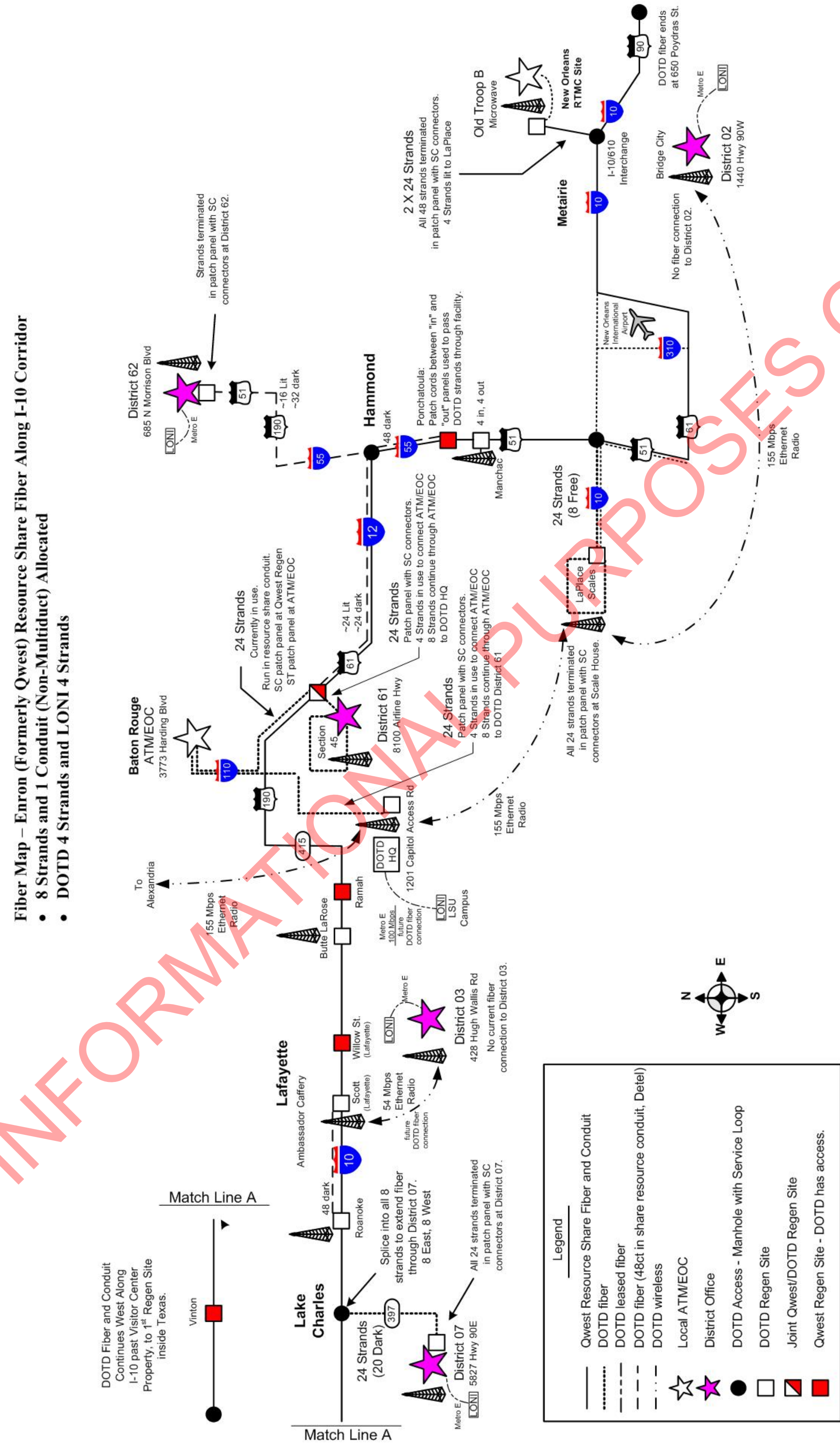


Figure 5: Existing Communication Infrastructure

4.5 System Overview

The Baton Rouge to New Orleans ITS-TIM Phase 3 proposed project architecture is based on a distributive system design with a centralized TMC computer server located at the DOTD BR TMC. The system shall bring all data and video communication together on one backbone network making all data and video available to any system that has access to the same backbone network.

DOTD BR TMC is currently connected to the DOTD communication backbone. Upgrade to existing communications and integration of the ITS field equipment deployed by the project with the Statewide TMC will be provided by others outside of the deployment project.

A distributed traffic incident and emergency management system requires a highly reliable and robust communications network. As previously stated, DOTD existing fiber backbone as shown in **Figure 5** is available to supplement the communication needs for the project limits.

The ITS field equipment deployed by this project will initially be operated by vendor software. DOTD will integrate the deployed ITS field equipment with traffic management software outside of the deployment project at a later date.

4.6 Operational Environment

The operational environment for the Baton Rouge to New Orleans ITS-TIM Phase 3 Project includes a description of operational procedures, skills and experience of personnel, security issues and processes, communications, data management, and ownership. Since this project is adding ITS field devices to an existing system, the operational environment will not change.

Currently, TMC operations staff are operating each TMC based on the Standard Operator's Procedures (SOP) for the DOTD BR TMC. The Statewide TMC Operations Manager is in the process of developing an SOP for each TMC. Each SOP will standardize operations across the state, yet cater to the local needs of the region. For additional information or a copy of the DOTD BR TMC SOP, please contact the DOTD ITS Section.

4.7 Operational Scenarios

The Operational Scenarios describes a sequence of events and activities that are carried out by the user, system, and environment. Operational Scenarios identify what event or action initiates the sequence, who or what performs each step, and when communications occur (to/from whom or what). A typical incident scenario may unfold as follows:

- A truck travelling Southbound on I-10 overturns spilling its load of pipe, triggering a chain reaction of secondary accidents, blocking southbound lanes of traffic
- Motorists dial 911, and first responders are dispatched.
- If TMC Operators have not yet already visually verified the incident, vehicle detectors trigger alarm conditions which notify TMC Operators that traffic is building up behind it.

- TMC Operators move CCTV cameras to get visual verification.
- TMC Operators post messages to local DMS signs warning motorists of a traffic incident, and notify them of the alternate route.
- TMC Operators continue to visually monitor the emergency situation until traffic incident is cleared by first responders
- TMC Operators remove posted messages to DMS signs.
- All conditions return to normal operation.

For this project, each function consists of a process used to respond to traffic incidents and access ITS field equipment.

4.7.1 Traffic Incident Management Operations (TIM)

The major steps in an incident scenario as applicable to this project can be broken down as follows.

- **Detection**

The TMC Operators at DOTD ITS Statewide TMC and DOTD BR TMC will have the ability to use CCTV cameras and vehicle detectors located along I-10 for their operations. These cameras and detectors, along with other existing detectors outside of the project, will be used to determine travel times, gather traffic data, and help detect traffic incidents. DOTD ITS Statewide TMC and DOTD BR TMC will have the ability to view data from the detectors via compiled reports and the graphical user interface that is part of the traffic management software. The other major detection source are the cell phone emergency calls to “911.”

- **Verification**

In the event of an incident, if the given location is near a CCTV camera, the TMC Operator will have the ability to verify the incident from either TMC. TMC operations staff can monitor CCTV cameras in the system through its connection into DOTD’s network.

- **Response**

The TMC Operators at DOTD ITS Statewide TMC and DOTD BR TMC will have the ability to post messages on DMS boards to be located at decision points, defined as points where motorists can make a decision whether or not to take an alternate route or remain on the route. Alternate routing will be provided in the occurrence of an incident or emergency. Note DMS deployed by the project are only within DOTD BR TMC operations region.

- **Traffic Management**

When interstate traffic is redirected via an alternate route, the responsible traffic operations engineer's office is notified via e-mail of the incident and the posted alternate route. Hourly updates are also provided. DOTD BR TMC will notify DOTD ITS Statewide TMC of such occurrences. Likewise, the adverse may occur.

- **Return to Normal Traffic Flow**

After an incident has been cleared and verified, the TMC Operators clear rerouting messages on the DMS.

4.7.2 Other Event Management

During other events, the TMC Operator will post specific advisory messages on DMS. There are many potential types of events, including:

- Construction/maintenance activities
- Planned special events
- Major emergencies involving regional evacuation (e.g., hurricanes)
- Amber Alerts
- Miscellaneous motorist advisories.

In each case, the response and management effort must be geared to the severity and extent of the event.

For events within the region, TMC Operators will operate the system from the DOTD BR TMC. For multi-region or statewide emergencies (e.g., hurricane evacuation), the DOTD ITS Statewide TMC will control and operate the CCTV cameras, VD, and DMS.

4.8 Summary of Impacts

Table 1 shows the project impacts of deployment resulting from this study document for each center below. This table lists the connections that will be established as a part of this project. It should be noted that additional operations and maintenance will vary for each center based on the level of use chosen. As connections are made to the local and statewide backbone, the regional architecture will need to be updated to show the connections.

Table 1: Summary of Impacts

Center	Impact				
Connected Centers	Network surveillance (Monitor CCTV cameras)	Network surveillance (Control CCTV cameras)	Post messages to DMS	Post messages to HAR	Monitor Vehicle Detectors
DOTD ITS Statewide TMC	•	•	•	•	•
DOTD Baton Rouge TMC	•	•	•	•	•

5 Requirements

Requirements provide a foundation of information needed to move from the conceptual view presented in the ConOps to the concrete view that defines what must be done and included in the project design. These requirements form the basis for design, implementation, testing and operations. The requirements shown herein are based on the system as envisioned to date. The final requirements for the deployment project will be identified within the project contract.

The DOTD BR TMC will manage the ITS field equipment deployed as part of this project. To facilitate efficient flow of information, all needs have been identified as being functional requirements (FR) Note some functional requirements contain performance measures.

5.1 ITS Field Equipment Roadside Devices

Due to budgetary constraints, the needs identified in Figure 3 may not be fully satisfied by the final designed and constructed project. The design-builder will be required to provide the best solution within DOTD's constrained budget. Possible roadside devices to be deployed may include dynamic message signs, closed circuit television cameras, vehicle detectors and highway advisory radio (HAR). The design-builder will be required to meet these functional requirements when implementing these roadside devices as part of the ITS.

5.1.1 Dynamic Message Signs

- The system shall control DMS from the computer console at the DOTD BR TMC using the graphical user interface (GUI) provided as part of vendor software

FR1.1 The system shall post a message on the selected DMS within 10 seconds after the user's execution of the GUI command to post the message

FR1.1.1 The system shall post a message in upper case text

FR1.1.2 The system shall post a message composed of a maximum of 3 lines of text with 15 characters per line

FR1.1.3 The system shall post a message composed of a maximum of 2 frames

FR1.1.4 The system shall post a flashing message

FR1.1.5 The system shall post a message in reverse video (black characters on amber background)

FR1.1.6 The system shall post a scrolling message

FR1.2 The system shall display confirmation of a message posted on the selected DMS within 15 seconds after the user's execution of the GUI command to post the message

FR1.3 The system shall control the flashing strobe on the selected DMS

FR1.3.1 The system shall activate the flashing strobe within 10 seconds after the user's execution of the GUI command to activate the flashing strobe

FR1.3.2 The system shall deactivate the flashing strobe within 10 seconds after the user's execution of the GUI command to deactivate the flashing strobe

FR1.4 The system shall display fault information from the DMS on the GUI within 30 seconds after the fault occurs

FR1.4.1 The system shall display notification of power failure

FR1.4.2 The system shall display notification of unrecognized commands

FR1.4.3 The system shall display notification of communication errors

FR1.4.4 The system shall display notification of pixel failure

FR1.5 The system shall control DMS reset features from the GUI

FR1.5.1 The system shall reset the DMS controller

FR1.5.2 The system shall reset the DMS pixel assemblies

FR1.5.3 The system shall reset the DMS IP addressable battery backup

5.1.2 Video Surveillance – closed circuit television cameras

FR2 The system shall control CCTV cameras from the computer console at the DOTD BR TMC using the GUI provided as part of the vendor software

FR2.1 The system shall display live video from the selected CCTV camera within 10 seconds after the user's execution of the GUI command to display the live video

FR2.1.1 The system shall display live video at the user defined frames per second

FR2.2 The system shall stream live video with a maximum of 5 seconds of latency

FR2.3 The system shall pan the selected CCTV camera within 1 second after the user's execution of the GUI command to pan the camera

FR2.3.1 The system shall pan the camera between 0 and 360 degrees continuously

FR2.4 The system shall tilt the selected CCTV camera within 1 second after the user's execution of the GUI command to tilt the camera

FR2.4.1 The system shall tilt the CCTV camera to intervals between 0 (horizontal) to 90 degrees (straight down)

FR2.5 The system shall zoom the selected CCTV camera within 1 second after the user's execution of the GUI command to zoom the camera

FR2.6 The system shall pan, tilt, and zoom to the selected user defined preset for the selected CCTV camera within 1 seconds after the user's execution of the GUI command to execute the preset

FR2.7 The system shall block-out zones designated by the user on the selected CCTV camera

FR2.8 The system shall display the selected CCTV camera's user defined text (i.e., name) within 5 seconds after the user's execution of the GUI command to display the user defined text

FR2.9 The system shall display the CCTV camera's IP address within 5 seconds after the user's execution of the GUI command to display the IP address

FR2.10 The system shall display fault information from the CCTV camera on the GUI within 30 seconds after the fault occurs

FR2.10.1 The system shall display notification of power failure

FR2.10.2 The system shall display notification of communication errors

FR2.10.3 The system shall display notification of pressure loss

FR2.11 The system shall control the CCTV camera's reset features from the GUI

FR2.11.1 The system shall reset the CCTV camera IP addressable battery backup

FR2.11.2 The system shall reset the CCTV camera power supply

FR2.11.3 The system shall reset the CCTV camera controller

FR2.11.4 The system shall reset the CCTV camera video encoder

5.1.3 Vehicle Detection

FR3 The system shall control vehicle detectors from the computer console at the DOTD BR TMC using the GUI provided as part of the vendor software

FR3.1 The system shall download data collected from selected vehicle detectors at the user defined poll rate

FR3.1.1 The system shall download average time mean speed per lane

FR3.1.2 The system shall download the total vehicle per hour per lane

FR3.1.3 The system shall download the volume of the classifications in vehicles per hour per lane

FR3.2 The system shall stream live data with a maximum of 5 second of latency

FR3.3 The system shall display data collected from the selected vehicle detector within 10 seconds after the user's execution of the GUI command to display the data

FR3.3.1 The system shall display average time mean speed per lane

FR3.3.1.1 The system shall display the time of the average time mean speed

FR3.3.1.2 The system shall display the duration of the average time mean speed

FR3.3.1.3 The system shall display the date of the average time mean speed

FR3.3.2 The system shall display the total vehicle per hour per lane

FR3.3.2.1 The system shall display the time of the total vehicle volume

FR3.3.2.2 The system shall display the duration of the total vehicle volume

FR3.3.2.3 The system shall display the date of the total vehicle volume

FR3.3.3 The system shall display the volume of the selected classification in vehicles per hour per lane

FR3.3.3.1 The system shall display the time of the volume

FR3.3.3.2 The system shall display the duration of the volume

FR3.3.3.3 The system shall display the date of the volume

FR3.4 The system shall display the selected vehicle detector user defined text (i.e., name) within 5 seconds after the user's execution of the GUI command to display the user defined text

FR3.5 The system shall display the selected vehicle detector IP address within 5 seconds after the user's execution of the GUI command to display the IP address

FR3.6 The system shall display fault information from the vehicle detector on the GUI within 30 seconds after the fault occurs

FR3.6.1 The system shall display notification of power failure

FR3.6.2 The system shall display notification of communication errors

FR3.7 The system shall control the selected vehicle detector’s reset features from the GUI

FR3.7.1 The system shall reset the vehicle detector IP addressable battery backup

FR3.7.2 The system shall reset the vehicle detector power supply

FR3.7.3 The system shall reset the vehicle detector controller

5.1.4 Highway Advisory Radio – HAR

FR4 Highway advisory radio (HAR) shall be used to disseminate information to in-route travelers

FR4.1 HAR shall provide in-route messages to travelers via AM radio broadcast.

FR4.1.1 HAR shall be broadcasted on a predefined AM radio station

FR4.2 HAR messages shall provide transportation related information

FR4.2.1 HAR messages shall warn motorists of possible hazards, road delays or detours i.e.: forest fire, weather advisories, chemical spill, survey/testing crews, and/or construction or maintenance

FR4.2.2 HAR messages shall warn motorists of road closure or delay due to a incident or emergency situation

FR4.2.3 HAR messages shall advise motorists of future activities that may result traffic disruptions such as construction and/or maintenance activities

FR4.2.4 HAR messages shall advise motorists of speed limit changes which may be temporary

FR4.2.5 HAR messages shall provide safety initiatives such as i.e.: Buckle Up, Drive Safely

FR4.3 HAR messages shall be FCC licensed AM band broadcast

FR4.3.1 HAR to be broadcast on a licensed frequency between 530 kHz and 1710 kHz

FR4.4 HAR shall be broadcasted using a minimum of 10-watt transmitters

FR4.4.1 Broadcast radius shall be a minimum of 3 miles depending on topography, atmospheric conditions, and the time of day

FR4.5 HAR shall be point broadcasted

FR4.5.1 A single transmitter shall be used to broadcast over a given area

FR4.6 HAR shall be programmable

FR4.6.1 HAR controller shall be programmed using a central control software on a desktop computer

FR4.6.1.1 Central control software shall allow digital audio messages to be entered into the system

FR4.6.2 HAR controller shall be programmed using telephone (cell phone or landline)

FR4.7 HAR shall provide live broadcast

FR4.8 HAR shall store a minimum of 250 pre-recorded messages

FR4.9 HAR shall have minimum of 80 minutes of recording time allowed

FR4.10 HAR shall have minimum 2 day message backup

FR4.11 HAR controller shall provide fault information to the center

FR4.11.1 HAR controller shall provide transmitter power failure

FR4.11.2 HAR controller shall provide advisory sign failure

FR4.11.3 HAR controller shall provide unrecognized commands

FR4.11.4 HAR controller shall provide IO board errors

FR4.11.5 HAR controller shall provide communication failure

FR4.12 HAR controller shall provide the status information at a minimum to the center

FR4.12.1 HAR controller shall provide a unique HAR ID

FR4.12.2 HAR controller shall provide the HAR location

FR4.12.3 HAR controller shall provide the time and date of the broadcasted message

FR4.13 HAR shall manage a minimum of 4 roadside advisory signs per transmitter

FR4.13.1 User shall be able to activate the flashing beacons on the roadside sign

FR4.13.2 HAR roadside advisory signs shall be able to activated/deactivated independently

FR4.14 HAR transmitter site shall have an IP addressable battery backup

FR4.14.1 IP addressable battery backup shall allow for the broadcast of programmed messages for 3 days minimum

5.2 Requirements Traceability Matrix

The purpose of the requirements traceability matrix is to identify the section of the Concept of Operations document from which the requirement is derived, as well as the high level and associated detailed requirements. Once design and implementation are completed, the matrix will contain the linking information to the design specifications and implementation information that addresses requirements. The Traceability Matrix provides a check list for construction testing and acceptance by the Project Engineer, as well as the link between completion of individual pay items and implementation of the basic purpose and scope of the project. The Requirements Traceability Matrix is provided in **Appendix B, Table B-1**.

6 System Design

As part of a Systems Engineering process, a system design is required for an ITS project. The system design process defines how a system will be built. The design activities supported in a DOTD ITS project result in a design document that contains both high-level and detailed design specifications as well as any supporting information needed to implement and integrate ITS facilities.

A system design is developed from the system requirements. For the Baton Rouge to New Orleans ITS-TIM Phase 3 Project, these requirements have been previously defined (please refer to Section 5). Since the previous requirements section has defined what the system will do, the requirements will be translated into a hardware and software design that can be deployed.

The system design process has two phases. The first phase is high-level design where high level requirements are translated into decisions about how the system will be built, how subsystems are organized, and how verification should be handled at a high level. In the high-level design process, design concepts are developed. During the second phase of design, plan sets and top-level specifications are defined in detail and at a level where implementation is supported. As part of this project, design concepts are satisfied and detailed design specifications are developed.

Since the Baton Rouge to New Orleans ITS-TIM Phase 3 Project is to use the design-build method, the high-level design is provided as part of the Proposal submitted in response to the Request for Proposals (RFP) document. The detailed design will be required to meet the technical specifications section of the RFP.

6.1 High-Level Design

The high-level design process gives way to the development of an overall system design prior to working out the details of an individual system. While the Concept of Operations and Requirements of the project have been identified based on the purpose and the need for the ITS project (sections 4 and 5, respectively), the detailed design, to be completed by the Designer, will contain all the intricate details of the overall project.

The project is divided into subsystems, based on similar components, and will ultimately be aggregated onto a single communications backhaul to the TMC. Each subsystem has its purpose, functionality, and interface with other subsystems and component parts. Major data flows can be seen in the Project Physical Architecture, **Figure 2**.

Subsystems comprised of the ITS devices located along the primary and alternate routes within the project will possibly include vehicle detection devices, CCTV cameras, highway advisory radios (HAR) and DMS signs. The DOTD Statewide TMC and DOTD BR TMC networks are a part of the larger statewide network architecture. All of these communicate through the communications backbone, passing data, video images, and control to achieve the desired ITS functionality and improve operations and safety.

6.1.1 Hardware and Software Components

The hardware and software components of each subsystem are connected to the communication backbone. These components are defined in the Functional Requirements section of the Technical Specifications.

A communications alternative section has been developed as part of this System Engineering analysis. Please refer to section 9, Alternative Communications Configurations, for information regarding connections between subsystems, hardware components, and software implementation. Please note that different types of communication connectivity are explored.

6.2 Detailed Design

As previously stated, the detailed design provides the detailed plans and configuration needed for system implementation. For the Baton Rouge to New Orleans ITS-TIM Phase 3 Project, refer to section 7 for the Alternative Communications Configurations, section 7.2 for power configuration analysis, section 7.3 for Software Alternative Configuration, and Appendix C for analysis on the various design options available for the deployment of this project.

7 Alternative Configurations

The alternatives analysis evaluates a number of communication and power technologies to determine their application to fulfill the needs of this project. For power service, the trade-offs from a distributed power system are evaluated to that of an individual point-source supply. Satisfactory communications require the identification of a transmission medium that accommodates the current information demand and provides capacity to meet future system demand. The selected transmission medium must be capable of handling system communication needs at a high operational performance level. Various communication technologies are provided and discussed in **Appendix A.**

Life cycle cost (LCC) analyses have been provided for this system engineering analysis. See section 7.4 of this document. The LCC provides a look at the overall project cost for various project configurations. For the configurations analyzed, specific field devices were chosen to meet the project need. Although these configurations were chosen for this document, the design-builder is not limited to. The configurations analyzed are summarized below.

The first configuration analyzed predominately consists of fiber optic communications to all proposed ITS devices and point source power where local utility service is available. The proposed DMS sign for I-10 westbound located East of the I-10/US-61 interchange requires power from the proposed Hub building at the I-10/US-61 interchange. Vehicle detection sites along I-10 per this scenario use solar power and communicate via a low bandwidth wireless transceiver.

The second configuration analyzed predominately consists of fiber optic communications to all ITS devices as well a distributed power system. The analyzed distributed power system is a continuation of the existing system deployed as part of Baton Rouge ITS Deployment Phases 1 and 2 projects, US-61 Widening project, and I-10 Widening Project. This system uses 480 VAC power sources from the Hub buildings and step down transformers at the ITS device locations. The analysis takes into consideration the required power runs (distances), the cost of copper wiring, and voltage drops. The caveat to this scenario is the capital costs for copper wiring. Vehicle detection sites along I-10 between Siegen and the WB DMS East of Highland are connected to the distributed power and communicate via fiber. The remaining vehicle detectors use solar power and communicate via wireless transmission.

The final configuration analyzed consists of wireless communications and point source power. All DMS, vehicle detection, and CCTV cameras communicate via spread spectrum and point-to-point wireless communication media, dependent on line of sight and required bandwidth. All vehicle detection sites along I-10 use solar power.

7.1 Project Communications

Implementation of the Baton Rouge to New Orleans ITS-TIM Phase 3 project directly connects ITS field equipment to DOTD ITS BR TMC and the DOTD ITS Statewide TMC.

The connection of the center and the ITS field equipment is in compliance with the requirements for the Baton Rouge Regional Architecture which promotes maximizing interoperability for the statewide ITS network.

Three viable communications technologies are considered feasible: fiber optics, point-to-multipoint high frequency wireless, and point-to-point microwave. Each one (or a combination) can provide the data transmission capacity, reliability, and scalability to address the communications needs per the different applications identified for the project. The primary element of differentiation for these technologies is the cost and reliability associated with their implementation.

The existing fiber backbone presented in **Figure 5** of this document was provided to DOTD as part of previous projects and/or through permits. DOTD currently owns 3 towers within the project limits that may allow for wireless expansion to cover communications to field devices as well. Towers identified within the project limits include (1) DOTD HQ at 1201 Capital Access Rd., (2) District 61[1] at 8100 Airline Hwy., and (3) tower located in Brittany, LA.

7.2 Power Configuration

Electrical power for the Baton Rouge to New Orleans ITS-TIM Phase 3 Project is a significant component in its implementation. The criteria for power design are primarily the power needs of the ITS field equipment (DMS, CCTV, HAR and/or VD) and the ease of accessing commercial power. The cost of supplying commercial power to ITS field equipment components can be substantial if it is not readily accessible. DOTD has deemed, in order to obtain the reliability required to operate the ITS field equipments, commercial power is required at all ITS device locations.

As previously indicated, the existing ITS in Baton Rouge operates via a distributed power system due to the close spacings of devices. Also a project adjacent to the Baton Rouge Metropolitan Area uses a distributed power system where a high voltage primary power source is run for long distances, and then stepped down to secondary power via step down power transformers. This option was used because of the desire to locate ITS devices on the bridges extending over the Bonnet Carre spillway that lack power sources to tap. This type of option is very costly mainly because of the increased cost in copper wiring, and the quantity of cabling to cover long distances. However, the benefits include providing a single point for commercial power and for back-up power. There is less risk of the entire fiber network going down due to a single device power outage.

In the current project, field visits and the use of aerial photography allow for overhead power utilities to be identified where ITS devices are desired. Due to the location of commercial power, the design-builder can request a metered power source to be located adjacent to almost any ITS device location. Expenses in copper wiring is greatly reduced compared to a distributed power such as was required for the Bonnet Carre spillway. However, the trade-off to cost is reliability.

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[1] Tower at District 61, 150 ft. self supporting, is not currently connected to the DOTD fiber backbone.

There are a few areas along I-10 where vehicle detection is needed and commercial power is not readily available. In those locations, it may be appropriate to consider solar power options as an alternative. In these cases, the detection devices than can easily be served by solar due to the low power draw.

7.3 Software Alternative Configurations

An important component of the Baton Rouge to New Orleans ITS-TIM Phase 3 Project is the system software necessary to manage and communicate with the different ITS field components associated with the project. As previously mentioned, DOTD currently is using MIST™ to operate the DMS and VD from the BR TMC. Also, TMC Operators use vendor software to operate some DMS as well as other field devices when the primary operations system is out of service.

More recently, DOTD has implemented a traffic management software product by 360 Surveillance titled Cameleon ITS at the DOTD ITS Statewide TMC, Houma Subdistrict 02, and District 04 TMC - Shreveport. Cameleon ITS is a system software package that allows operators to monitor and manage ITS field equipment from a central TMC (or multiple TMCs). DOTD envisions Cameleon as an interim solution until they better define their statewide ITS software integration needs.

It is a requirement of this project that the system be tested using vendor software. Outside the deployment project, DOTD will integrate the ITS field equipment with the traffic management software operating at the DOTD ITS Statewide TMC and DOTD BR TMC.

7.4 Life Cycle Funding

Life cycle funding from the systems engineering perspective is a total project process. In other words, the total costs (i.e. need for funding in constant or inflated dollars) associated with the successful development, implementation, operation, and maintenance for the "life" of an ITS project must be determined. A life cycle cost analysis provides DOTD with a realistic assessment of funding needs for their ITS projects and programs. This information is used to develop future funding requests and in developing benefit/cost analyses for their ITS program and individual projects.

A life cycle funding analysis is comprised of three components: equipment installation, operations, and maintenance.

Equipment installation refers to the actual procurement and installation of ITS equipment. For example, the purchase and installation for a pedestal mounted DMS is approximately $200,000 per sign. Additionally, estimating the life-cycle funding for ITS equipment must take into account the useful life expectancy of each component. For example, the useful life-expectancy of a DMS is 8 to 10 years. The useful life of fiber optic cable is 20 years, and the life expectancy for conduit and structures is 20 years plus. One way to estimate equipment cost is to use the component that has the longest life expectancy as a base line. Then, estimate the replacement cycle of other components with shorter life expectancies. An example would be if the conduit system lasts 20 years and the DMS only last 5 years, then the DMS replacement costs will re-occur 3 times during the project life cycle.

Estimating cost of operations is straight forward. If the project is estimated to last 20 years (before replacement or decommissioning), then DOTD will need to determine how many staff persons (or contracted maintenance) will be required over that period of time. Presented in **Appendix C** are life cycle cost analyses for this project. It should be noted that the quantity of equipment and locations in the life cycle cost analyses are approximated based on conceptual designs.

The life cycle cost analyses uses operations and maintenance (O&M) cost based on the data obtained from the USDOT ITS Unit Cost Database when available. The costs are in terms of 2007 dollars. The price per unit is based on current DOTD project estimates. The cells within the table have been highlighted in yellow where USDOT numbers are used. Although some equipment presented has a longer life cycle then 10 years, only the first 10 years have been presented. It should be noted that replacement costs for equipment that has a life cycle less than 10 years is covered under the cost of O&M and that there is no salvage value at the end of the equipment's life.

Maintenance funding for an ITS project is determined by the complexity (i.e., the type and quantity of devices) and the operational life of the project. The longer the system operates, the greater the maintenance costs. The older the equipment, the more maintenance (staff time and replacement parts) will be required to keep it functioning within specified limits. For planning purposes, a general rule-of-thumb for estimating overall annual maintenance costs for an ITS system is 5 percent of the total capital costs. Also, the 10 year total life cycle cost has been provided in 2 ways. First is linear where the annual O&M is continuous for the 10 year period. In the second, O&M is inflated at a rate of 3% per year.

7.5 Conclusion

The project will be executed as a design-build, and it will be incumbent that the design-builder provides the best solution based on DOTD's constrained budget. The exact budgeted amount will be defined as part of the Design-Build procurement documents.

The preferred design and implementation is a carefully calculated balance between what is physically practical and constructible, being cost effective in terms of initial capital expenditures and keeping in mind the operating and maintenance costs for the total useful lifespan of the project.

At first glance, the Life Cycle cost analysis reveals that a predominantly wireless implementation is an attractive choice because of initial capital costs. This approach, however, is laden with risks associated with the high use of unlicensed wireless apparatus within the region, high O&M costs and susceptibility to interference and undesirable performance. The quality of the installation together with qualifications of the construction contractors are factors of the initial commissioning and the rate that the equipment will degrade over time.

The high concentration of wireless transmission paths within close proximity of each other also has risks. The implementation can become its own nemesis with a phenomenon known as intermodulation, where the frequencies start to mix causing 3^{rd} order harmonic distortion.

This discussion is not meant to discourage the use of wireless, but instead bring to the surface possible difficulties. These types of phenomena are very hard to predict through theoretical propagation modeling, but can often be avoided or greatly reduced. Limited use of wireless technologies, together with careful planning, good design, proper installation and configuration can ultimately have favorable results.

This project may incorporate a hybrid design of fiber optic communications together with spread spectrum and point-to-point wireless technologies where it's advantageous from a cost vs. reliability perspective,

It is encouraged that distributed power for field devices be used when deployed adjacent to hub buildings where 480 VAC will be available. Considerations for the use of distributed power shall include practical wire size gauges, commercial cost of copper and necessary electrical service capacity.

It has been noted through field visits that overhead power utilities exist at various locations within the project boundaries. It is encouraged that these facilities be used when it's practical to do so. Vehicle detectors not in close proximity to commercial power sources can be powered via solar panels, and can also communicate through low power spread spectrum radio. All DMS signs for this project shall be connected to commercial AC power.

8 Testing

Testing fulfills the system engineering requirements of verification and validation. Verification can be simple described as “was the system built correctly?” While validation may be described as “was the correct system built?”, testing through the project development until the completion of the project provides for a successful project. The use of traceability matrices allows for the stakeholders to ensure that the envisioned system described in the ConOps is the actual functional system deployed. During the construction of the project, equipment must be tested at various stages to ensure its operability, function, and performance. These tests are detailed in the specification document developed to accompany the detailed design plans. Also, once the system is constructed, tests on integrating the equipment into the existing system are required. These tests are also as defined and required by the request for proposal.

During the detailed design of this project, the designer will be required to trace the conception of the project through the testing phase using the traceability matrix. During construction, the contractor along with the Project Engineer will use the traceability matrix to verify the project requirements and design. Ultimately, this matrix will allow for DOTD personnel to check off the project deployment requirement and to ensure a successful final system. A sample has been provided as **Appendix B**.

9 Operations and Maintenance

DOTD will be the agency responsible for operating and maintaining the equipment deployed as part of this project. Currently, DOTD uses contract and agency personnel to provide both operations and maintenance on ITS equipment through DOTD's ITS Section. Currently, an ITS retainer contract provides TMC operations staff for all the TMCs throughout the state.

The DOTD Maintenance and Communications Engineer has been tasked with approximately 30 staff members to ensure the continued function of the various ITS systems statewide. DOTD currently has an anticipated annual budget of $2.5 million dollars for maintenance across the state.

DOTD is currently developing an ITS maintenance plan to evaluate and determine a 3 year outlook on maintenance, device replacement, budget and maintenance by others. The plan will provide management the ability to set planned service targets for each maintenance function and to prioritize maintenance functions. The plan will also assist in allocating financial resources among maintenance functions and identify priorities based on needs.

10 ITS Standards

Standards are specifications that define how the different ITS sub-components interconnect and interact within the established parameters of the National ITS Architecture. Specifically, they stipulate how the different technologies interoperate to automatically share information. DOTD benefits from ITS standards for this project in several ways including:

- Reducing the risk of equipment obsolescence
- Reducing the risk of a single point of supply and proprietary products
- Lowering prices for equipment
- Minimizing design and implementation confusion
- Assuring quality

Additionally, federal regulations require that ITS projects must conform to the National ITS Architecture and its standards if they are financed using funds from the Highway Trust Fund. The architecture currently identifies 13 key standards areas that can be found in the ITS Standards Requirements Document (SRD).

ITS projects that are currently deployed by DOTD incorporate standards developed by a number of standards developing bodies. The American Association of State Highway and Transportation Officials (AASHTO), Institute of Transportation Engineers (ITE), and National Electrical Manufactures Association (NEMA) have taken the lead in developing standards for traffic management devices and their interoperability. These devices include DMS, traffic signals, traffic sensors, etc. The Institute of Electrical and Electronic Engineers (IEEE) and the International Standards Organization (ISO) primarily provide the standards for communication infrastructure. This includes communication cables, switches, nodes, etc. Finally, the National Electric Code (NEC) provides standards to all related electrical and power requirements associated with ITS projects. It should be noted that the development of standards is an ongoing and evolving process; therefore, standards will need to be continually reviewed as DOTD implements future projects.

The purpose of this chapter is to identify the standards that will be used in developing design concepts, detailed design, and operational procedures associated with this project.

10.1 Project Standards

The most significant set of standards for ITS projects is the National Transportation Communications for ITS Protocol (NTCIP). This family of standards will establish the parameters for the development, design, and implementation of the ITS component of the project. AASHTO, ITE, and NEMA have taken the lead in developing NTCIP standards. NTCIP is a family of communication protocols (protocol is a system of rules and procedures governing communications between two devices) and data definition standards that serve and address the diverse needs of the various subsystems and user services presented in the national, state, and regional ITS architectures. NTCIP consists of a whole family of protocols covering the spectrum from point-to-point command/response to sophisticated object oriented techniques. NTCIP provides standards for two different ITS applications: center-to-field (C2F) and center-to-center (C2C), both of which are applicable to this project.

10.1.1 Center-to-Field Standards

There are two existing application protocols (and one protocol under development) for C2F communications: the Internet's Simple Network Management Protocol (SNMP) and the Simple Transportation Management Protocol (STMP). These protocols use the get-/set-messaging model. Each protocol has its advantages: SNMP is the simplest to implement while STMP is the most flexible and band width efficient. **Table 3** presents the comparison of the two protocols.

Table 3: SNMP and STMP Comparisons

Characteristic	SNMP	STMP
Can send any base date element	Yes	Yes
Bandwidth Efficiency	Worse	Better (uses dynamic objects)
Supports routing and dial-up	Options	Options
Message Set	Supported	Limited to 13
Ease of Implementation	Easy	Hard

Devices with either of the two protocols can use the same communication lines with other devices using the same protocols. The manufacturer or type of device (traffic signals, DMS, etc.) is not important. Each device is assigned an address that is unique on that line or channel which allows the management system to communicate with that device.

The communication link for C2F can be any type of medium (i.e. fiber optics, cable, spread spectrum, radio, etc.). It does not matter whether the communications medium is owned or leased by DOTD. The only requirement assumes that communication is a half-duplex poll and response and that the time for transmission and the response time for the end device are within the tolerances the devices need to communicate.

Although STMP is designed to use communication channels with slow transmission rates, it is not as bandwidth efficient as proprietary protocols used in the past.

10.2 Standards Applicable to the Project

A number of technical standards must be considered in the development of this project. There are over 100 ITS standards now being developed by different standards development organizations (SDOs). ITS designers are encouraged by United States Department of Transportation (U.S. DOT) to use SDO approved standards when developing ITS projects.

Mapping the applicable ITS standards to the project architecture provides a clearer understanding as to how each standard should be considered in design of the project. There are three architectural components to which the standards must be applied for this project: Center-to-Field, Center-to-Center and Center-to-Vehicle/Traveler. Adhering to these standards will assure interoperability and interchangeability of the project's components and its overall integration with current ITS operations. **Table 4** presents the relevant standards for each architectural component that may be used in the implementation of this project.

Table 4: ITS Standards Applicable to Project

Standard Number	Standard Name	C2F	C2C	Center to Veh/Traveler
NTCIP 1101	Simple Transportation Management Framework (STMF)	•		
NTCIP 1102	Octet Encoding Rules (OER)	•	•	
NTCIP 1103	Transportation Management Protocols (TMP)	•	•	
NTCIP 1104	Center-to-Center Having Convention Specification		•	
NTCIP 1201	Global Object Definitions	•		
NTCIP 1202	Object Definitions for Actuated Traffic Signal Controller	•		
NTCIP 1203	Object Definitions for Dynamic Message Signs	•		
NTCIP 1205	Object Definitions for CCTV Camera Control	•		
NTCIP 1206	Object Definitions for Data Collection and Monitoring (DCM) Devices	•		
NTCIP 1208	Object Definitions for CCTV Switching	•		
NTCIP 1209	Object Definitions for Transportation Sensor Systems (TSS)	•		
NTCIP 1210	Field Management Stations - Part 1: Object Definitions for Signal System Masters	•		
NTCIP 1211	Object Definitions for Signal Control and Prioritization (SCP)	•		
NTCIP 2101	Point-to-Point Using RS-232 Subnetwork Profile		•	
NTCIP 2102	Point-to-Multi-Point Protocol Using FSK Modem Subnetwork Profile		•	
NTCIP 2103	Subnet Profile for Point-to-Point Over RS-232		•	
NTCIP 2104	Ethernet Subnetwork Profile		•	
NTCIP 2202	Internet (TCP/IP and UDP/IP) Transport Profile	•	•	
NTCIP 2301	Application Profile for Simple Transportation Management Framework (STMF)	•		
NTCIP 2302	Application Profile for Trivial File Transfer Protocol	•		
NTCIP 2303	Application Profile for File Transfer Protocol	•	•	
NTCIP 2304	Application Profile for Data Exchange ASN.1 (DATEX-ASN)	•		

Standard Number	Standard Name	C2F	C2C	Center to Veh/Traveler
NTCIP 2306	Application Profile for XML Message Encoding and Transport in ITS Center0to-Center Communications (C2C XML)		●	
NTCIP 8003	Profile Frame Work	●	●	
NTCIP 9001	NTCIP Guide	●	●	●
EIA-794	Data Radio Channel (DARC) System			●
EIA-795	Sub carrier Traffic Information Channel (STIC) System			●
IEEE Std 1404		●	●	
IEEE Std 1488, 2000	Trail-Use Standard for Message Set Template for ITS	●	●	●
IEEE Std 1489, 1999	Data Dictionaries for ITS	●	●	●
IEEE Std 1512, 2000	Common Incident Management Sets for Use by Emergency Management Centers	●		●
IEEE SH 94633-94638	Analysis of Existing Standards and Those Under Development Applicable to the needs of ITS Short Range and Wide Area Wireless Communications	●	●	●
ITE-AASHTO TM 1.03	Traffic Management Data Dictionary	●	●	
ITE-AASHTO TM 2.01	Message Sets for External Traffic Management Center Communications	●	●	
SAE J1763	General Reference Model	●	●	●
SAE J2353	Advanced Traveler Information Systems (ATIS) Data Dictionary	●		●
SAE J2354	Advanced Traveler Information Systems (ATIS) Message Sets	●		●
SAE J2369	ATIS Message Sets Delivered Over Bandwidth Restricted Media			●

APPENDIX A

COMMUNICATION TECHNOLOGIES

A.1 Communication Technologies Overview

There are a number of different types of communication technologies available for ITS network applications. Some of the technologies cited below are not applicable for this project. However, it is important that DOTD be aware of the variety of technologies currently being used throughout the communication industry. They are:

- Fiber optic cable (Single Mode)
- Cellular Digital Packet Data (CDPD)
- Global System for Mobile Communication (GSM/EDGE) Enhanced Data for Global Evolution
- Radio Frequency (Spread Spectrum)
- Terrestrial Microwave Links
- Area Radio Network (ARN)
- Telephone Lease Lines
- Code-Division Multiple Access (CDMA)
- Orthogonal Frequency Division Multiplexing (OFDM)

The critical factors in the selection of a preferred alternative are the following:

- High reliability and availability
- Low capital and operating (i.e., maintenance) costs
- Provisions for high bandwidth capacity and transmission speed with flexibility to accommodate future expansion
- Protection of the interconnected server, workstations and controllers from unauthorized access and malicious intent

General advantages of direct wire connection versus a wireless connection:

- Bandwidth is limited only by the edge devices
- Life span of 15+ years
- Connection can only be interrupted by invasive measures (e.g. break in the fiber)
- Maintenance is generally less than that of wireless

General disadvantages of direct wire connection versus a wireless connection:

- Susceptible to being broken during construction
- Requires costly conduit/duct (e.g. structure mounted bullet resistant conduit)
- Installation cost is higher than that of wireless

A.2 Fiber Optic Cable (Single Mode)

The advantages of single mode fiber optic cable are the following:

- Allowable distance between transmission equipment, transmission rate, and bandwidth capacity is significantly greater than any other communication method, thereby providing nearly unlimited future System expansion

- Lightning protection devices are not required
- Ratio of cable diameter to bandwidth capacity is very small
- Provides highest level of security when properly monitored
- Not susceptible to electro-magnetic and radio frequency interference
- Not susceptible to corrosion
- Provides high transmission reliability if quality materials are specified and testing is performed to verify compliance
- Preterminated fiber available for quick installation and no splicing required

The disadvantages of single mode fiber optic cable are the following:

- Splicing and connector termination requires specialized equipment and skilled technicians
- Technician training required for repairing, replacing, and testing fiber cable
- Test equipment is more complex and expensive relative to copper test equipment
- Susceptible to breaking if the fiber bends are smaller than the recommended bending radius or excessive load is applied
- Requires devices to convert from optical to electrical end user equipment
- Substantial capital cost of installation
- Preterminated fiber requires additional planning because fiber that is dropped off the backbone is no longer continuous beyond that drop point

A.3 Cellular Digital Packet Data (CDPD)

CDPD is a packet-switched, full duplex data communication system that cellular carriers use specifically for data transmission and as a means of filling unused voice channel capacity. The advantages of CDPD are the following:

- Eliminates need for incurring underground cable installation costs
- Not susceptible to electro-magnetic interference and limited susceptibility to radio frequency interference
- Maximum flexibility in locating and moving the required modem (assuming adequate cell coverage)

The disadvantages of CDPD are the following:

- Requires payment of a recurring service fee (payment is only for data sent and received in packets, not minutes)
- Major carriers plan to discontinue CDPD service with the migration to 3G technologies
- Transmission Speed limited to 28.8 Kbps
- Dependent on cellular coverage provided by existing infrastructure. Connection likely to be lost if signal strength falls below –105 dBm
- Requires separate modem for each controller
- Unencrypted data is susceptible to eavesdropping

A.4 Global System for Mobile Communication (GSM)

CDMA is the dominant technology for cellular and/or PCS networks in North America (see section 8.1.8 for CDMA). GSM is the dominant technology for cellular and/or PCS networks in Europe. Cellular and PCS differ primarily in their respective operational frequency bands: 800 MHz for cellular and 1900 MHz for PCS. The advantages of GSM are the following:

- Lower cost of data rate plans for wireless WANs. Prices for these plans have fallen significantly, creating a more compelling reason to switch to wireless data networks for remote device communications
- New technology gives wireless gateways the ability to maintain an "always on" connection without being charged for total airtime, so users pay only for the data they actually send over the wireless connection
- Maximum flexibility in locating and moving the required gateway (assuming adequate cell coverage)
- Transmission speeds of 3.0 Mbps can be achieved with EDGE technology where service is available

The disadvantages of GSM are the following:

- Airtime cost excessive for continuous communication service
- Only two providers in one area
- Actual data throughput reduced due to protocol overhead
- Remote areas may not have service

A.5 Radio Frequency (Spread Spectrum)

Spread spectrum uses wideband modulation to impart noise-like characteristics to an RF signal. The bandwidth is spread by means of a code which is independent of the data. The independence of the code distinguishes this from standard modulation schemes in which the data modulation will always spread the spectrum. The receiver synchronizes to the transmitter code to recover the data. The use of an independent code and synchronous reception allows multiple users to access the same frequency band at the same time without interference. Frequency hopping and direct sequence systems are the most widely used implementations of this technology and the associated equipment is commercially available. The advantages of radio frequency transmission are the following:

- Eliminates need for incurring underground cable installation costs
- Not susceptible to electro-magnetic interference
- Provides a low probability of intercept and includes anti-jam features
- Radio frequency interference with narrowband communications is minimized by use of lower spectral power density and for a frequency hopping implementation, an ability to reconstruct the data when some frequencies are blocked
- Does not require a FCC license to operate

The disadvantages of radio frequency transmission are the following:

- Requires overhead locations to mount antennas that maintain line of sight
- Requires routing cable and conduit from antenna to modem installed in cabinet
- Requires separate modem for each controller
- Limited susceptibility to radio frequency interference
- Requires the highest equipment expenditure that includes sufficient spares (Also expected to have the highest total cost consisting of initial capital cost and net present value of operating/maintenance cost)
- Antenna is susceptible to vandalism
- Requires special skills and equipment to maintain
- Requires the most training to maintain

A.6 Terrestrial Microwave Links

Terrestrial microwave is a line-of-sight technology that cannot extend beyond the earth's horizon. Long distance terrestrial transmission of data is accomplished using relay points known as "hops). Typically, each hop consists of a tower with one antenna for receiving and another for transmitting. Terrestrial microwave systems operate in the low-gigahertz range, typically at 4-6 GHz, 11 GHz, 18 GHz, and 21- 23 GHz.

The advantages of terrestrial microwave links are as follows:

- Useful as a point-to-point trunk
- Can transmit data and a limited number of full motion video channels
- Can control groups of traffic control devices
- Can use both analog and digital transmission
- Offers the highest data throughput rates of any wireless technology

The disadvantages of terrestrial microwave links are as follows:

- Line-of-sight may be required based on the frequency
- In most cases, requires FCC license
- Channel availability limited
- May have little choice in operating frequency
- Possible interference due to rain, snow, and atmospheric effects
- May require antenna tower
- Available bandwidth usually limited
- Typically most expensive wireless technology to implement

A.7 Area Radio Network (ARN)

Area Radio Network (ARN) is representative of a radio network usually operating in the UHF/VHF frequency bands. These networks are normally used for in-house communications of equipment devices and maintenance staff and personnel.

The advantages of ARN are as follows:

- Can operate traffic controllers or other devices
- Can provide voice communications to highway maintenance vehicles
- Can support 9600 baud data rate
- Can prove cost effective depending on application

The disadvantages of ARN are as follows:

- Terrain may be limited
- Limited channel availability in urban area
- Requires antenna at each site
- Turnaround time excessive for some applications
- Service reliability may limit use for some applications (Example, CTV video)

A.8 Telephone Lease Lines Line

The advantages of telephone line are as follows:

- Can operate traffic controllers or other devices
- Can provide video transmission at low fps
- Asymmetric Digital Subscriber (ADSL) can support full motion video

The disadvantages of telephone are as follows:

- ADSL leasing cost
- Limited video availability

A.9 Code-Division Multiple Access (CDMA)

CDMA (Code-Division Multiple Access) refers to any of several protocols used in so-called second-generation (2G) and third-generation (3G) wireless communications. As the term implies, CDMA is a form of multiplexing, which allows numerous signals to occupy a single transmission channel, optimizing the use of available bandwidth. The technology is used in ultra-high-frequency (UHF) cellular telephone systems in the 800-MHz and 1.9-GHz bands.
CDMA employs analog-to-digital conversion (ADC) in combination with spread spectrum technology. Audio input is first digitized into binary elements. The frequency of the transmitted signal is then made to vary according to a defined pattern (code) so that it can be intercepted only by a receiver whose frequency response is programmed with the same code and so it follows along with the exact transmitter frequency. There are trillions of possible frequency-sequencing codes which enhance privacy and make cloning difficult.

The CDMA channel is nominally 1.23 MHz wide. CDMA networks use a scheme called soft handoff which minimizes signal breakup as a handset passes from one cell to another. The combination of digital and spread-spectrum modes supports several times as many signals per unit bandwidth as analog modes. CDMA is compatible with other cellular technologies which allows for nationwide roaming.

The original CDMA standard, also known as CDMA One and still common in cellular telephones in the U.S., only offers a transmission speed of up to 14.4 Kbps in its single channel form and up to 115 Kbps in an eight-channel form. CDMA2000 and wideband CDMA deliver data many times faster.

The advantages of CDMA are as follows:

- Frequency diversity
- Multi-path resistance
- Privacy/security
- Graceful degradation

The disadvantages of CDMA are as follows:

- Self- jamming[2]
- Near-far problem
- Soft hand-off
- Not suitable for very high bit rate (like in WLAN)
- Monthly service subscription

A.10 Orthogonal Frequency Division Multiplexing (OFDM)

OFDM is a modulation technique for transmitting large amounts of digital data over a radio wave. OFDM works by splitting the radio signal into multiple smaller sub-signals that are then transmitted simultaneously at different frequencies to the receiver. This spacing provides the "orthogonality" technique which prevents the demodulators from seeing frequencies other than their own. OFDM reduces the amount of crosstalk in signal transmissions. 802.11a WLAN, 802.16 and WiMAX technologies use OFDM. OFDM is best used in high dense area where multipath effect is severe such as in a building or in a city where multipath is severe. OFDM should not be implemented in areas where multipath is not an issue, such as open space rural areas/LOS.

[2] Self-jamming is a phenomena that arises because the sequence in which multiple user signals received are not exactly orthogonal. It results in an elevated noise floor and a higher bit error rate in regards to the receiving end, otherwise known as the up-link.

The advantages of OFDM are as follows:

- High bandwidth efficiency
- Robust in multipath environments (typically urban)
- Suitable for very high bit rate systems (like WLAN)
- Offers flexibility in modulation and multiple accesses

The disadvantages of OFDM are as follows:

- Sensitive to carrier frequency offset causing incorrect carrier frequency
- Large Peak-to-Average ratio (PAR) which causes amplifier non-linearity
- Sensitive to channel fade (flat fade)

APPENDIX B

TRACEABILITY MATRIX

Need	Requirement (Tier 1)	Requirement (Tier 2)	Requirement (Tier 3)	Requirement (Tier 4)	Component/ Subsystem/Device	PE Sign Off
• To detect, verify, and assess traffic congestion and incidents • To distribute information to motorists in a timely manner						
	FR1 The system shall control DMS from the computer console at the DOTD Statewide TMC using the graphical user interface (GUI) provided as part of vendor software					
		FR1.1 The system shall post a message on the selected DMS within 10 seconds after the user's execution of the GUI command to post the message				
			FR1.1.1 The system shall post a message in upper case text			
			FR1.1.2 The system shall post a message composed of a maximum of 3 lines of text with 18 characters per line			
			FR1.1.3 The system shall post a message composed of a maximum of 2 frames			
			FR1.1.4 The system shall post a flashing message			
			FR1.1.5 The system shall post a message in reverse video (black characters on amber background)			
			FR1.1.6 The system shall post a scrolling message			
		FR1.2 The system shall display confirmation of a message posted on the selected DMS within 15 seconds after the user's execution of the GUI command to post the message				
		FR1.3 The system shall control the flashing strobe on the selected DMS				
			FR1.3.1 The system shall activate the flashing strobe within 10 seconds after the user's execution of the GUI command to activate the flashing strobe			
			FR1.3.2 The system shall deactivate the flashing strobe within 10 seconds after the user's execution of the GUI command to deactivate the flashing strobe			

Need	Requirement (Tier 1)	Requirement (Tier 2)	Requirement (Tier 3)	Requirement (Tier 4)	Component/ Subsystem/Device	PE Sign Off
		FR1.4 The system shall display fault information from the DMS on the GUI within 30 seconds after the fault occurs				
			FR1.4.1 The system shall display notification of power failure			
			FR1.4.2 The system shall display notification of unrecognized commands			
			FR1.4.3 The system shall display notification of communication errors			
			FR1.4.4 The system shall display notification of pixel failure			
		FR1.5 The system shall control DMS reset features from the GUI				
			FR1.5.1 The system shall reset the DMS controller			
			FR1.5.2 The system shall reset the DMS pixel assemblies			
			FR1.5.3 The system shall reset the DMS IP addressable battery backup			
	FR2 The system shall control CCTV cameras from the computer console at the DOTD Statewide TMC using the GUI provided as part of the vendor software					
		FR2.1 The system shall display live video from the selected CCTV camera within 10 seconds after the user's execution of the GUI command to display the live video				
			FR2.1.1 The system shall display live video at the user defined frames per second			
		FR2.2 The system shall stream live video with a maximum of 5 seconds of latency				
		FR2.3 The system shall pan the selected CCTV camera within 1 second after the user's execution of the GUI command to pan the camera				
			FR2.3.1 The system shall pan the camera between 0 and 360 degrees continuously			
		FR2.4 The system shall tilt the selected CCTV camera within 1 second after the user's execution of the GUI command to tilt the camera				

Need	Requirement (Tier 1)	Requirement (Tier 2)	Requirement (Tier 3)	Requirement (Tier 4)	Component/ Subsystem/Device	PE Sign Off
			FR2.4.1 The system shall tilt the CCTV camera to intervals between 0 (horizontal) to 90 degrees (straight down)			
		FR2.5 The system shall zoom the selected CCTV camera within 1 second after the user's execution of the GUI command to zoom the camera				
		FR2.6 The system shall pan, tilt, and zoom to the selected user defined preset for the selected CCTV camera within 1 seconds after the user's execution of the GUI command to execute the preset				
		FR2.7 The system shall block-out zones designated by the user on the selected CCTV camera				
		FR2.8 The system shall display the selected CCTV camera's user defined text (i.e., name) within 5 seconds after the user's execution of the GUI command to display the user defined text				
		FR2.9 The system shall display the CCTV camera's IP address within 5 seconds after the user's execution of the GUI command to display the IP address				
		FR2.10 The system shall display fault information from the CCTV camera on the GUI within 30 seconds after the fault occurs				
			FR2.10.1 The system shall display notification of power failure			
			FR2.10.2 The system shall display notification of communication errors			
			FR2.10.3 The system shall display notification of pressure loss			
		FR2.11 The system shall control the CCTV camera's reset features from the GUI				
			FR2.11.1 The system shall reset the CCTV camera IP addressable battery backup			
			FR2.11.2 The system shall reset the CCTV camera power supply			
			FR2.11.3 The system shall reset the CCTV camera controller			
			FR2.11.4 The system shall reset the CCTV camera video encoder			

Need	Requirement (Tier 1)	Requirement (Tier 2)	Requirement (Tier 3)	Requirement (Tier 4)	Component/ Subsystem/Device	PE Sign Off
	FR3 The system shall control vehicle detectors from the computer console at the DOTD Statewide TMC using the GUI provided as part of the vendor software					
		FR3.1 The system shall download data collected from selected vehicle detectors at the user defined poll rate				
			FR3.1.1 The system shall download average time mean speed per lane			
			FR3.1.2 The system shall download the total vehicle per hour per lane			
			FR3.1.3 The system shall download the volume of the classifications in vehicles per hour per lane			
		FR3.2 The system shall stream live data with a maximum of 5 second of latency				
		FR3.3 The system shall display data collected from the selected vehicle detector within 10 seconds after the user's execution of the GUI command to display the data				
			FR3.3.1 The system shall display average time mean speed per lane			
				FR3.3.1.1 The system shall display the time of the average time mean speed		
				FR3.3.1.2 The system shall display the duration of the average time mean speed		
				FR3.3.1.3 The system shall display the date of the average time mean speed		
			FR3.3.2 The system shall display the total vehicle per hour per lane			
				FR3.3.2.1 The system shall display the time of the total vehicle volume		
				FR3.3.2.2 The system shall display the duration of the total vehicle volume		
				FR3.3.2.3 The system shall display the date of the total vehicle volume		
			FR3.3.3 The system shall display the volume of the selected classification in			
				FR3.3.3.1 The system shall display the time of the volume		
				FR3.3.3.2 The system shall display the duration of the volume		
				FR3.3.3.3 The system shall display the date of the volume		

Need	Requirement (Tier 1)	Requirement (Tier 2)	Requirement (Tier 3)	Requirement (Tier 4)	Component/ Subsystem/Device	PE Sign Off
		FR3.4 The system shall display the selected vehicle detector user defined text (i.e., name) within 5 seconds after the user's execution of the GUI command to display the user defined text				
		FR3.5 The system shall display the selected vehicle detector IP address within 5 seconds after the user's execution of the GUI command to display the IP address				
		FR3.6 The system shall display fault information from the vehicle detector on the GUI within 30 seconds after the fault occurs				
			FR3.6.1 The system shall display notification of power failure			
			FR3.6.2 The system shall display notification of communication errors			
		FR3.7 The system shall control the selected vehicle detector's reset features from the GUI				
			FR3.7.1 The system shall reset the vehicle detector IP addressable battery backup			
			FR3.7.2 The system shall reset the vehicle detector power supply			
			FR3.7.3 The system shall reset the vehicle detector controller			
	FR4 Highway Advisory Radio (HAR) shall be used to disseminate information to in-route travelers					
		FR4.1 HAR shall provide in-route messages to travelers via AM radio broadcast.				
			FR4.1.1 HAR shall be broadcasted on a predefined AM radio station			
		FR4.2 HAR messages shall provide transportation related information				
			FR4.2.1 HAR messages shall warn motorists of possible hazards, road delays or detours ie: forest fire, weather advisories, chemical spill, survey/testing crews, and/or construction or maintenance			

Need	Requirement (Tier 1)	Requirement (Tier 2)	Requirement (Tier 3)	Requirement (Tier 4)	Component/ Subsystem/Device	PE Sign Off
			FR4.2.2 HAR messages shall warn motorists of road closure or delay due to a incident or emergency situation			
			FR4.2.3 HAR messages shall advise motorists of future activities that may result traffic disruptions such as construction and/or maintenance activities			
			FR4.2.4 HAR messages shall advise motorists of speed limit changes which may be temporary			
			FR4.2.5 HAR messages shall provide safety initiatives such as ie: Buckle Up, Drive Safely			
		FR4.3 HAR messages shall be FCC licensed AM band broadcast				
			FR4.3.1 HAR to be broadcast on a licensed frequency between 530 kHz and 1710 kHz			
		FR4.4 HAR shall be broadcasted using a minimum of 10-watt transmitters				
			FR4.4.1 Broadcast radius shall be a minimum of 3 miles depending on topography, atmospheric conditions, and the time of day			
		FR4.5 HAR shall be point broadcasted				
			FR4.5.1 A single transmitter shall be used to broadcast over a given area			
		FR4.6 HAR shall be programmable				
			FR4.6.1 HAR controller shall be programmed using a central control software on a desktop computer			
				FR4.6.1.1 Central control software shall allow digital audio messages to be entered into the system		
			FR4.6.2 HAR controller shall be programmed using telephone (cell phone or landline)			
		FR4.7 HAR shall provide live broadcast				
		FR4.8 HAR shall store a minimum of 250 pre-recorded messages				
		FR4.9 HAR shall have minimum of 80 minutes of recording time allowed				
		FR4.10 HAR shall have minimum 2 day message backup				

Need	Requirement (Tier 1)	Requirement (Tier 2)	Requirement (Tier 3)	Requirement (Tier 4)	Component/ Subsystem/Device	PE Sign Off
		FR4.11 HAR controller shall provide fault information to the center				
			FR4.11.1 HAR controller shall provide transmitter power failure			
			FR4.11.2 HAR controller shall provide advisory sign failure			
			FR4.11.3 HAR controller shall provide unrecognized commands			
			FR4.11.4 HAR controller shall provide IO board errors			
			FR4.11.5 HAR controller shall provide communication failure			
		FR4.12 HAR controller shall provide the status information at a minimum to the center				
			FR4.12.1 HAR controller shall provide a unique HAR ID			
			FR4.12.2 HAR controller shall provide the HAR location			
			FR4.12.3 HAR controller shall provide the time and date of the broadcasted message			
		FR4.13 HAR shall manage a minimum of 5 roadside advisory signs per transmitter				
			FR4.13.1 User shall be able to activate the flashing beacons on the roadside sign			
			FR4.13.2 HAR roadside advisory signs shall be able to activated/deactivated independently			
		FR4.14 HAR transmitter site shall have an IP addressable battery backup				
			FR4.14.1 IP addressable battery backup shall allow for the broadcast of programmed messages for 3 days minimum			