Systems Engineering Analysis Report

Aesthetic Lighting of Existing State Highway (ITS Portion)

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Prepared by:

Gresham, Smith and Partners, MS, P.C.

MDOT ITS Mission Statement:

"MDOT will use ITS technologies to improve the quality of life for State residents and visitors by providing more reliable, informative, safer, and flexible passenger and freight multi-modal transportation services."

Document Control

Date	Version	Description
03/23/09	0.1	Draft for internal team review.
03/24/09	0.2	Draft for MDOT review.
04/03/09	1.0	Final version submitted for MDOT use.

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1.0 Purpose

This *Systems Engineering Analysis (SEA) Report* documents the systems engineering analysis for the Aesthetic Lighting of Existing State Highway project, which is a lighting project on the U.S. 65 and U.S. 84 bridges over the Mississippi River and also includes some ITS elements. Consistent with the Federal Highway Administration's (FHWA) Rule 940, the Mississippi Department of Transportation (MDOT) has adopted an ITS Project Life Cycle framework that incorporates systems engineering into the traditional project development process. This *SEA* follows the recommended ITS project development process and fulfills the minimum SEA requirements as outlined in the current version of MDOT's *Systems Engineering Management Plan (SEMP)*.

The ITS portion of the Aesthetic Lighting of Existing State Highway project involves the installation of closed circuit television (CCTV) cameras and video detection systems (VDS) on the bridges for U.S. 65 and U.S. 84 over the Mississippi River, for the purpose of monitoring vehicular traffic on the roadway and barge traffic on the river below. Although not within the scope of the subject project, a communications path back to the MDOT Statewide Transportation Management Center (TMC) in Jackson will initially be provided by leased lines, with the intent to install a wireless communications system in the medium-term and MDOT-owned fiber to the devices in the long-term. It is anticipated that this communications connection will be established prior to completion of this project.

2.0 Project Description

The Aesthetic Lighting of Existing State Highway project is unique in the fact that the project limits span two side-by-side bridges (each serving one direction of travel) over the Mississippi River, and includes the installation of fiber optic cable and ITS elements in both Mississippi and Louisiana.

This project will provide pan-tilt-zoom (PTZ) CCTV cameras at both ends of both bridges as well as a camera in the center of the southern bridge for monitoring purposes. This project also provides 2 PTZ cameras under the southern bridge to monitor barge traffic, which will also serve an important security function. Additionally, there will be VDS units on the ends of both bridges for monitoring the traffic moving onto the bridges for both the Mississippi and Louisiana approaches. The VDS units will provide counts and associated traffic data. This project also provides the installation of a fiber optic backbone between Mississippi and Louisiana, which will provide the necessary infrastructure for center-to-center communications across state lines.

Subsequent projects will be needed to provide a communications link on the Mississippi side back to the MDOT Traffic Management Center (TMC) in Jackson. Communications will be provided in the short-term via leased lines, but this connection is outside the scope of this project. It is anticipated that the communications connection to the MDOT TMC in Jackson will be established prior to the completion of this project. It should be noted that the necessary equipment and software licenses at the MDOT Statewide TMC that enable TMC operators to view and control the cameras are not part of the subject project and will need to be provided through a subsequent project. Likewise, the Louisiana Department of Transportation and Development (LADOTD) will need to provide a communications link on the Louisiana side to obtain use of the devices and connect to the MDOT ITS system.

Design for the project is currently underway with an anticipated advertisement date of April 24, 2009 and letting date of May 26, 2009.

The general information for this project is summarized in **Table 1**. A map of the general project area is shown in **Figure 1**.

Table 1: General Project Information

General Project Information	
Project Location / Limits	• Adams County, Mississippi and Concordia Parish, Louisiana • U.S. 65 and 84 Mississippi River bridges
Funding Source	The design for this project is being funded under the MDOT ITS Integrator contract. Construction for this project is being funded with National Highway funds (80% Federal, 20% State). LADOTD will reimburse MDOT for half of the construction cost.
Nature of Work	• Seven (7) PTZ CCTV camera sites will be installed. Three (3) of the cameras are to be mounted on the bridge structure and four (4) are to be installed just off the bridge on mast arms. • Two (2) fixed VDS cameras will be installed just off either bridge approach on mast arms. • A 72 fiber trunk cable will be installed across the bridge to provide C2C communications between MDOT and LADOTD.
Relationship to Other Projects / Phases	This project will require subsequent projects to connect the fiber trunk line on the bridge to the MDOT and LADOTD ITS systems. Additionally, the equipment and software licenses that are necessary for viewing and controlling the cameras at the MDOT Statewide TMC in Jackson will need to be procured through a separate project.
Type of Equipment to be Installed	• Fiber Optic communications cable • CCTV Cameras (pan-tilt-zoom) • Video Detection Systems
Period of Performance	This project is currently in the design phase. This project is anticipated to be advertised on April 24th and included in the May 26, 2009 letting.

Figure 1: Project Area

3.0 Compliance with the Statewide ITS Architecture

Compliance with Mississippi's Statewide ITS Architecture (which is the applicable Regional ITS Architecture for this MDOT District) was evaluated. It was determined that the Aesthetic Lighting of Existing State Highway project is listed in the description associated with the MDOT CCTV system listed in Table 4-1: Mississippi Statewide ITS Inventory in the Statewide Architecture.

Market Packages were identified in the Statewide Architecture that are being implemented as part of this project. Each Market Package addresses a specific service and is often an assimilation of several different subsystems, equipment packages, terminators, and architecture flows that provide the desired service.

Table 2 contains a listing of the ITS Market Packages and their associated elements that were identified in the Statewide Architecture and are being implemented as part of this project. The enabling elements of the project (i.e., elements that will be performing the primary project system functions once the system is implemented) are shown in **bold type** and are directly related to the project functional requirements, which are defined in **Section 5** of this *SEA Report.*

Table 2: ITS Market Packages and Associated Elements

Category	Market Package	Market Package Name	Associated Element
Advanced Traffic Management Systems (ATMS)	ATMS01	Network Surveillance	**- MDOT District Traffic Sensors** **- MDOT District Traffic Surveillance Equipment** - MDOT Statewide TMC
	ATMS04	Freeway Control	**- MDOT District Traffic Sensors** **- MDOT District Traffic Surveillance Equipment** - MDOT Statewide TMC
	ATMS08	Traffic Incident Management System	- County Emergency Operations Centers - Local City/County 911 Dispatch Centers - Local City/County Emergency Vehicles - MDOT District Maintenance and Construction Offices **- MDOT District Traffic Sensors** **- MDOT District Traffic Surveillance Equipment** - MDOT MSTraffic.com - MDOT Statewide TMC - Media

The utilization of the Market Packages listed in **Table 2**, with their subsystems and equipment packages, provides for the later utilization of the National ITS Architecture process specifications as a basis for the development of the project functional requirements.

The following individual Market Package diagrams (**Figures 3, 4 and 5**), excerpted from the *MDOT ITS Concept of Operations*, have been tailored to meet MDOT needs. The diagrams define the major system components, interconnection between these components, and interfaces to external systems that are most important to the operation of the Market Package. Additionally, the diagrams were modified for this *SEA Report* in order to indicate the specific Equipment Packages that are being implemented as part of the Aesthetic Lighting of Existing State Highway project. The Equipment Packages are directly related to the functional requirements identified in **Section 5** of this report.

Figure 2 shows the basic elements of the Market Package diagrams.

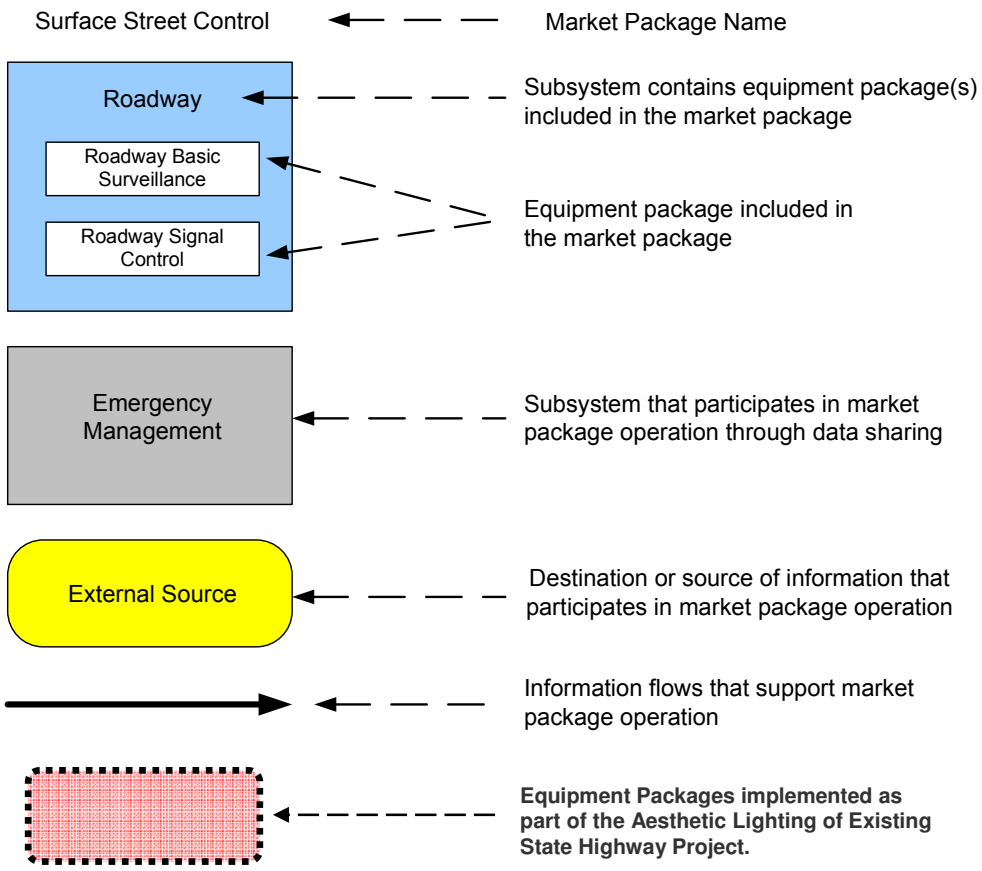
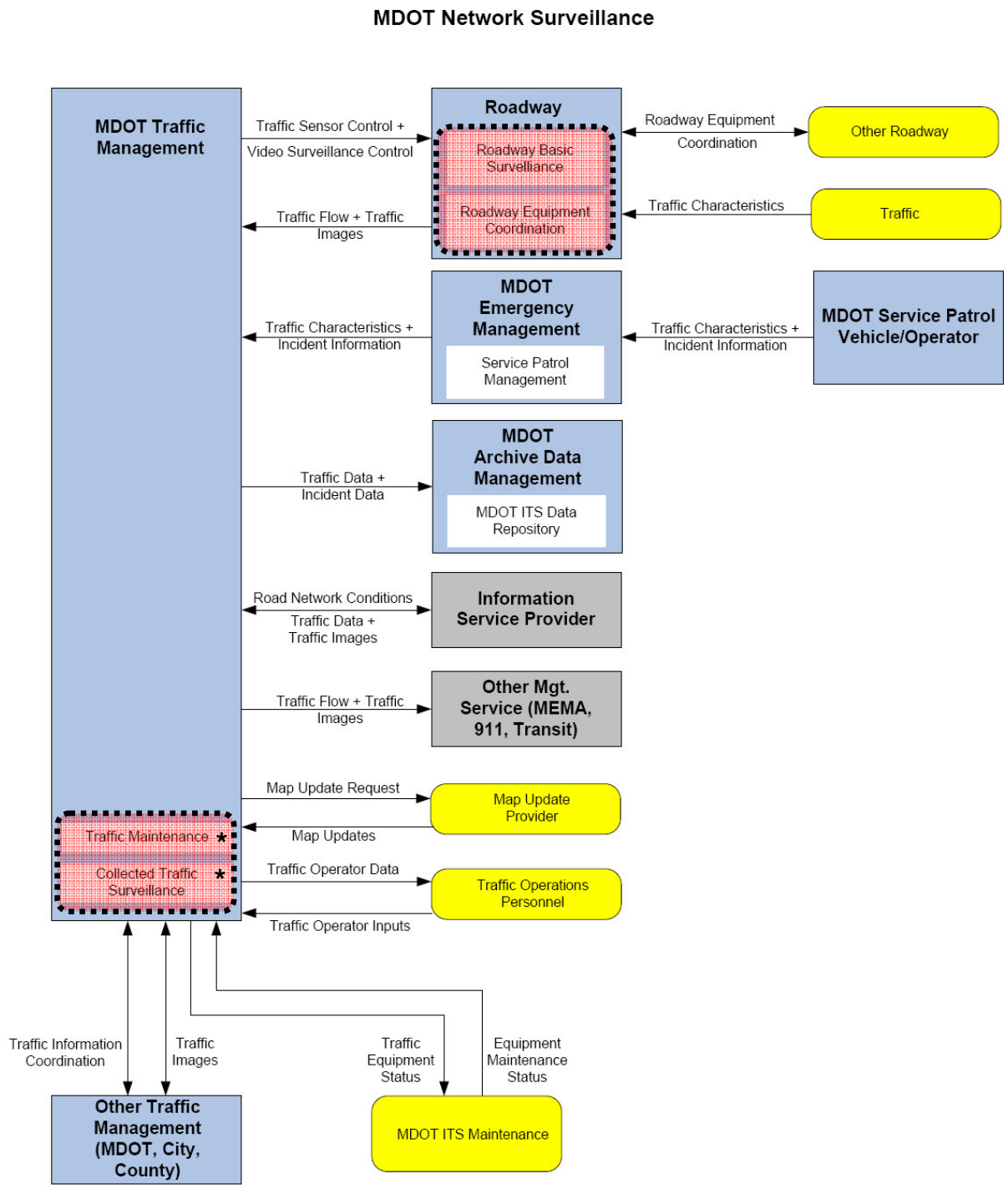
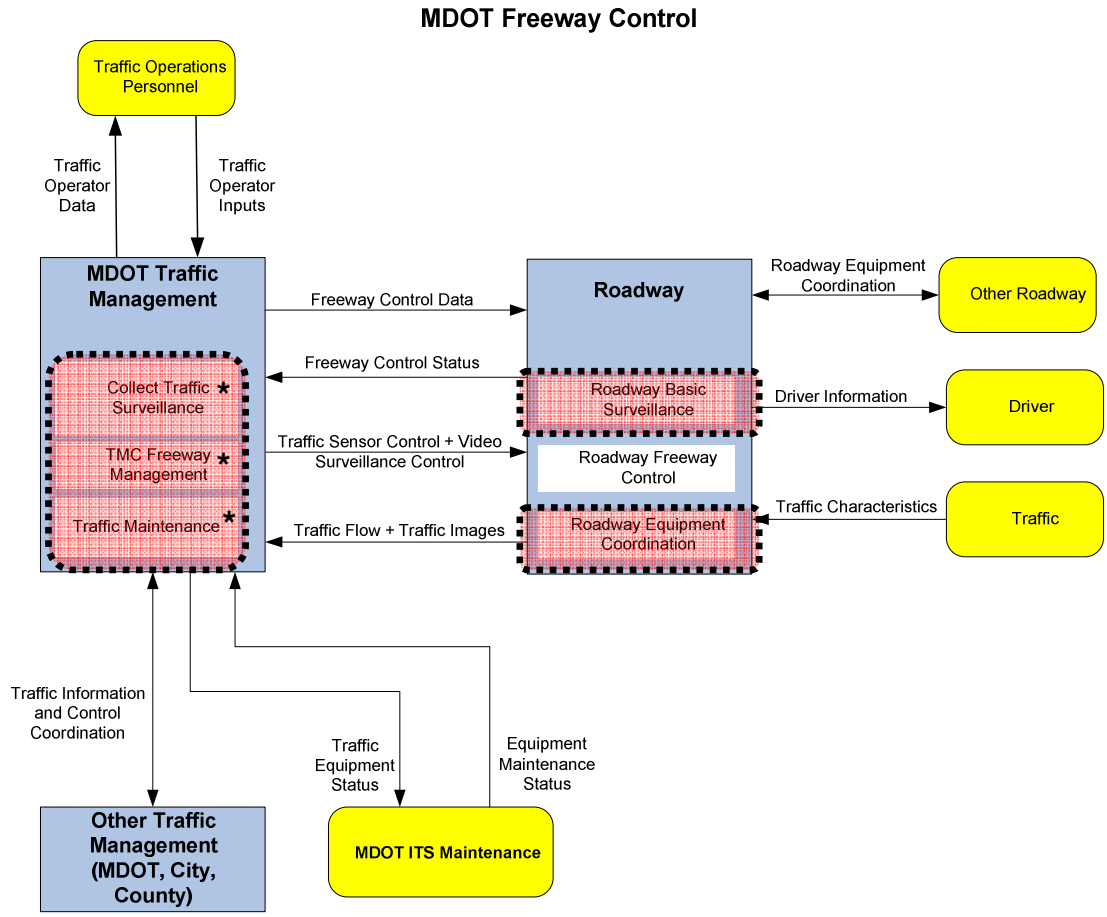


Figure 2: Basic Elements of a Market Package Diagram



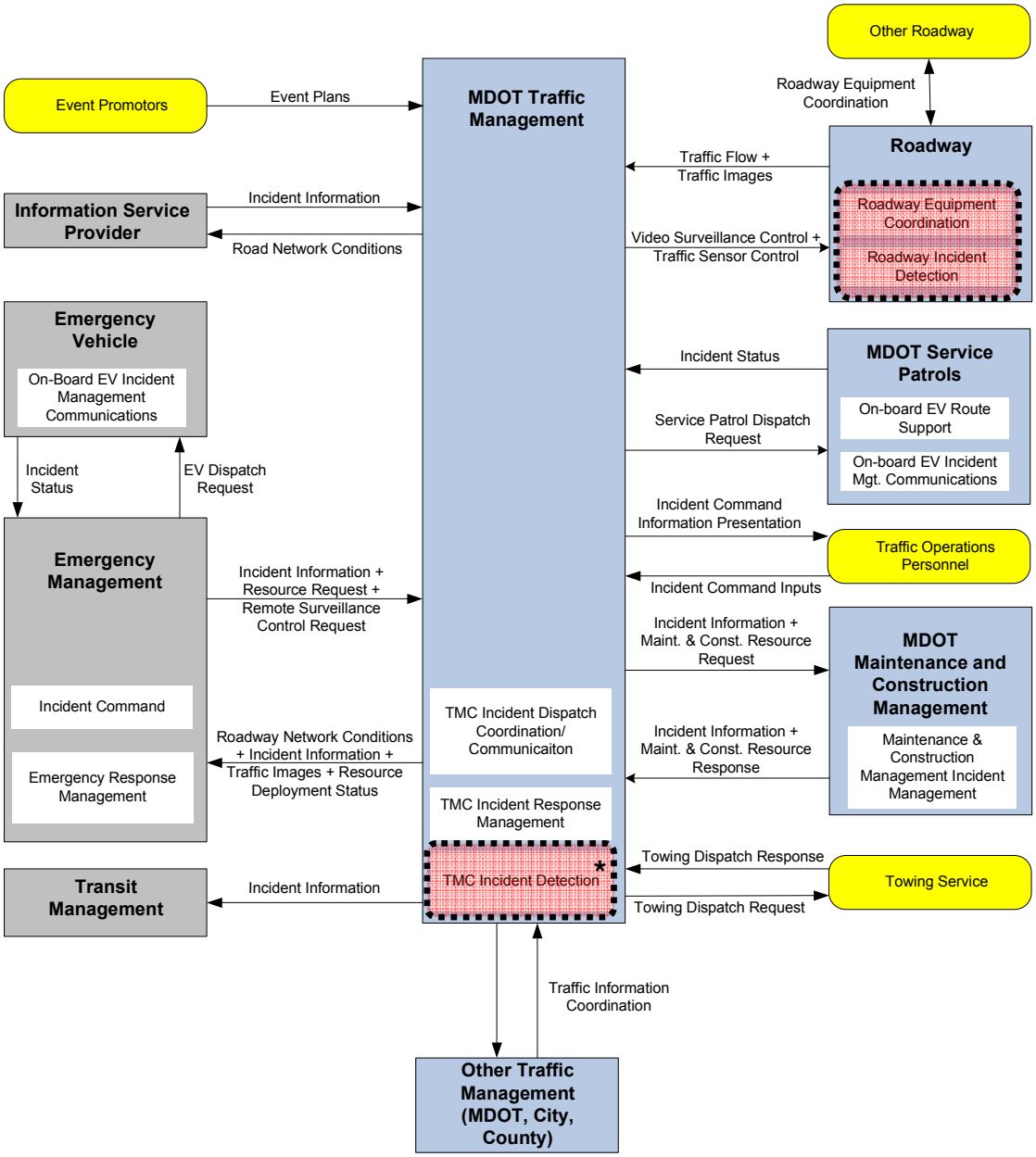
* provided through subsequent project.

Figure 3: MDOT Network Surveillance Market Package Diagram



* provided through subsequent project.

Figure 4: MDOT Freeway Control Market Package Diagram



* provided through subsequent project.

Figure 5: MDOT Traffic Incident Management Market Package Diagram

4.0 Identification of Participating Agencies' Roles and Responsibilities

The roles and responsibilities of the involved stakeholders documents their key responsibilities with regard to the implementation and operation of the ITS system. The primary stakeholders and their associated roles and responsibilities are listed in **Table 3**.

Table 3: Primary Stakeholder Roles and Responsibilities

Agency Name	Role / Responsibility
Mississippi Department of Transportation (MDOT Central Office and the Statewide TMC)	• Lead agency in the coordination of the design and construction of this project. • Lead Agency in the operation of this project within Mississippi. • Review and approve project tasks, plans, budget and schedules. • Fund the project. • Manage, operate and control ITS field equipment. • Perform incident verification through video surveillance[1]. • Coordinate incident response, road closures and detours with local incident response agencies. • Provide traffic, emergency, and incident information to the public, other agencies and between TMCs[1]. • Maintain the MDOT ITS system.
Louisiana Department of Transportation and Development	• Lead agency in the operation of this project within Louisiana. • Pay for the electrical service for the project. • Reimburse Mississippi for half of the construction cost of the project. • Manage, operate, control and maintain ITS field equipment (LADOTD owned). • Coordinate incident response, road closures and detours with local incident response agencies.
Adams County, Mississippi	• Coordinate incident response, road closures and detours with local incident response agencies. • Distribute incident information to the public.
Concordia Parish, Louisiana	• Coordinate incident response, road closures and detours with local incident response agencies. • Distribute incident information to the public.

[1] Capability provided through subsequent projects.

5.0 Requirements Definitions

Functional project-level requirements that support the Aesthetic Lighting of Existing State Highway project are listed in **Table 4**. A complete listing of the functional requirements for the Statewide ITS System is available in Appendix B of the Statewide ITS Architecture.

Table 4 includes the following information for each functional requirement:

- **Element:** Name of the system that will be performing the function
- **Entity:** Describes the National ITS Architecture subsystem to which the element is mapped
- **Functional Area:** Description of the function performed by the element
- **Requirement:** High-level functional requirement to be performed by the element supporting the functional area

The Entities and Functional Areas listed in **Table 4** are essentially the Subsystems and Equipment Packages that are being implemented as part of this project. The Subsystems and Equipment Packages are directly related to the Market Packages listed in **Table 2** and the Market Package diagrams included in **Section 3**.

Table 4: Functional Requirements[1]

Element	Entity	Functional Area	Requirement
MDOT CCTV	Roadway Subsystem	Roadway Basic Surveillance	The field element shall collect, process and send traffic images to the center for further analysis and distribution.
			The field element shall return sensor and CCTV system operational status to the controlling center.
			The field element shall return sensor and CCTV system fault data.
MDOT Traffic Sensors	Roadway Subsystem	Roadway Data Collection	The field element shall collect, process, digitize, and send traffic sensor data (speed, volume and occupancy) to the center for further analysis and storage, under center control.
			The field element shall return sensor and CCTV system operational status to the controlling center.
			The field element shall return sensor and CCTV system fault data.
MDOT Statewide TMC (Jackson)	Traffic Management	Collect Traffic Surveillance	The center shall monitor, analyze and store traffic sensor data (speed, volume, occupancy) collected from field elements under remote control of the center.
			The center shall monitor, analyze and distribute traffic images from CCTV systems under remote control of the center.
			The center shall distribute road network conditions data (raw or processed) based on collected and analyzed traffic sensor surveillance data to other centers.
			The center shall maintain a database of surveillance and sensors and their location, to which part(s) of the network their data applies, the type of data, and the ownership of each link in the network.
		TMC Incident Detection	The center shall collect and store traffic flow and image data from the field equipment to detect and verify incidents.
			The center shall provide road network conditions and traffic images to emergency management centers to support detection, verification and classification of incidents.
			The center shall provide video and traffic sensor control commands to the field equipment to detect and verify incidents.
		TMC Evacuation Support	The center shall collect and store traffic flow and image data from the field equipment to detect and verify incidents.
			The center shall provide road network conditions and traffic images to emergency management centers to support detection, verification and classification of incidents.

[1] All of the functional requirements listed for this project assume that a communications link will be established between the ITS devices installed as part of this project and the MDOT Statewide TMC. This connection is not included in the scope of this project.

6.0 Analysis of Alternative System Configurations

The ITS portion of the Aesthetic Lighting of Existing State Highway project involves the installation of closed circuit television (CCTV) cameras and video detection systems (VDS) on the bridges for U.S. 65/U.S. 84 over the Mississippi River for the purpose of monitoring vehicular traffic on the roadway and barge traffic on the river below. Fiber optic cable will be installed on the bridge for connecting the equipment and for future communications needs between MDOT and LADOTD. Initially, communications back to the MDOT Statewide TMC in Jackson will be provided by leased lines, with the intent to install a MDOT-owned communications link to the devices in the future.

Various ITS field device locations were considered, but the final locations were selected based on their ability to meet the needs to monitor vehicular traffic both on the bridges and the approaches to the bridges as well as monitor the barge traffic passing underneath.

Communications

A 72 fiber trunk line was selected to be installed on the bridge because it will provide sufficient bandwidth for future center to center communications between MDOT and LADOTD. Although fiber optic cable is the preferred communications medium by MDOT, this project is located approximately 100 miles from the MDOT fiber trunk line. Leased lines were chosen as the communications medium back to the Statewide TMC in Jackson in the interim until a more permanent connection can be made. The installation of a wireless connection or MDOT-owned fiber optic cable is cost prohibitive at the current time, however, it is anticipated that a wireless connection may be feasible in the medium-term with a MDOT-owned fiber optic cable connection being established in the long-term.

CCTV Cameras

Since three (3) of the CCTV cameras are to be mounted on the bridge structure itself, it is important that the vibration on the bridge does not negatively impact the camera images. It was included in the technical specification for the cameras that they shall have electronic image stabilization. Although interfacing with the Statewide TMC in Jackson will occur through a subsequent project, a Notice to Bidders was included that requires the contractor ensure that all devices installed are capable of working with the 360 Software that is used at the TMC. Additionally, the contractor must install the system so that it can be controlled from the communication hub cabinet with a laptop loaded with vendor supplied software.

It should also be noted that the vibration on the bridge may cause maintenance issues with the mounting of the CCTV cameras, which will be addressed by routine checks and maintenance.

Video Detection Systems

Video Detection Systems (VDS) were selected over radar detection systems, because the camera images from the VDS cameras can be used for traffic monitoring, in addition to collecting traffic flow and count data.

7.0 Procurement Options

The design for this project is being funded through the MDOT ITS Integrator contract with construction being funded with National Highway Funds (80% Federal Funds with a 20% State match). MDOT will use a traditional construction contract with competitive bidding for project implementation.

8.0 Agreements / Integration

The specific coordination of operation and maintenance of the ITS components of this project are addressed in a Memorandum of Understanding between MDOT and LADOTD. Integration with the MDOT Statewide TMC is not within the scope of this project. However, steps were taken during the design process to ensure a seamless integration process in the future.

9.0 Applicable ITS Standards

ITS standards define how ITS systems, products, and components can interconnect, exchange information and interact to deliver services within a transportation network. ITS standards are not design standards, however, the use of standards gives transportation agencies confidence that components from different manufacturers will work together.

Although stand-alone ITS applications create benefits, most ITS systems are comprised of multiple applications integrated together. These integrated systems result in the greatest efficiencies and provide the most benefit to the user. ITS standards are a critical piece to the successful integration of multiple disparate ITS technologies into a fully functioning ITS system across many geographic areas through the use of a common communications interface. To this end, ITS standards should make the sharing of video and data between MDOT and other municipalities a relatively seamless connection.

Table 5 contains of listing of the ITS standards that are applicable to the Aesthetic Lighting of Existing State Highway project.

Table 5: Applicable ITS Standards

ITS Standards			
National ITS Architecture Interface Class	**Standards Application Area**	**Associated Standards***	
Center-to-Center	Incident Management	• NTCIP 1102 • NTCIP 1104 • NTCIP 1201 • NTCIP 1211 • NTCIP 2104 • NTCIP 2202 • NTCIP 2303 • NTCIP 2304 • NTCIP 2306 • NTCIP 8003 • NTCIP 9001	• IEEE 1512-2006 • IEEE 1512.1-2006 • IEEE 1512.2-2004 • IEEE 1512.4 • SAE J2266 • SAE J2354 • SAE J2540 • SAE J2540-1 (P) • SAE J2540-2 (P) • SAE J2540-3 (P)
	Traffic Management	• ITE TMDD Guide • NTCIP 1102 • NTCIP 1104 • NTCIP 1201 • NTCIP 2104 • NTCIP 2202 • NTCIP 2303 • NTCIP 2304 • NTCIP 2306	• NTCIP 8003 • NTCIP 9001 • IEEE 1512.1-2006 • SAE J2266 • SAE J2354 • SAE J2369 • SAE J2540 • SAE J2540-1 • SAE J2540-2 • SAE J2540-3
Center to Roadside	Data Collection/Monitoring	• NTCIP 1102 • NTCIP 1103 • NTCIP 1201 • NTCIP 1204 • NTCIP 1206 • NTCIP 1209 • NTCIP 2101 • NTCIP 2102 • NTCIP 2103 • NTCIP 2104 • NTCIP 2201	• NTCIP 2202 • NTCIP 2301 • NTCIP 2302 • NTCIP 2303 • NTCIP 8003 • NTCIP 9001 • ASTM E2259-03 • ITE ATC Controller 5.2 • ITE ITS Cabinet • SAE J2266
	Vehicle Sensors	• NTCIP 1102 • NTCIP 1103 • NTCIP 1201 • NTCIP 1209 • NTCIP 2101 • NTCIP 2102 • NTCIP 2103 • NTCIP 2104 • NTCIP 2201	• NTCIP 2202 • NTCIP 2301 • NTCIP 2302 • NTCIP 2303 • NTCIP 8003 • NTCIP 9001 • ITE ATC Controller 5.2 • ITE ITS Cabinet • SAE J2266
	Video Surveillance	• NTCIP 1102 • NTCIP 1103 • NTCIP 1201 • NTCIP 1205 • NTCIP 1208 • NTCIP 2101 • NTCIP 2102 • NTCIP 2103 • NTCIP 2104	• NTCIP 2201 • NTCIP 2202 • NTCIP 2301 • NTCIP 2302 • NTCIP 2303 • NTCIP 8003 • NTCIP 9001 • ITE ATC Controller 5.2 • ITE ITS Cabinet • SAE J2266

* All listed standards have a “Published“ development status as of February 16, 2009

10.0 Operations and Maintenance Plan

Operations and maintenance (O&M) planning should occur incrementally during system implementation and be updated during the on-going operation of the system. The O&M plan should describe resource organization, responsibilities, and MDOT policies and procedures. It is critically important that the O&M plan provide sufficient information for the system to be effectively operated and maintained in the event of complete staff turnover. The following information should be identified and documented:

- Personnel responsible for operation and maintenance
- Resources (staff, tools, etc.) needed for operation and maintenance
- Funding source for on-going operations and maintenance
- Procedure for training new operations and maintenance personnel
- Safety and security of the system
- Configuration Management (how changes, repairs and upgrades will be handled and documented)
- Preventative maintenance and reactive maintenance

Operations

It is anticipated that operations will formally begin sometime in late 2010. The operation of the system will follow the guidelines set forth in the TMC Operational Procedures document. A Memorandum of Understanding between MDOT and LADOTD addresses the issue of coordination of the operations and maintenance of the ITS components of this project.

Maintenance

The existing ITS Maintenance staff for MDOT consists of an ITS Maintenance Manager with a limited number of ITS Maintenance and Network Specialists. The ITS Maintenance Manager and ITS Maintenance Specialists have responsibility for the existing ITS communications and field equipment statewide. Additionally, there is an ITS Maintenance Specialist dedicated to resolving equipment issues in the Southern Region. The existing maintenance staff track network performance and provide emergency equipment repairs and maintenance. Warranty-level support and maintenance for the field devices will be provided by product vendors and maintenance contractors under contract to the Traffic Engineering Office of MDOT. Repair parts support is accomplished through the statewide parts contract and by vendor warranty repair of parts procured through this contract.