# SYSTEMS ENGINEERING ANALYSIS

# I-12 Ramp Metering

FINAL

February 2010

Presented to:

Louisiana Department of Transportation
And Development



ABMB ENGINEERS, INC.

ABMB
ENGINEERS, INC.

February 26, 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. 700-99-0411**
**T.O. No. 701-65-1052**
**F.A.P. No. ITS-9906(549)**
**I-12 FIELD DEVICES – SYSTEMS ENGINEERING ANALYSIS**

Dear Mr. Glascock:

Please find the attached final submittal of the Systems Engineering Analysis (SE) for the I-12 Ramp Metering 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 ITS field devices including ramp meters and wire line communications. Since the Baton Rouge area has an existing ITS, this project will be a continuation of the deployed system with the addition of ramp meters.

Due to ramp metering being new to Louisiana, this SE provides detailed analysis on the options of ramp metering, how ramp meters are envisioned to operate, who will operate and maintain the ramp meters. Through the use of this SE, the ITS Section, Traffic Management Center (TMC) Operations Staff, District 61 Traffic Engineering, District 62 Traffic Engineering, and Traffic Services can understand their roles and responsibilities for ramp meter operations and maintenance.

We can meet at your first available time to discuss any comments or questions.

Sincerely,

**ABMB ENGINEERS, INCORPORATED**

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

Cc:
Mary Stringfellow, FHWA

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# 1 Acronyms and Abbreviations

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

| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| ALINEA | Asservissement LINeaire d'Entree Autoroutiere |
| ATIS | Advanced Traveler Information Systems |
| ATMS | Advanced Traffic Management System |
| ATM/EOC | Advanced Traffic Management and Emergency Operations Center |
| ASC | Actuated Traffic Signal Controller |
| C2C | Center-to-center |
| CCTV | Closed Circuit Television |
| CFR | Code of Federal Regulations |
| DATEX-ASN | Data Exchange ASN.1 |
| DOTD | Louisiana Department of Transportation and Development |
| DMS | Dynamic Message Sign |
| EOC | Emergency Operations Center |
| FAP | Federal Aid Project |
| FHWA | Federal Highway Administration |
| FSK | Frequency-shift Keying |
| GIS | Geographic Information Systems |
| GUI | Graphical User Interface |
| ITE | Institute of Transportation Engineers |
| ITS | Intelligent Transportation Systems |
| LA | Louisiana |
| LED | Light Emitting Diode |
| MAP | Motorist Assistance Patrol |
| MS/ETMCC | Message Sets for External TMC Communication |
| NEMA | National Electrical Manufactures Association |
| NTCIP | National Transportation Communications for ITS Protocol |
| O&M | Operations and Management |
| OER | Octet Encoding Rules |
| OSI | Open Systems Interconnection |
| RMC | Ramp Meter Control |
| RMS | Ramp Meter System |
| SDO | Standard Development Organizations |
| SOP | Standard Operating Procedures |
| STMF | Simple Transportation Management Framework |
| TCP/IP | Transmission Control Protocol/Internet Protocol |
| TFTP | Trivial File Transfer Protocol |
| TMC | Traffic Management Center |
| TMDD | Traffic Management Data Dictionary |
| TMP | Transportation Management Protocols |
| TO | Task Order |
| UDP/IP | User Datagram Protocol/Internet Protocol |
| U.S. | United States |
| XML | Extensible Markup Language |

# 2 Physical Architecture

## 2.1 Architecture Creation Process

The Project ITS Architecture is based primarily on *the Baton Rouge Regional ITS Deployment Plan, Baton Rouge Regional ITS Architecture,* developed in 2006, referenced herein as the regional ITS architecture. The U.S. National ITS Architecture and the Louisiana Statewide ITS Architecture were also used to supplement the Baton Rouge architecture where necessary.

### 2.1.1 Identify the Portion of the Regional ITS Architecture

Turbo Architecture was used to create an initial architecture that includes the portion of the regional ITS architecture that is relevant to the Interstate route 12 (I-12) Ramp Metering Project. As part of this process, the regional ITS architecture was upgraded from version 5.0 of the National ITS Architecture to version 6.1, the most current version of the architecture. Project documents including the Task Order Scope of Services were used to determine the portion of the regional ITS architecture that would apply to the I-12 Ramp Metering Project. The overall project limits are shown in **Figure 1**. Note the I-12 Ramp Metering Project will be constructed under two construction phases. See **Section 3.3** for the detailed phase breakdown.



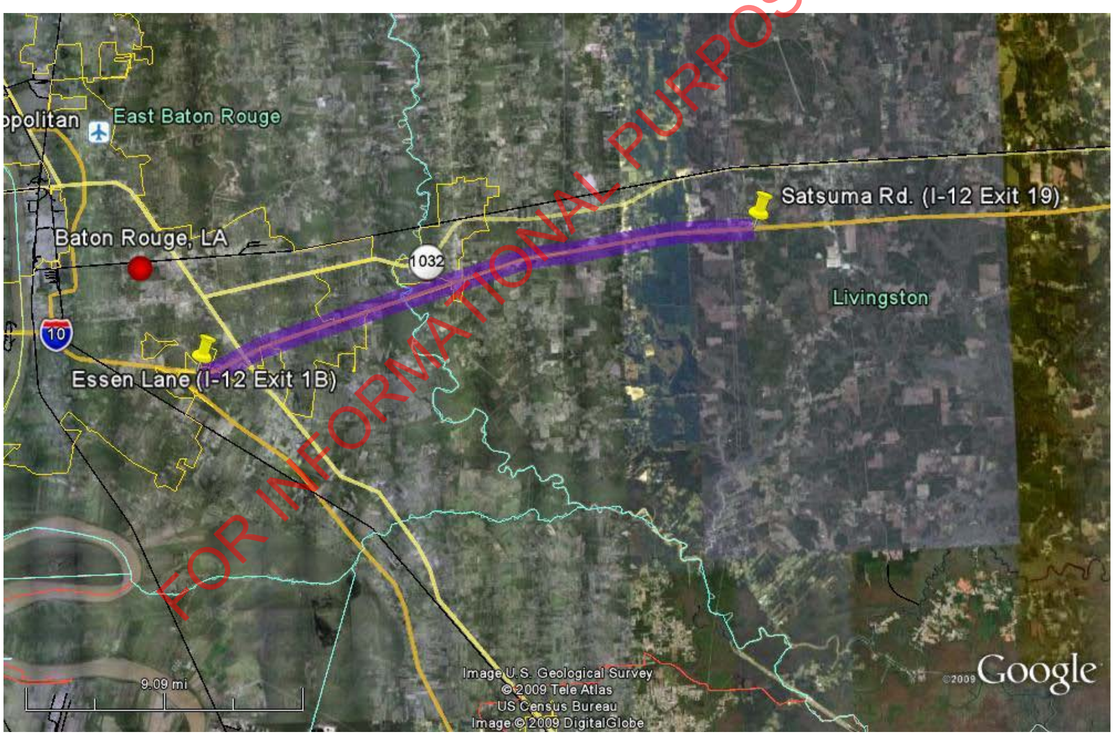


**Figure 1: Project Limits**

## 2.2 The I-12 Ramp Metering Project ITS Architecture

### 2.2.1 Stakeholders

The stakeholders associated with this project are indicated below.

- DOTD ITS Section
- DOTD Statewide TMC
- DOTD Baton Rouge TMC
- DOTD District 61 – Traffic Engineering
- DOTD District 62 – Traffic Engineering
- DOTD Traffic Services

### 2.2.2 I-12 Ramp Metering Inventory Elements

The regional ITS architecture inventory identifies the existing and planned systems in the region as a list of "inventory elements". The inventory elements of central interest are the "DOTD District 61 ITS Field Devices" and "DOTD District 62 ITS Field Devices" elements. These elements are elaborated in the I-12 Ramp Metering Project ITS architecture to more specifically identify the field devices that will be included in this project. **Table 1** identifies the inventory elements from the regional ITS architecture that are associated with this project. The elements that will be added for this project architecture have a "Planned" status and are highlighted in the table. An additional comment for each element explains the relevance of the element and identifies any potential issues associated with the element as it is defined in the regional ITS architecture.

Many of the elements in the regional ITS architecture are named as organizations (e.g., DOTD District 61 Traffic Engineering), not physical systems (e.g., DOTD District 61 Advanced Traffic Management System). This project architecture follows this convention for the additional center elements that were created. In all cases, the elements should be interpreted to represent the systems that each organization will implement and use to support ITS operations.

**Table 1: I-12 ITS Field Devices Project Inventory Elements**

| Element | Status | Description | Comment |
|---|---|---|---|
| DOTD Baton Rouge I-12 Ramp Meters | **Planned** | This element includes the ramp meters that will be installed or interconnected for this project. This element includes the ramp meters on I-12 between Essen Lane and Walker Road. | This is a specific instance of the 'DOTD District 61 ITS Field Devices' Element and 'DOTD District 62 ITS Field Devices' Element. The Baton Rouge Regional ITS Architecture will be adjusted in the future to consolidate district-specific ITS field device elements to facilitate use and maintenance. |
| DOTD District 61 Traffic Engineering (ATM/EOC) | Existing | This element represents a traffic operations center or traffic engineering division within the district office that is responsible for traffic management activities within the district's jurisdiction. The typical activities include traffic monitoring, traffic data collection, traffic signal operations, and other traffic management related activities. This also includes communicating with other departments like maintenance for roadway maintenance activities. | This is the 'DOTD District 61 Traffic Operations Center' element from the regional ITS architecture. For this project, it was renamed so that it is more consistent with other elements in the ATM/EOC. The description was also updated to better differentiate between district traffic engineering responsibilities and the responsibilities of the ITS section for this project. |
| DOTD District 62 Traffic Engineering | Existing | This element represents a traffic operations center or traffic engineering division within the district office that is responsible for traffic management activities within the district's jurisdiction. The typical activities include traffic monitoring, traffic data collection, traffic signal operations, and other traffic management related activities. This also includes communicating with other departments like maintenance for roadway maintenance activities. | This is the 'DOTD District 62 Traffic Operations Center' element from the regional ITS architecture. For this project, it was renamed so that it is more consistent with the actual DOTD structure. The description was also updated to better differentiate between district traffic engineering responsibilities and the responsibilities of the ITS section for this project. |
| DOTD Baton Rouge TMC (ATM/EOC) | Existing | This element represents the ITS Section systems and personnel at the ATM/EOC that are responsible for the operations and maintenance of all district ITS field devices. For this project, this element will monitor and control the ITS field devices during normal ATM/EOC operating hours. | This is a new element for this project. In the regional ITS architecture, the 'DOTD District 61 Traffic Operations Center' controls both ITS devices (the role of this element) and traffic signals that are managed by the traffic engineering division. These two distinct roles are split out as two separate elements in this project architecture. |

| Element | Status | Description | Comment |
|---|---|---|---|
| DOTD ITS Section | Existing | This element represents ITS section under the DOTD. The ITS section is responsible for the Statewide TMC located in the DOTD headquarters annex building. Also, the ITS section is responsible for management information system for transportation; state-wide ITS elements operations, and maintenance. The ITS section is also responsible for maintenance of all ITS equipment in the state including district 61 and 62. | As included in the regional ITS architecture. |
| DOTD Statewide TMC | Existing | This element represents the Statewide TMC located in the DOTD headquarters annex building. For this project, the Statewide TMC will monitor and control the ITS field devices after hours, supplementing the ATMS/EOC for 24/7 operation. | This is a specific instance of the 'DOTD ITS Division' element that is included in the regional ITS architecture. |

### 2.2.3 I-12 Ramp Meter Interfaces

This section includes an architecture flow diagram that defines the interfaces that are included in the I-12 Ramp Metering Project. In the diagram, "Planned" interfaces are shown where interfaces will actually be implemented as part of the project. These project interfaces are set against the context of existing interfaces related to the project.

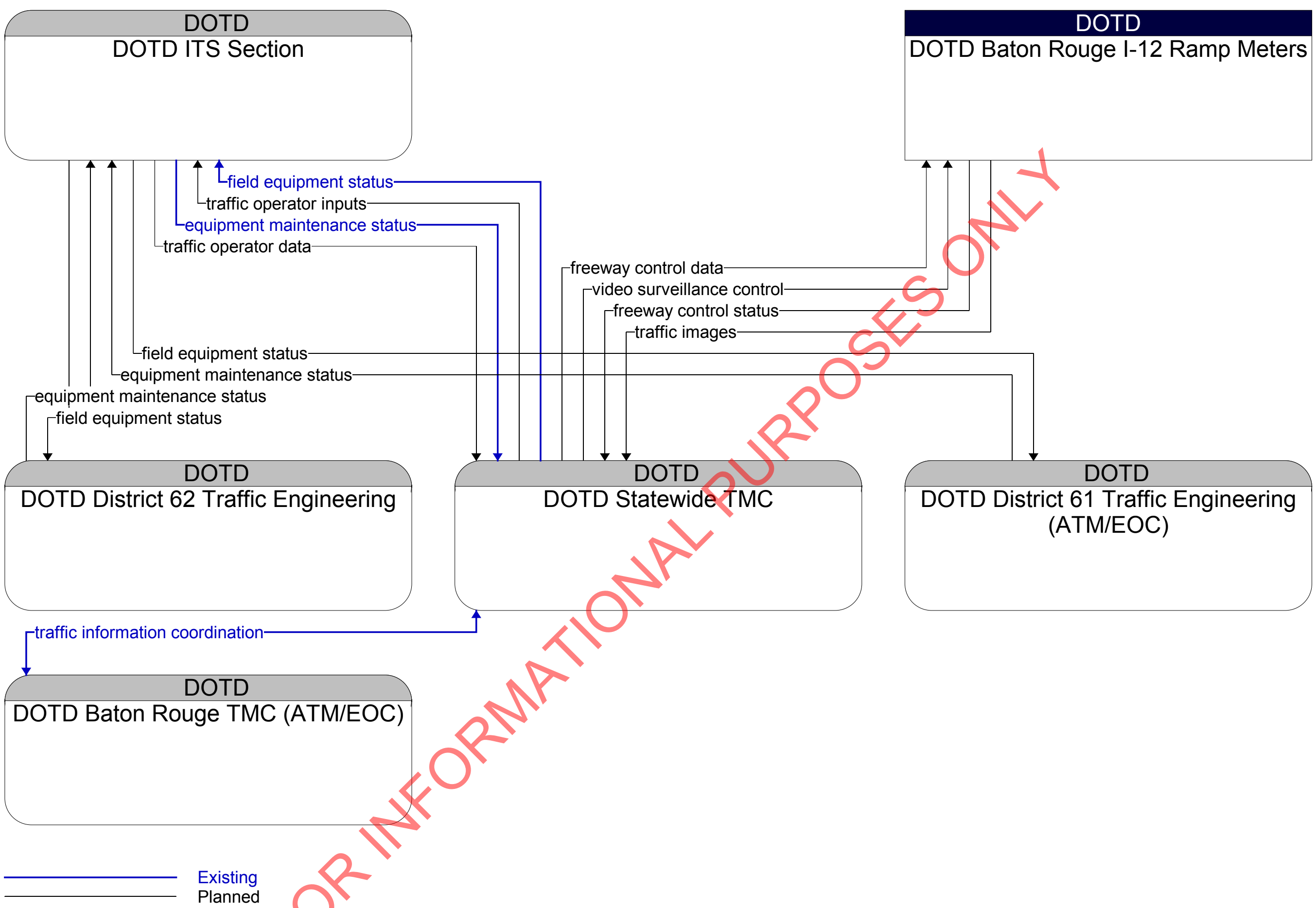





**Figure 2: Project Interfaces**

As shown in **Figure 2** Project Interfaces, the DOTD Statewide TMC monitors and controls the ramp meter equipment. TMC DOTD Statewide TMC operation hours are 24/7. DOTD ITS Section provides commands to the DOTD Statewide TMC for ramp meter operations during unplanned events. The DOTD District 61 Traffic Engineering (ATM/EOC) and DOTD District 62 Traffic Engineering will coordinate maintenance of the ramp meters with the DOTD ITS Section. The DOTD Baton Rouge TMC (ATM/EOC) will use an existing center-to-center interface as identified in the regional ITS architecture to support regional traffic management coordination and ITS field device maintenance management.

All of the architecture flows in the preceding diagrams are described in **Table 2**.

**Table 2: Architecture Flow Definitions**

| Name | Description |
|---|---|
| Equipment Maintenance Status | Current status of field equipment maintenance actions. |
| Field Equipment Status | Identification of field equipment requiring repair and known information about the associated faults. |
| Freeway Control Data | Control commands and operating parameters for ramp meters, mainline metering/lane controls and other systems associated with freeway operations. |
| Freeway Control Status | Current operational status and operating parameters for ramp meters, mainline metering/lane controls and other control equipment associated with freeway operations. |
| Traffic Information Coordination | Traffic information exchanged between TMC's. Normally would include incidents, congestion data, traffic data, signal timing plans, and real-time signal control information. |
| Traffic Images | High fidelity, real-time traffic images suitable for surveillance monitoring by the operator or for use in machine vision applications. This flow includes the images and the operational status of the surveillance system. |
| Traffic Operator Data | Presentation of traffic operations data to the operator including traffic conditions, current operating status of field equipment, maintenance activity status, incident status, video images, security alerts, emergency response plan updates and other information. This data keeps the operator apprised of current road network status, provides feedback to the operator as traffic control actions are implemented, provides transportation security inputs, and supports review of historical data and preparation for future traffic operations activities. |
| Traffic Operator Inputs | User input from traffic operations personnel including requests for information, configuration changes, commands to adjust current traffic control strategies (e.g., adjust signal timing plans, change dynamic message sign (DMS) messages), and other traffic operations data entry. |
| Video Surveillance Control | Information used to configure and control video surveillance systems. |

# 3 Concept of Operations

## 3.1 Scope

### 3.1.1 Overview

I-12 between Essen Lane and Walker Road is a heavily traveled route. The route is a 6-lane facility from Essen to O'Neal (3-lanes with a shoulder in each direction) and a 4-lane facility from O'Neal to Walker (2-lanes with a shoulder in each direction). The route is heavily congested during the morning (westbound) and evening (eastbound) commutes with limited alternative routes. The concept is to provide ramp metering to support recurrent congestion, incident, emergency management functions, and data collection. Currently, this corridor is undergoing construction to expand the travel way from O'Neal to Juban to a 6-lane facility. **Table 3** is an overview of how the existing devices and ramp meters will be used to support these functions.

**Table 3: Device Supporting Functions**

| Function | Stages | Devices |
|---|---|---|
| **Incident Management**<br><br>**Emergency Management** | Detection | Cell phones (911)<br>Vehicle Detection (fixed sites)<br>Video Surveillance<br>On-Site responder (Radio) |
| | Verification | Video Surveillance<br>On-Site responders (Radio) |
| | Response | Dynamic Message Signs<br>Video Surveillance<br>Ramp Metering |
| | Clearing | Dynamic Message Signs<br>Video Surveillance<br>Ramp Metering |
| | Restore Traffic Flow | Dynamic Message Signs<br>Video Surveillance<br>Ramp Metering |
| **Congestion Management (Recurrent)** | Pre-Congestion | Dynamic Message Signs<br>Vehicle Detection<br>Video Surveillance<br>Ramp Metering |
| | During Congestion | Dynamic Message Signs<br>Vehicle Detection<br>Video Surveillance<br>Ramp Metering |
| | Post Congestion | Dynamic Message Signs<br>Vehicle Detection<br>Video Surveillance<br>Ramp Metering |



Communications undergird the ramp meters allowing the DOTD Statewide TMC to monitor, control, collect data, and implement response plans to the events that occur on I-12 within the project limits.

The dissemination of video and traffic information to the news media would be responsibility of the DOTD.

### 3.1.2 Audience for this Concept of Operations

State Agency Stakeholders

- DOTD District 61 Traffic Engineering
- DOTD District 62 Traffic Engineering
- DOTD Baton Rouge TMC (ATM/EOC)
- DOTD ITS Section
- DOTD Statewide TMC

## 3.2 Existing Operations

DOTD currently operates ITS field devices throughout the project limits. These devices include CCTV cameras, vehicle detectors, dynamic message signs, and portable changeable message signs.

The ITS Operations Staff at the DOTD Baton Rouge TMC (ATM/EOC) are responsible for operating all ITS field devices within the Baton Rouge metropolitan area. Therefore, the existing devices within the project limits are operated at the ATM/EOC. ITS operators at the ATM/EOC are scheduled for 16 hour/day, 5 day/week operations, typically 6:00 a.m. to 10:00 p.m. ITS Operations Staff at the DOTD Statewide TMC are responsible for after hours operations.

In the ATM/EOC, the DOTD ITS Operations Staff utilize a graphical user interface (GUI) from the MIST® system to operate and manage the existing dynamic message signs and vehicle detectors. An algorithm in MIST provides an icon on the GIS map to indicate when an incident has occurred. Also, the GIS map shows abnormal reductions in speeds using a color scheme on the interstate highways. CCTV cameras are managed through a separate software package, ICX 360 Surveillance's Cameleon Version 4 Enterprise. Portable changeable message signs are operated using vendor software. Also, some of the DOTD Baton Rouge DMS operations require vendor software.

The ITS Operations Staff at the DOTD Statewide TMC interface with the DOTD Baton Rouge CCTV cameras using Cameleon Version 4 Enterprise. DOTD Baton Rouge vehicle detectors and DOTD Baton Rouge DMS are operated by the Statewide TMC using MIST through a client connection into the DOTD Baton Rouge TMC or vendor software.



Depending on the location of events within the project limits, ITS operators post messages to existing DMS or portable changeable message signs to inform motorist. A large video wall is present in the control room of both TMCs to displays the CCTV camera video in a touring or stationary mode. At the ATM/EOC the other stakeholders on the control room floor are able to view the live video on the video wall as well as directly communicate with the TMC Operators. In the Statewide TMC the ITS Operations Staff coordinate incident management events with other stakeholder via land line phone calls. In both centers ITS operators use hand held radios to coordinate with the Motorist Assistance Patrol (MAP) vans based on available video surveillance and data gathered from vehicle detectors.

Still images from existing CCTVs are available to the public via the Internet. Local public enforcement agencies (e.g., Louisiana State Police Troop A) use these still images to verify 911 calls when available.

Prior to departure, commuters use the images to determine if an alternate route or delayed departure is feasible based on the level of congestion.

Portable changeable message signs on I-12 are located within the District 62 portion of the project limits. These signs are primarily used for congestion management and are operated by the ITS Operators at the ATM/EOC during normal business hours and by the Statewide TMC after hours. Vendor software is used to interface with the portable changeable message signs.

### 3.3 System Overview

The Project shall consist of the deployment of the ramp meters. Note the Project described by this document will be deployed in two construction phases. These phases have been summarized below. Ramp meters will be deployed for each indicated interstate on-ramp, and they will be tied into the DOTD communication network, Louisiana Transportation Information System (LaTIS), via hard wired communications.

This project will be the first Louisiana deployment of a ramp meter system. Ramp meters are being used throughout the country for regulating the impact of congestion on freeways. An analysis of ramp meters from a traffic engineering standpoint was performed by ABMB Engineers, Inc. for DOTD and FHWA under a separate Task Order. The analysis demonstrated the benefits for the implementation of a ramp meter system for both eastbound (EB) and westbound (WB) I-12 from Airline Highway to Range Road (See **Appendix G**). DOTD is currently preparing construction plans for deploying the ramp meters. DOTD is anticipating constructing ramp meters on the on ramps for both eastbound and westbound I-12 from Essen Lane to Walker Road.

**Phase 1**
Walker WB
Juban WB
Range WB
O'Neal WB
Millerville WB
Millerville EB
Sherwood Forest WB
Sherwood Forest EB
Airline WB
Airline WB Loop Ramp
Airline EB
Airline EB Loop Ramp
Jefferson EB
Essen WB

**Phase 2**
Range EB
O'Neal EB

### 3.3.1 Roles and Responsibilities

The roles and responsibilities as related to this Project have been outlined in the table below. It should be noted that the roles and responsibilities listed are not fully inclusive of all the roles and responsibilities of the stakeholders. A ramp metering policy (draft) has been developed to outline the roles and responsibilities for ramp metering planning, design, maintenance, etc. A copy of the draft policy can be seen in **Appendix F**.

**Table 4: Project Roles and Responsibilities**

| Stakeholder | Roles | Responsibilities |
|---|---|---|
| DOTD ITS Section | • Operations<br>• Maintenance | • System design<br>• Construction oversight<br>• Coordination operations<br>• Managing operation staff<br>• Performing maintenance<br>  o Communications<br>• Ramp meter Operations<br>  o Evaluates traffic congestion during abnormal and planned events and directs the TMC Operators when to manually turn ramp meters ON and OFF.<br>• Ramp meter maintenance<br>  o Communications and TMC Operator workstations only |
| DOTD Statewide TMC | • ITS Field Device Operations<br>• Coordination | • Maintain device inventory and status<br>• Report hardware failure/malfunctions to DOTD ITS Section<br>• Monitor and operate ramp metering during peak traffic hours<br>  o Stop ramp metering upon any of the following:<br>    • Incident at ramp entrance onto interstate<br>    • Hardware failure/malfunction<br>    • Traffic spilling back onto surface street<br>    • Direction by DOTD ITS Section<br>  o Start ramp metering:<br>    • As directed by DOTD ITS Section<br>    • If ramp metering was initially stopped by the TMC Operator, ramp metering can be restarted if all the following are met:<br>      • If still within the normal operating time for the ramp meter<br>      • If there is no incident in the ramp entrance area<br>      • If traffic is not spilling back onto the surface street<br>      • If hardware/malfunction has been resolved and ramp meter is fully functional |

<table>
<tr><th>Stakeholder</th><th>Roles</th><th>Responsibilities</th></tr>
<tr><td>DOTD District 61 – Traffic Engineering</td><td rowspan="2">• Operations<br>• Maintenance</td><td rowspan="2">• Perform maintenance on ramp meters<br>o Initial response and investigation to complaints<br>o Perform routine maintenance<br>• LED module replacement<br>• Detector angle adjustments<br>• Sign replacements<br>o Coordinate with DOTD Traffic Services for maintenance support (see below)</td></tr>
<tr><td>DOTD District 62 – Traffic Engineering</td></tr>
<tr><td>DOTD Traffic Services</td><td>• Maintenance</td><td>• Perform maintenance support on ramp meters upon request from district traffic engineers<br>o Timing changes<br>o Controller issues (malfunctions)<br>o Cabinet/pole knock downs<br>o Reoccurring system issues<br>o Operation software issues</td></tr>
</table>

### 3.4 Operational Environment

The ramp meters to be deployed under this project are located along a 14-mile stretch of I-12 between Essen Lane and Walker Road. DOTD currently has existing field devices as well as fiber communications readily available along this route.

Southern Louisiana weather conditions demand field hardened rating to maintain an acceptable life span. High winds and poor soil conditions are also design considerations.

Traffic demand along this route is very high and directional in the peak hours. The morning ingress is comparable to the evening egress. Motorists are demanding up to date traffic reports and congestion information.

DOTD has contracted ITS Operations Staff to operate the existing and the deployed equipment. The equipment to be deployed is envisioned to operate via the existing network, servers, and desk top computers. Software will be installed on a dedicated workstation at the Statewide TMC for ramp meter operations.

### 3.5 Needs

The needs for the I-12 corridor are outlined in the tables within this section. It should be noted that these needs are in support of the operational scenarios. However, the deployment of this project may not satisfy all these needs.

**Table 5: ITS Field Device Needs**

| # | User Need ID | Need Type | Description | Stakeholders |
|---|---|---|---|---|
| 2.1 | Need_4 | Monitoring and Control of real-time surveillance | Monitoring and control of all Real time surveillance cameras | Baton Rouge TMC \| Statewide TMC |
| 2.2 | Need_6 | Monitoring and Control of ramp meters | Monitor and control of all ramp metering | Statewide TMC |
| 2.3 | Need_7 | Monitoring and Control of DMS | Monitor and control of all DMS | Baton Rouge TMC \| Statewide TMC |
| 2.4 | Need_8 | Monitoring and Control of vehicle detection | Monitor and control of all Vehicle Detection stations | Baton Rouge TMC \| Statewide TMC |
| 2.5 | Need_15 | Monitoring and Control of signal timing | Monitor and control of signal timing | District 61 \| District 62 |

**Table 6: Monitoring Needs**

| # | User Need ID | Need Type | Description | Stakeholders |
|---|---|---|---|---|
| 3.1 | Need_9 | Monitoring of field device status | Field device status (meaningful health information about the field devices) | Baton Rouge TMC \| Statewide TMC |
| 3.2 | Need_14 | Monitoring only of roadway surveillance | Real-time roadway surveillance information | District 61 \| District 62 \| Livingston Parish \| Denham Springs \| Walker \| East Baton Rouge \| LSP Troop A \| Baton Rouge DPW \| Baton Rouge TMC \| Statewide TMC |
| 3.3 | Need_17 | Monitoring only of traffic information | Real time traffic information (Speed, occupancy, count, vehicle type) | District 61 \| District 62 \| Livingston Parish \| Denham Springs \| Walker \| East Baton Rouge \| LSP Troop A \| Baton Rouge DPW \| Baton Rouge TMC \| Statewide TMC |

### 3.6 Requirements

Based on the needs for incident and emergency management as well as traffic congestion and the envisioned operations, requirements were developed for the I-12 Ramp Metering Project.

**Table 7: Communication Requirements**

| # | Sys Rqmt ID | Title | Description | Market Package |
|---|---|---|---|---|
| 1.1 | SysReq_25 | Communications - General Requirements | Communications shall conform to the following industry standard protocols:<br>- Gigabit Ethernet<br>- Fast Ethernet (copper)<br>- Open Systems Interconnection (OSI) Layer 2 and 3 | ATMS04<br>ATMS07<br>MC07 |
| 1.2 | SysReq_26 | Communications - General Requirements | Communications network shall have a latency no greater than 7 milliseconds per switch. | |
| 1.3 | SysReq_27 | Communications - General Requirements | Communications shall provide at a minimum the following fault information:<br>- Number retries before failure<br>- Delivery failure<br>- Unknown or corrupted protocol<br>- Device failed to respond | |
| 1.4 | SysReq_28 | Communications - General Requirements | Communication shall provide at a minimum the following status information:<br>- Network status (available/not available)<br>- End device response (normal/not normal)<br>- Number of end devices<br>- End device addresses<br>- Protocol type | ATMS04<br>ATMS07<br>MC07 |
| 1.5 | SysReq_39 | Communications - General Requirements | Communications shall have a bit rate error less than 10 (-12th). | |
| 1.6 | SysReq_35 | Communications Support | DOTD ITS Sections shall have support equipment to trouble shoot and maintain the following:<br>- Communications network<br>- Field equipment | |

**Table 8: Ramp Metering Requirements**

| # | Sys Rqmt ID | Title | Description | Market Package |
|---|---|---|---|---|
| 2.1 | SysReq_18 | Ramp Metering General | I-12 roadway shall contain a ramp metering system (RMS) | ATMS04<br>ATMS07<br>MC07 |
| 2.1.1 | SysReq_19 | Ramp Metering General | The ramp meter controller shall control the ramp meter advanced warning sign | |
| 2.1.2 | SysReq_38 | Ramp Metering General | Ramp metering system shall collect ramp detector data. | |
| 2.1.2.1 | SysReq_20 | Ramp Metering Collection | When activated, ramp meter system shall collect data from the following ramp detectors at a minimum:<br>- Stop bar detector<br>- Count detector<br>- Queue detector<br>- Main-line detectors | |
| 2.1.3 | SysReq_21 | Ramp Metering Status | The ramp meter controller shall provide the following status information at a minimum to the center.<br>- Unique Ramp Meter ID<br>- Location<br>- Time and date of the status report | |
| 2.1.4 | SysReq_22 | Ramp Metering States | The ramp meter controller shall provide current reported state of the RMS, including:<br>- Fault status<br>- Current timing plan<br>- Loop configuration<br>- Time and date of the last timing plan<br>- Configuration change | |
| 2.1.5 | SysReq_23 | Ramp Metering Faults | The ramp meter controller shall provide fault information at a minimum to the center:<br>- Firmware faults<br>- Communication failure<br>- Power failure<br>- Detection failure<br>- Signal head indication failure | ATMS04<br>ATMS07<br>MC07 |
| 2.1.6 | SysReq_2 | Ramp Metering Surveillance | The ramp meter system shall display live video of the ramp meter signal indications | |
| 2.1.6.1 | SysReq_3 | Ramp Metering Surveillance | The  ramp meter system shall stream live video with less than 5 seconds of latency | |
| 2.1.6.2 | SysReq_4 | Ramp Metering Surveillance | The  ramp meter system shall display live video at the user defined frames per second | |
| 2.2 | SysReq_42 | Ramp Metering Modes | The ramp metering system shall have the following modes of operation:<br>- Pre-defined fixed ramp metering rate with actuation<br>- Remote ramp metering control | |
| 2.2.1 | SysReq_43 | Ramp Metering Fixed Rates | The pre-defined fixed ramp metering with actuation shall include:<br>- User defined metering rates<br>- User defined scheduler<br>- User defined actuation parameters | |

| # | Sys Rqmt ID | Title | Description | Market Package |
|---|---|---|---|---|
| 2.2.1.1 | SysReq_58 | Ramp Metering Operations | The ramp meter shall operate the user defined timing plan during the user defined time of day. | |
| 2.2.1.1.1 | SysReq_59 | Ramp Metering Operations | The ramp meter scheduler shall be programmed on the following basis:<br>- Minute<br>- Hourly<br>- Daily<br>- Weekly | |
| 2.2.1.1.2 | SysReq_60 | Ramp Metering Operations | The user defined ramp metering plan shall include:<br>- Number of phases<br>- Green indication time per phase<br>- Red indication time per phase | |
| 2.2.1.1.3 | SysReq_56 | Ramp Metering Operations | Ramp metering shall be suspended (ramp metering off) when the ramp queue reaches a user defined length. | |
| 2.2.1.1.4 | SysReq_57 | Ramp Metering Operations | Ramp metering shall resume operations from a suspended state when the ramp queue returns within the user defined length. | |
| 2.2.2 | SysReq_61 | Ramp Metering Actuation | The pre-defined fixed ramp metering shall be operated with the following user defined actuation parameters.<br>- Vehicle presence time<br>- Stop bar presence time | |
| 2.2.2.1 | SysReq_62 | Ramp Metering Actuation | Ramp metering shall be suspended (dark indications) when vehicles are present in the queue detection zone for the user defined time. | |
| 2.2.2.2 | SysReq_63 | Ramp Metering Actuation | Ramp metering shall resume operations from a suspended stat when the vehicles are no longer present in the detection zone at the stop bar. | |
| 2.2.2.3 | SysReq_73 | Ramp Metering Actuation | The pre-defined fixed ramp metering shall be operated with the following user defined actuation parameters.<br>- Vehicle presence time<br>- Stop bar presence time | |
| 2.2.3 | SysReq_64 | Ramp Metering Central Control | The ramp metering system shall be remotely controlled from a ramp metering workstation co-existing with SteetWise Traffic Management System software (central system). | |
| 2.2.3.1 | SysReq_65 | Ramp Metering Schedule | The central system shall control the ramp meter schedule operations. | ATMS04<br>ATMS07<br>MC07 |
| 2.2.3.1.1 | SysReq_66 | Ramp Metering Schedule | The central system shall upload schedule changes to the selected ramp meter controller. | |
| 2.2.3.1.2 | SysReq_71 | Ramp Metering Schedule | The central system shall upload timing changes to the selected ramp meter controller. | |
| 2.2.3.2 | SysReq_67 | Ramp Metering Override | The central system shall control the ramp meter manual override of the pre-timed actuated operations. | |
| 2.2.3.2.1 | SysReq_68 | Ramp Metering Override | The system shall turn off the ramp meter after the user executes the Graphical User Interface (GUI) command to terminate the ramp meter. | |
| 2.2.3.2.2 | SysReq_69 | Ramp Metering Override | The system shall turn on the ramp meter after the user executes the GUI command to initiate the ramp meter. | |

| # | Sys Rqmt ID | Title | Description | Market Package |
|---|---|---|---|---|
| 2.3 | SysReq_70 | Ramp Metering GUI Status | The central system shall display the Ramp controller state status of the selected ramp meter controller using the systems GUI | |
| 2.4 | SysReq_72 | Ramp Metering GUI Status | The central system shall display the following status of the selected ramp meter using the central systems GUI:<br>- Fault status<br>- Current timing plan<br>- Loop configuration<br>- Time and date of the last timing plan<br>- Configuration changes | |

**Table 9: Existing Field Elements (No Requirements)**

| # | Sys Rqmt ID | Title | Description | Market Package |
|---|---|---|---|---|
| 4.1 | SysReq_36 | Existing field element - no requirements needed | This is to identify that this is existing and that no requirements are needed to fulfill this need. | N/A |

# 4 Design Analysis

As part of the high level design, the various ramp meter configurations options have been analyzed for their applicability in the project. The design analysis can be seen in **Appendix H**.

In summary:

- Ramp meters consisted of:
    - Pedestal mounted indications versus overhead indications for Pre-timed
    - Pre-timed versus Pre-timed with actuation versus local responsive versus system responsive

## 4.1 Ramp Metering

Since this project is the first implementation of ramp metering in Louisiana, this analysis evaluated the available options of ramp metering. Ramp metering has been ongoing since the late 1960's and has evolved with the advancements in technologies. There are two basic methodologies in ramp metering: local and system.

### 4.1.1 Local Ramp Metering

Local ramp metering is the application of ramp metering specific to the traffic demand on the on-ramp and the mainline traffic. The most simplistic application of ramp metering is a pre-timed or fixed time approach to ramp metering. Advanced applications of local ramp metering are responsive to the local traffic demand of the ramp and mainline (i.e., local responsive).

Fixed time ramp metering consists of using a controller that is programmed to operate a specified plan with a set cycle length for a specified period of time. It has been proven that fixed time ramp metering is an effective tool for breaking entry platoons. One or two vehicles are released during each green phase to allow for each vehicle to find a gap in the mainline traffic and merge.

Fixed time ramp metering is unaware of actual conditions on the ramp and mainline as the programming is based on analyzed traffic data considered typical (average) at the ramp. However, fixed time ramp metering may be supplemented by actuation parameters. When a ramp meter is programmed with actuation, the ramp meter stop bar detectors and queue detectors can be used to temporarily suspend the ramp meter until the queue has be dissipated.

Another option of ramp metering is a local responsive ramp meter. Local responsive ramp metering utilizes vehicle detection to determine the metering rate to optimize the performance of the system. Typically, vehicle detectors are positioned at the on-ramp for the collection of the approach, departure, cross street queue, and ramp queue vehicle volumes. Mainline detection may or may not be used depending on the type of algorithm or logic statements used in the programming. Based on current traffic on the ramp, the control logic will adjust the ramp meter timing to the appropriate cycle to release the vehicles. Asservissement LINeaire d'Entree Autoroutiere (ALINEA) is the most well-known algorithm for local responsive ramp metering. ALINEA uses mainline detection to dynamically adjust timing to maintain the mainline below the target occupancy level by restricting inflow from the on-ramps. The ALINEA algorithm has been used in Texas and Southern California. Georgia DOT has recently deployed ramp metering in Atlanta using a local responsive system. The firmware running in the controller is logic based using user defined speed, volume, or occupancy thresholds to determine which cycle plan to run as well as if the ramp meter is ON or OFF.

### 4.1.2 System Responsive Metering

System responsive is another methodology of ramp metering that responds to the corridor as a system. System responsive ramp metering uses an overview of the vehicular demand on the corridor before adjusting timing. Because of this overview methodology, system responsive ramp metering is also known as "coordinated."

There are several types of system responsive ramp meters. They are outlined blow.

- Coordinated ALINEA – Ramp meter timing based on the local responsive ALINEA and coordinates for the system. This approach has been used in California.
- ZONE – Ramp metering algorithm based on controller logic equating the input into a zone to the output of the zone. Thus the system would operate at the mainline capacity. ZONE is used in Minneapolis, MN.
- Cooperative – Ramp meter timings are computed based on the local traffic volumes then adjusted based on the system. Some examples of cooperative include HELPER (Denver) and LINKED (United Kingdom).
- Competitive – Ramp meter timings are computed based on both local and system inputs. The more restrictive of two is implemented. Competitive systems may use predictions to determine the bottlenecks in the network and are thus preventative. However, if the prediction is poor, the result may be worse than the original bottleneck based on measured values. Some examples of competitive ramp metering includes SWARM (CA, OR, & GA) and FLOW (formerly in Seattle).
- Integrated – Ramp meter timings are based on the incorporation of both local and system inputs to determine the optimal. Integrated includes FUZZY LOGIC (WA), and METALINE (Paris).

### 4.1.3 Ramp Metering Methodology

Operation of the freeway system is a critical component of transportation system infrastructure. Ramp metering is a tool utilized to aid in these operations. Unlike other ITS field equipment, ramp meters provide a direct element of control. Based on the timings set for the ramp meter, the ramp meter dictates the number of vehicles entering the corridor and the rate at which they enter. This control may cause motorist to alter their travel patterns based on the impact the ramp meter affects their trip. Motorist may choose a different route or change their departure time.

Restrictive ramp metering is the methodology when ramp metering timings promote the mainline movement, limit mainline entry, promote the use of alternate routes, and/or change motorist's departure times. Typically, restrictive ramp metering requires additional storage on the ramp to hold the queue. Conversely, "non-restrictive" is when ramp metering does not dictate adjustment and travel patterns. Non-restrictive ramp metering is suited for installing ramp meters on existing interchange ramps that are limited in storage length and construction budget.

The analysis on ramp meters from a traffic engineering standpoint, by ABMB Engineers, Inc., gives an in depth analysis o the use of restrictive versus non-restrict ramp metering for the I-12 corridor. An executive summary of this analysis has been provided (See **Appendix G**).

#### 4.1.4 Ramp Metering Conclusion and Recommendations

Since ramp metering has been ongoing since the 1960's, there is an abundance of analysis and experience on ramp metering. With the advancement in traffic simulation software, the impact and benefits of ramp metering can be shown and presented for public buy-in. Throughout the existing research and documentation on ramp metering, a common theme can be found; ramp metering improves the overall network performance. The degree of improvement depends on local traffic and geometric conditions.

For the I-12 corridor in the project limits, ramp metering has been shown to improve overall travel time, travel speed, delay, and reliability. Since this project will serve as DOTD's first experience with ramp metering, it is recommended that a fixed timed ramp metering with actuation solution and remote communications be implemented. This will require field equipment at the ramp meter site to include vehicle detection, communications, and controllers capable of accepting logic parameters for suspending operations.

### 4.2 Procurement Options

Various procurement options are available by DOTD for deploying an ITS project. A summary of the various options have been compiled in. The table provides the applicability of each option, pros, cons, and the recommendation. When feasible, the recommendation may indicate a specific ITS field device component be deployed under an independent project or by the ITS Maintenance.

**Table 10: Procurement Options Matrix**

| Options | Applicability | Pros | Cons | Recommendations |
|---|---|---|---|---|
| Sole Source | Purchase of a required supply, service, or major repair without competition | • Least time consuming since competitive bids are not required<br>• Items purchased may be letter bid for installation at later day | • Restricted to commodities costing less than $500<br>• Permissible only if item is available from a single supplier<br>• Requires reason why no other product is suitable or acceptable for their needs, unique characteristics, and why sold through only one source<br>• Installation is typically not included or is limited | Not applicable for project this size |
| Proprietary Purchase | Purchase of one specific product (only one in kind) but is sold through multiple distributors | • A proprietary purchase is allowed<br>• Items purchased may be letter bid for installation at later day | • Requires a letter stating why only one brand name or item is suitable<br>• Requires solicitation from multiple distributors | Not applicable for project this size |

| Options | Applicability | Pros | Cons | Recommendations |
|---|---|---|---|---|
| Sealed Bids | Purchases of exempt commodities (including ITS equipment) having an estimated cost which exceeds $25,000 (or the latest revision to R.S. 48:205, whichever is higher) | • Competitive offers allow for obtaining commodities at the lowest price<br>• Items purchased may be letter bid for installation at later day | • Restricted to awarding procurement on basis of lowest responsive price quotation<br>• Required to advertise in the Official Journal of the State and newspaper of general circulation printed in the parish, published no less than 10 days prior to the date set for opening the bids<br>• Minimum advertising period of 21 days required for bids over $25,000 (or R.S. 48:205) | Not applicable for project this size |
| Term Contract (Indefinite Quantity Purchase) | Purchase by which a source of supply is established for a specific period of time and based on indefinite quantities to be ordered “as needed” | • Once contract is established, competitive bids for commodities covered under contract are not required<br>• Qualitative & cost based selection | • Approval to by-pass a DOTD Term Contract requires written approval from the DOTD Procurement Director and would only be approved in cases of emergency<br>• Time consuming process for supplier to get term contract<br>• DOTD required to obtain bids from multiple suppliers when available | Equipment to be used for the project is expected to come out of existing DOTD stocked equipment and restocked using existing term contracts. |

| Options | Applicability | Pros | Cons | Recommendations |
|---|---|---|---|---|
| Letter Bid | Used for the selection of a contractor to perform maintenance, repairs, renovations, upgrades, or preservation of on-system roads, bridges, and other DOTD facilities. | • Faster process than typical construction projects due to solicitation directly sent to 3 proposals.<br>• Required to be advertised for a minimum of 10 calendar days prior to the scheduled bid opening.<br>• Must be advertised electronically on the DOTD web page. | • Applicable to projects that have a value of $50,000 to 500,000.<br>• Federally funded projects are not allowed to be letter bid.<br>• Not applicable to any project for which the primary purpose or object is the purchase or acquisition of materials, equipment, or supplies.<br>• Addenda are prohibited, except to withdraw the invitation for bids. | • Due to the high estimated cost of the phase 1 deployment, this option is not applicable.<br>• Phase 2 may be deployed as a letter bid. |
| Design-Bid-Build | Process for obtaining a deployed system in which design is separate from construction. The design is provided for DOTD. Once the design is complete, DOTD bids the project. The contractor with the lowest reasonable price is awarded the construction. | • Allows most control over design and freedom of design changes before construction<br>• Process has been vetted for DOTD<br>• More reliable than design-build in estimating construction cost | • "Gap" on time between design and construction can lead to outdated technology<br>• Demarcation line between design and construction phases of ITS projects may not be easily established as is typically the case in traditional roadway construction projects | • The majority of ITS deployments by DOTD in Louisiana used this procurement method and was considered successful.<br>• Due to the cost to deploy ramp meters being greater than the letter bid amount, the ramp metering component of this project may follow the design-bid-build process. Only the conduit, power, and communications components are to be contracted. DOTD Traffic service to install signal equipment. |

| Options | Applicability | Pros | Cons | Recommendations |
|---|---|---|---|---|
| Design-Build | Process for obtaining a deployed system in which one entity provides both the design and construction. | • Equipment installed is not prone to be outdated at the time of construction<br>• Design-Builder selected by review committee<br>• Designer still under contract during construction & maintenance | • More effort is required during planning prior to advertising for design-build<br>• Current laws requires a 30 day advertisement period.<br>• Procurement process has not been well vetted by DOTD<br>• Laws are subject to change in 2009 LA legislation session. | Not applicable for this project as DOTD Traffic Services to provide construction of the signal and surveillance equipment. |

# 5 Operations and Maintenance (O&M)

## 5.1 TMC Operations

At the direction of DOTD and Federal Highway Administration, the TMCs throughout the state are required to uniformly operate. The use of Standard Operations Procedure (SOP) Manuals aids in uniform operations. Since the Baton Rouge TMC has been in operation for several years, its SOP has been vetted and all TMCs are operating under its policies and procedures. The only variance expected in the SOPs will be items specific to coordination with local agencies, the ITS equipment, and TMC operations software. The ramp meters deployed by this project will fall under the Statewide TMC and its operating procedures.

Since this is the first ramp meter deployment in the state, DOTD has decided that the Statewide TMC Operations Staff shall operate the ramp meters. This system engineering document shall serve as operational procedures for the ramp meter operations. Once the I-12 ramp meters have been deployed, operated, and experienced gained, DOTD will reevaluate the operational procedures from this SE document and develop standard operating procedures for ramp meters. See **Section 3.3.1** for the roles and responsibilities of the TMC operators. It should be noted that the existing CCTV cameras along I-12 and the ramp meter system video cameras for viewing indications will be used for ramp meter operations.



## 5.2 Ramp Meter Field Operations

As vehicles enter the interstate on-ramp they are notified of the status of the ramp meter operations by the advanced warning sign. It is composed of a mast arm pole with two overhead flashing beacons adjacent to a warning sign with the text, "Ramp Metered When Flashing." Further down the ramp, the vehicles encounter the ramp meter signal, which appears similar to a traditional intersection traffic signal. The ramp meter differs from the traffic signal in the number of indications, signage, and the timing. Respectively, there are two indications per ramp meter head (red and green), the signage indicates one vehicle per green, and the timing is approximately four to eight seconds per cycle. If there are no vehicles on the ramp when the ramp meter is active, the indications will remain red (i.e., rest in red). Therefore, the first approaching vehicle will always have to fully stop. Once detected, the ramp meter will start the timing cycle, changing from red to green to release one vehicle per lane, one lane at a time. The vehicles are now adequately spaced so that they can easily negotiate and maneuver to merge into the interstate traffic.

Due to the interstate on-ramps having a finite amount of storage, the ramp meters have detection zones for actuated response. The zones of detection are at the stop bar and in advance of the surface street (advanced queue detector). If the maximum queue is detected by the advanced queue detector, the ramp meter automatically goes into a "flush function." The flush function enables the ramp meter indications to go "dark" until the queue has dissipated. During the time of day operations, the ramp meters can automatically initiate and terminate the flush function.

If a queue is detected by the advanced queue detector during the start up of the time of day plan, the ramp meter indications will remain dark until the queue has dissipated. Likewise, if the ramp is running the flush function at the end of time of day plan, the ramp meter will remain dark until the ramp meter is turned on by the next time of day plan.

Outside of the peak traffic time, the ramp meters can be remotely initiated and terminated by the TMC Operator at the direction of the DOTD ITS Section. Anytime the ramp meter is ON, whether by manual turn ON or by the time of day plan, the flush function is automatically activated based on the detection scheme previously described.

## 5.3 Envisioned Ramp Meter Management Structure

Based on the Roles and Responsibilities and the envisioned operations, the management structure for the I-12 project ramp metering deployment has been developed. Maintenance reporting from the Statewide TMC Manager is performed by email submittal of the standard TMC equipment maintenance form to the ITS Maintenance and Communications Engineer (ITS Section). The ITS Maintenance and Communications Engineer provides maintenance request to the District 61 Traffic Operations Engineer and/or District 62 Traffic Operations Engineer by phone or by email depending on the details of the required maintenance efforts need by Traffic Services. The District 61 Traffic Operations Engineer and/or District 62 Traffic Operations Engineer provide the equipment maintenance status by phone or by email.

### 5.3.1 Envisioned Ramp Meter Deployment

DOTD has chosen to use both contracted labor and DOTD Traffic Services personnel to deploy the ramp meter system. Ramp meter design plans have been developed detailing the responsibilities of the contractor versus the responsibility of DOTD.



Contractor Responsibilities:

The Contractor shall coordinate, plan, install, test, commission, and provide a fully functional communications, power, and underground conduit system, in place, and ready for the ramp meters as described in the plans and specifications

The power system required to be provided by the Contractor includes the service connection with the local power company, power pedestal (disconnect), and all underground conduit and junction boxes between the service connection and the power pedestal.

The communications system required to be provided by the Contractor includes fiber splicing with the LADOTD fiber backbone, fiber terminations in the LADOTD installed ramp meter cabinets, testing, and all underground conduit and junction boxes between the splice closure and the ramp meter cabinets.

The underground conduit system to be provided by the Contractor includes all underground conduit and junction boxes between the ramp meter cabinet and the mast arm for the “RAMP METERED WHEN FLASHING” sign.

DOTD Responsibilities:

The DOTD Traffic Services staff shall coordinate, plan, install, test, commission, and integrate all equipment required for fully functional ramp metering system, in place, and ready operations.

DOTD shall provide, install all foundations, support poles, cabinets, controllers, ramp meter signal heads, vehicle detectors, signs, striping, and wiring.

Once the contractor and DOTD have completed the equipment installation, DOTD Traffic Services and the ITS Section shall integrate the system. The ITS Section will integrate and configure the field Ethernet switches with the Hub sites and the head end switch and servers at the Statewide TMC. The StreetWise software will be installed in a dedicated console at the Statewide TMC. DOTD Traffic Services along with the manufacturer, Naztec, will facilitate the installation and integration. DOTD Traffic Service shall provide an on-site technician for ramp meter controller programming and start up support.

The turn-on of the ramp meters is envisioned to be a sequential process. Rather than turn the on all at once, DOTD has chosen to stagger the turn-on to one or two at a time. This will give both DOTD and the motorist time to adapt to the new system. During the start up at each ramp meter site, the DOTD Traffic Service technician along with the ramp meter design consultant will evaluate and provide on-site tweaks to the timing schemes. Once the final timing scheme is observed to be operating efficiently, no further ongoing timing change are required.

#### 5.3.2 Ramp Meter O&M Funding

Naturally, funding plays an important role in the decision making process on every project from initial deployment to operations and maintenance to replacement. With DOTD operating on a highly constrained budget due to the economy, the O&M cost must be evaluated and planned for successfully and continuous operations.

Evaluation of the capitol cost has been ongoing. DOTD has planned to use a contractor to deploy the power, communication, and conduit infrastructure for the project. Traffic Services' construction staff will install the ramp meter site equipment. "State Only" funds are expected to be used for the contractor's installation components. Federal funds will be used in part to purchase the ramp meter equipment.

After the completion of the construction, operations and maintenance will follow the process previously described herein. DOTD staff, whether ITS Section, TMC Operations, District Traffic Engineering, or Traffic Services, will be responsible for the O&M as an extension of their current responsibilities. Based on the FHWA cost database, the annual O&M for each ramp meter ranges on average between $1,200 to $2,400 with an estimated life span of 5 years. This estimate includes the ramp meter assembly, signal displays, controller, cabinet, detection, and optimization.

DOTD has committed to ramp meter deployments, operations and maintenance along the I-12 corridor. Each DOTD section responsible for O&M has been instructed to commit the appropriate manpower and funding as part of its annual budget to ensure the success of the ramp meters. Both state and federal funds are expected to be used for ramp metering operations and maintenance.

### 5.4 Maintenance

DOTD's ITS Section and DOTD district traffic engineers are responsible for maintaining the ramp meters. Ramp meters field equipment is to be maintained by the DOTD district traffic engineering department in which they are located. When ramp meter maintenance items are beyond the district traffic engineering department's capabilities, DOTD Traffic Services (Section 45) will be called on for assistance. Communications with the ramp meters and the TMC Operator console for the ramp meter software will be maintained by the ITS Section.

Until recently, contracted maintenance and DOTD ITS staff were used to maintain the field equipment. This contracted maintenance was included as part of each ITS deployment under an extended maintenance agreement. The contracted maintenance under the extended maintenance agreements have been proven to be unsuccessful, and DOTD ITS staff is now solely maintaining the ITS system. The DOTD ITS 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 of ITS throughout the state. Spending of the maintenance budget is based on priority as determined by the ITS Section.

DOTD's ITS Section is currently developing an ITS Maintenance Plan. In developing the ITS Maintenance Plan, the ITS Section is investigating and weighing its options including the following:

- DOTD provided maintenance
- Municipality provided maintenance
- Extended maintenance
- Letter bids
- State contracts
- Engineering led maintenance contracts

The ITS Maintenance Plan is expected to be completed by within the second quarter of 2009. The resulting maintenance support is expected to be in place by early 2011. Until the completion of the ITS Maintenance Plan and resulting support, the ITS staff will maintain the ITS field equipment deployed as part of this project.

# Appendix A

**Market Packages**

The regional ITS architecture identifies traffic management and maintenance market packages that will be supported by the I-12 Ramp Metering Project. The overall list of generic market packages in the regional ITS architecture was culled and "market package instances" were created for the I-12 project that more precisely define the specific transportation services that will be implemented or supported by this project. **Table A-1** lists the transportation services that will be supported by this project in the form of market packages and associated elements that will support each service. All selected market packages were also included in the regional ITS architecture.

**Table A-1: I-12 Ramp Metering Transportation Services**

| MP | MP Name | MP Description | Related Element |
|---|---|---|---|
| ATMS04 | I-12 Ramp Metering Project Freeway Control | This market package provides central monitoring and control, communications, and field equipment that support freeway management. This instance of the market package for the I-12 project provides a core service that supports ramp metering in the project area. | DOTD Baton Rouge I-12 Ramp Meters |
| | | | DOTD Baton Rouge TMC (ATM/EOC) |
| | | | DOTD Statewide TMC |
| ATMS07 | I-12 Ramp Metering Project Regional Traffic Management | This regional market package provides for the sharing of traffic information and control among traffic management centers to support regional traffic management strategies. This instance of the market package for the I-12 project focuses on coordination between the BR TMC and the Statewide TMC that supports coordinated traffic management of I-12 within the project area. | DOTD Statewide TMC |
| | | | DOTD Baton Rouge TMC (ATM/EOC) |
| MC07 | I-12 Ramp Metering Project Roadway Maintenance and Construction | This regional market package supports numerous services for scheduled and unscheduled maintenance and construction on a roadway system or right-of-way. The focus of this instance of the market package for the I-12 project is on repair and maintenance of ramp meters. | DOTD ITS Statewide TMC |
| | | | DOTD ITS Section |
| | | | DOTD District 61 Traffic Engineering |
| | | | DOTD District 62 Traffic Engineering |

# Appendix B

**Market Packages Functional Requirements**

The regional ITS architecture document lists the equipment packages associated with each of the market packages that were selected for the region. Building on this for the I-12 Ramp Metering Project, the relevant equipment packages identified in the regional ITS architecture and specific functional requirements from the National ITS Architecture that apply to the core ITS field devices elements are listed in **Table B-1**. The identified equipment packages and functional requirements apply to the DOTD Baton Rouge I-12 Ramp Meters" elements.

**Table B-1: I-12 ITS Ramp Metering Functional Requirements**

| Equipment Package | EP Description | ID | Requirement |
|---|---|---|---|
| Roadway Freeway Control | Freeway control equipment including ramp meters, mainline metering, and lane control equipment which controls traffic on freeways, including indicators to drivers. | 2 | The field element shall monitor operation of ramp meter, mainline meters, and lane control indicators and report to the center any instances in which the indicator response does not match that expected from the indicator control information. |
| | | 7 | The field element shall include ramp metering controllers under center control. |
| | | 8 | The field element shall monitor operation of ramp meters and report to the center any instances in which the response does not match that expected from the indicator. |
| | | 9 | The field element shall return ramp metering controller operational status to the controlling center. |
| | | 10 | The field element shall return ramp metering controller fault data to the maintenance center for repair. |

# Appendix C

**ITS Standards**

The Turbo Architecture database that was created for the I-12 Ramp Metering Project ITS Architecture identifies the ITS standards that support the planned system interfaces. **Table C-1** lists all of the ITS standards that are associated with one or more Project interfaces. Use the database to generate more detailed reports that associate specific standards with each of the I-12 Ramp Metering project interfaces.

Note that the ITS standards presented in this table represent a superset of options provided by the Turbo Architecture software, and in some cases, the listed standards provide redundant capabilities. In addition, these ITS standards are at different maturity levels. This set of potential ITS standards should be reviewed and analyzed for suitability for a particular application as part of the systems engineering analysis.

**Table C-1: ITS Standards Supporting Future I-12 ITS Field Devices Interfaces**

| Type | SDO | Doc ID | Title |
|---|---|---|---|
| Message/Data | AASHTO/ITE | ITE TMDD 2.1 | Traffic Management Data Dictionary and Message Sets for External TMC Communication (TMDD and MS/ETMCC) |
| | AASHTO/ITE/NEMA | NTCIP 1201 | Global Object Definitions |
| | AASHTO/ITE/NEMA | NTCIP 1202 | Object Definitions for Actuated Traffic Signal Controller (ASC) Units |
| | AASHTO/ITE/NEMA | NTCIP 1207 | Object Definitions for Ramp Meter Control (RMC) Units |
| | AASHTO/ITE/NEMA | NTCIP 1102 | Octet Encoding Rules (OER) Base Protocol |
| | AASHTO/ITE/NEMA | NTCIP 1103 | Transportation Management Protocols (TMP) |
| Communications Protocol | AASHTO/ITE/NEMA | NTCIP 1104 | Center-to-Center Naming Convention Specification |
| | AASHTO/ITE/NEMA | NTCIP 2101 | Point to Multi-Point Protocol Using RS-232 Subnetwork Profile |
| | AASHTO/ITE/NEMA | NTCIP 2102 | Point to Multi-Point Protocol Using FSK Modem Subnetwork Profile |
| | AASHTO/ITE/NEMA | NTCIP 2103 | Point-to-Point Protocol Over RS-232 Subnetwork Profile |
| | AASHTO/ITE/NEMA | NTCIP 2104 | Ethernet Subnetwork Profile |
| | AASHTO/ITE/NEMA | NTCIP 2201 | Transportation Transport Profile |
| | AASHTO/ITE/NEMA | NTCIP 2202 | Internet (TCP/IP and UDP/IP) Transport Profile |
| | AASHTO/ITE/NEMA | NTCIP 2301 | Simple Transportation Management Framework (STMF) Application Profile |
| | AASHTO/ITE/NEMA | NTCIP 2302 | Trivial File Transfer Protocol (TFTP) Application Profile |
| | AASHTO/ITE/NEMA | NTCIP 2303 | File Transfer Protocol (FTP) Application Profile |
| | AASHTO/ITE/NEMA | NTCIP 2304 | Application Profile for DATEX-ASN (AP-DATEX) |
| | AASHTO/ITE/NEMA | NTCIP 2306 | Application Profile for XML Message Encoding and Transport in ITS Center-to-Center Communications (C2C XML) |

# Appendix D

**Suggested Changes to Baton Rouge Regional ITS Architecture**

The section identifies potential issues and opportunities for improvement in the regional ITS architecture that were identified as the I-12 Ramp Metering Project ITS Architecture was developed. While quite a few issues were identified, the regional ITS architecture provided a satisfactory basis for project architecture definition.

Only significant potential regional ITS architecture changes are itemized in this section. Minor editorial changes were also made to descriptions and a few status changes were made that are not documented in this document. All potential changes are included in the Turbo Architecture database that was used to support the I-12 project architecture development. The database is a good resource that can be used to collect additional potential change information to support a future regional ITS architecture update.

Two tables contain lists of the more significant potential changes. The **Table D-1** identifies suggested inventory, service (market package) and functional requirements changes. **Table D-2** identifies all information flows updated based on a Region to Project comparison report that was run in the project Turbo file.

**Table D-1: Baton Rouge Regional ITS Architecture Comments – Inventory, Services, and Requirements**

| Area | Regional Item (Was) | Project Item (Is) | Comment |
|---|---|---|---|
| Inventory | LA DOTD District Office [stakeholder]<br>LA DOTD Central Office [stakeholder] | DOTD [Stakeholder] | The two DOTD stakeholders have been combined into one single stakeholder since the DOTD is one entity. There is no benefit gained by further separating the DOTD between the Central Office and the District Office as the stakeholders. |
| | DOTD District 61 Traffic Operations Center | DOTD District 61 Traffic Engineering (ATM/EOC)<br>DOTD Baton Rouge TMC (ATM/EOC) | The ATM/EOC is represented in the regional ITS architecture with a single "DOTD District 61 Traffic Engineering (ATM/EOC)" element. Consider updating the regional ITS architecture so that all organizations and systems within the ATM/EOC are clearly represented. This could be supported in the regional ITS architecture with a single ATM/EOC element that is renamed and associated with a stakeholder group of all resident agencies and an expanded description that covers all included systems. In this project architecture, we chose to clearly represent both agencies (DOTD Traffic Engineering, and DOTD Baton Rouge TMC operations) as two separate, consistently named elements as shown. All names consistently identify the organization and include "ATM/EOC", following the pattern established with the existing ATM/EOC element. We also felt it was important to show and distinguish between DOTD ITS Operations and DOTD District 61 Traffic Engineering responsibilities and interfaces within the ATM/EOC with separate elements. This granularity could also be added to the regional ITS architecture at the discretion of the region. |
| | DOTD ITS Division | DOTD ITS Section | Renamed to correctly identify the ITS organization within DOTD. Note that the current inventory includes elements that are named as organizations (e.g., DOTD ITS Division) and as systems (e.g., DOTD District 61 Traffic Operations Center). While it is generally recommended to use system names in your inventory, organization names can also be used if desired by the region. Consider also renaming the DOTD ITS Division to the DOTD ITS Section so that it better represents the maintenance system(s) that are used by the ITS Section. |
| | | DOTD Statewide TMC | A separate element was created for this system. This system is significant enough to also include explicitly in the regional ITS architecture. |
| Services | ATMS04: Freeway Control | ATMS04 : I-12 ITS Field Devices Project Freeway Control | The "DOTD Statewide TMC" and DOTD Baton Rouge TMC (ATM/EOC) elements should be added to the regional market package. |

| Area | Regional Item (Was) | Project Item (Is) | Comment |
|---|---|---|---|
| | ATMS07: Regional Traffic Control | ATMS07 : I-12 ITS Field Devices Project Regional Traffic Management within ATM/EOC | The "DOTD Statewide TMC" and DOTD Baton Rouge TMC (ATM/EOC) elements should be added to the regional market package. |
| | MC07: Roadway Maintenance and Construction | MC07 : I-12 ITS Field Devices Project Roadway Maintenance and Construction | The "DOTD Statewide TMC" and DOTD Baton Rouge TMC (ATM/EOC) elements should be added to the regional market package. |
| **Require-ments** | **(None)** | | Consider adding functional requirements to the regional ITS architecture in the next major revision. National ITS Architecture functional requirements were used in this project architecture. |

**Table D-2: Baton Rouge Regional ITS Architecture Comments – Missing Flows**

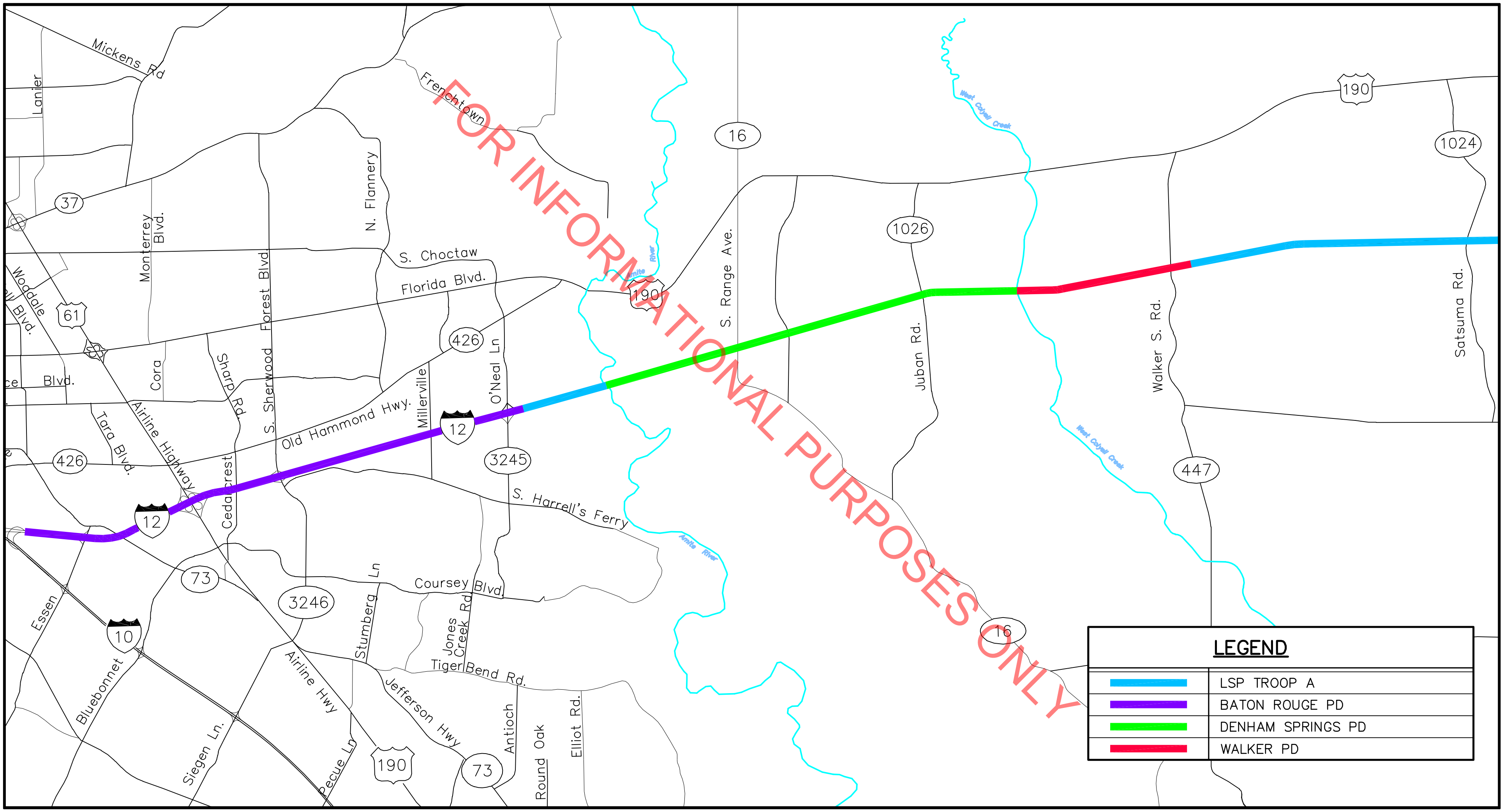
| Source | Destination | Flow | Comment |
|---|---|---|---|
| DOTD Baton Rouge ITS Field Devices | DOTD Statewide TMC | Traffic images | Add this flow |
| DOTD Baton Rouge ITS Field Devices | DOTD Baton Rouge TMC (ATM/EOC) | Freeway control status | Update the center-field interface with the District 61 ITS Field devices. The regional ITS architecture shows all of these interfaces with the District 61 Traffic Operations Center rather than ITS Operations. |
| DOTD Baton Rouge ITS Field Devices | DOTD Baton Rouge TMC (ATM/EOC) | Roadway information system status | |
| DOTD Baton Rouge ITS Field Devices | DOTD Baton Rouge TMC (ATM/EOC) | Traffic flow | |
| DOTD Baton Rouge ITS Field Devices | DOTD Statewide TMC | Freeway control status | Update the center-field interface with the District 61 ITS Field devices. The regional ITS architecture shows all of these interfaces with the ITS Section instead of a more specific DOTD Statewide TMC element. |
| DOTD Baton Rouge ITS Field Devices | DOTD Statewide TMC | Roadway information system status | |
| DOTD Baton Rouge ITS Field Devices | DOTD Statewide TMC | Traffic flow | |
| DOTD Baton Rouge TMC (ATM/EOC) | DOTD Baton Rouge ITS Field Devices | Video surveillance control | Update the center-field interface with the District 61 ITS Field devices. The regional ITS architecture shows all of these interfaces with the District 61 Traffic Operations Center rather than Baton Rouge TMC. |
| DOTD Baton Rouge TMC (ATM/EOC) | DOTD Baton Rouge ITS Field Devices | Freeway control data | |
| DOTD Baton Rouge TMC (ATM/EOC) | DOTD Baton Rouge ITS Field Devices | Roadway information system data | |
| DOTD Baton Rouge TMC (ATM/EOC) | DOTD Baton Rouge ITS Field Devices | Traffic sensor control | |
| DOTD District 61 Traffic Engineering (ATM/EOC) | DOTD ITS Section | Field equipment status | Add flows to provide capability for DOTD ITS Section to receive maintenance status from District Traffic Engineers |
| DOTD District 62 Traffic Engineering | DOTD ITS Section | Field equipment status | |
| DOTD ITS Section | DOTD Baton Rouge TMC (ATM/EOC) | Equipment maintenance status | Add flows to provide capability for DOTD ITS Section to report maintenance status to ATM/EOC, District Traffic Engineers, and Statewide TMC. Regional ITS |
| DOTD ITS Section | DOTD Statewide TMC | Equipment maintenance status | |

| Source | Destination | Flow | Comment |
|---|---|---|---|
| DOTD ITS Section | DOTD District 61 Traffic Engineering (ATM/EOC) | Equipment maintenance status | architecture appears to involve maintenance division in ITS equipment maintenance, but in the project architecture, the maintainer is the ITS Section. |
| DOTD ITS Section | DOTD District 62 Traffic Engineering | Equipment maintenance status | |
| DOTD Statewide TMC | DOTD Baton Rouge ITS Field Devices | Video surveillance control | If a distinct Statewide TMC element is added, also add interfaces to both D61 and D62 ITS field devices. |
| DOTD Statewide TMC | DOTD Baton Rouge ITS Field Devices | Freeway control data | |
| DOTD Statewide TMC | DOTD Baton Rouge ITS Field Devices | Roadway information system data | |
| DOTD Statewide TMC | DOTD Baton Rouge ITS Field Devices | Traffic sensor control | |
| DOTD Statewide TMC | DOTD Baton Rouge ITS Field Devices | Video surveillance control | |
| DOTD Statewide TMC | DOTD Baton Rouge ITS Field Devices | Freeway control data | |
| DOTD Statewide TMC | DOTD Baton Rouge ITS Field Devices | Roadway information system data | |
| DOTD Statewide TMC | DOTD Baton Rouge ITS Field Devices | Traffic sensor control | |
| DOTD Statewide TMC | DOTD District 62 Traffic Engineering | Traffic information coordination | Also add center to center interfaces for the Statewide TMC (interfaces not currently included for the ITS Division) |
| DOTD Statewide TMC | DOTD Baton Rouge TMC (ATM/EOC) | Traffic information coordination | |

# Appendix E

**Law Enforcement Jurisdiction Map**

# LAW ENFORCEMENT JURISDICTION MAP



# Appendix F

**Ramp Metering Policy (Draft)**

# RAMP METERING POLICY

## I. Background

To promote consistency statewide for all aspects of ramp metering implementation, operation and maintenance this policy for ramp metering has been adopted. Since ramp metering is new to Louisiana, it is expected that this policy will be refined over time. The Federal Highway Administration (FHWA) has developed a *Ramp Management and Control Handbook* to provide guidance for this tool. According to FHWA, ramp metering is defined as follows:

*Ramp metering is the deployment of traffic signal(s) on a ramp to control the rate vehicles enter a freeway facility. By controlling the rate vehicles are allowed to enter a freeway, traffic flow onto the freeway facility becomes more consistent, in essence smoothing the flow.*

## II. Goals and Objectives

a. Goal #1: Improve overall safety and decrease crashes
    i. Decrease collisions in the vicinity of the ramp merge and weave areas
b. Goal #2: Improve overall freeway travel speeds
    i. Typically, speeds in excess of 40 MPH are desirable
c. Goal #3: Improve the reliability and consistency of travel times for commuters
    i. Narrow the range of travel times for commuters
d. Goal #4: Increase freeway throughput by reducing congestion
    i. The primary intent of this goal is to reduce congestion, and improve the overall freeway level of service.
e. Goal #5: Increase ramp throughput while avoiding queues at the ramp meter that could spill back onto adjacent arterials
    i. The primary intent of this goal is to maintain queue lengths and queue times at acceptable levels
    ii. Traffic modeling software approved by the Traffic Engineering Section will be used to test and design alternatives
    iii. Where a high likelihood of queue spillback exists, detection will be required to respond to the potential spillback

f. Goal #6: Support Regional Air Quality
    i. Through the use of ramp meters, improve air quality through the reduction of overall vehicle delay

## III. Criteria Used to Select Ramp Metering

a. Ramp metering will be considered as a mitigation tool for congestion at all Interstate ramp entrance points where the mainline Level of Service is an "F" for any period of travel time or if the recorded travel speed falls below 40 MPH for more than one half hour in a 24-hour period
b. System-wide ramp metering is preferred over local ramp metering when the mainline congestion extends through two or more interchanges
    i. The limits of the system to be included will be determined by the Traffic Engineering Section of DOTD
    ii. Local or isolated meters may be deemed the best solution once the system is analyzed

IV. Trip diversion should not a goal of ramp metering. The timing schemes for ramp metering should not encourage drivers to use alternate corridors. Trip diversion may be desired to balance demand amongst adjacent ramps.

## V. Roles and Responsibilities

a. DOTD ITS Section will be responsible for the planning and design ramp meters
b. DOTD ITS Section will be responsible for monitoring and operating ramp meter signals
c. DOTD Districts Traffic Engineer Department will be responsible for maintaining all ramp meter signals
d. DOTD Public Relations group will be responsible for educating public about new ramp meter installations
e. DOTD ITS Section will be responsible for performance monitoring (this includes data collection, documentation and dissemination)

## VI. Deployment configurations

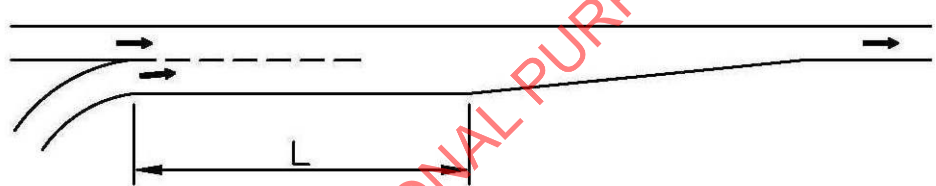
a. Signal Locations – Sufficient distance to reach a safe speed for merging onto the freeway should be provided. The acceleration lengths needed to achieve such a speed from the ramp meter location to the merge point are shown in Table 1.

**Table 1: Acceleration Length per AASHTO**

| Speed*<br>V (mph) | Speed Reached<br>$V_a$ (mph) | Acceleration Length<br>L (feet) |
|---|---|---|
| 40 | 31 | 360 |
| 45 | 35 | 560 |
| 50 | 39 | 720 |
| 55 | 43 | 960 |
| 60 | 47 | 1,200 |
| 65 | 50 | 1,410 |
| 70 | 53 | 1,620 |
| 75 | 55 | 1,790 |

* Estimated highway running speed during active ramp metering

**Figure 1: Acceleration Length for a Tapered Ramp per AASHTO**




b. Design of ramp signals -- Shall follow 2003 MUTCD, Section 4H.02 Design of Freeway Entrance Ramp Control Signals

c. Signage – Shall consist of advance warning signs with flashers activated when meter is in operation. The ramp meter signals shall be accompanied with signage indicating where to stop and how many cars can pass the meter per green indication

    i. "RAMP METERING WHEN FLASHING", yellow diamond warning sign
    ii. "STOP HERE ON RED", R10-6 and R10-6a
    iii. "X CAR(S) PER GREEN"
    iv. "LEFT LANE SIGNAL" and "RIGHT LANE SIGNAL" for staggered or alternating release
    v. W4-2L or W4-2R – Lane drop warning sign may be needed with staggered or alternating release

d. Approach lane configurations – The approach to the ramp meter can consist of one or two lanes. For volumes greater than 900 vehicles per hour, a two-lane configuration with a staggered or alternated release could be utilized

e. Detection – Ramp detection should consist of video or radar detection. The use of loop detection may be used only in the case of queue detection

f. Timing Alternatives – The theoretical minimum cycle length is 4 seconds (1 second green, 1 second yellow and 2 seconds red). However, a more reasonable minimum cycle length is 4.5 seconds (1 second green, 1 second yellow and 2.5 seconds red). The following table provides guidance for the different release schemes.

**Table 2: Comparison of Control Schemes**

| Control Scheme | No. of Lanes | Minimum Cycle Length (Sec) | Meter Range (VPH) | Capacity (VPH) |
|---|---|---|---|---|
| **One vehicle per Green** | 1 | 4 – 4.5 | 240-900 | 900 |
| **Multiple Vehicles per Green** | 1 | 6 – 6.5 | 240-1200 | 1100-1200 |
| **Staggered or Alternating** | 2 | 4 – 4.5 | 400-1700 | 1600-1700 |

## VII. Periods of Operation

a. Meters should only operate when analysis indicates that a benefit to the freeway exists

b. This can occur during periods of recurring congestion (typically during the morning and evening peak periods) or as part of non-recurring congestion (during an incident or special event)

## VIII. Implementation Phasing

a. Phasing of ramp meters for any introductory or "first" projects in a region will attempt to maximize benefits and minimize impacts to the greatest extent possible, since this will be the basis for how future projects will be perceived.

b. Ramp meters shall be installed and operational at least one week before they are turned on for public use for the first time to allow sufficient time to fully test the operation of each meter

c. Ramp meters shall be deployed in a logical sequence

d. Communications should be provided from the ramp meter provided to the TMC prior to deployment
e. DOTD shall be responsible for public outreach and education efforts prior to deployment

# Appendix G

**I-12 Ramp Metering Study**

# Executive Summary

## 1.0 INTRODUCTION

Currently, the segment of I-12 between Airline Highway and Range Avenue experiences significant congestion and incidents. The commute times along the corridor can be unreliable as well as lengthy. The Department of Transportation and Development (DOTD) is interested in using ramp metering as a tool to mitigate the existing congestion along the corridor. The Federal Highway Administration (FHWA) has developed a *Ramp Management and Control Handbook* to provide guidance for this tool. According to FHWA, ramp metering is defined as follows:

> *Ramp metering is the deployment of traffic signal(s) on a ramp to control the rate vehicles enter a freeway facility. By controlling the rate vehicles are allowed to enter a freeway, traffic flow onto the freeway facility becomes more consistent, in essence smoothing the flow.*



## 2.0 LITERATURE REVIEW

While other studies were evaluated in a literature review of ramp metering, the most comprehensive study to date was conducted in the Twin Cities Region in Minnesota, where the Minnesota Department of Transportation (Mn/DOT) has used ramp meters since 1969. While ramp metering was regarded as a success amongst transportation officials, some of the public and politicians questioned its effectiveness. The Minnesota Legislature passed a bill that required Mn/DOT to study ramp metering in the Twin Cities Region by comparing traffic operations with and without ramp metering.

The major findings of the study were that the shutdown of the ramp meters resulted in major degradation of freeway traffic operations and increases in the number of accidents. The following metrics were observed while the ramp meters were not in operations:

- Decline in mainline throughput of 14%
- Increase of annual system-wide travel time of 25,121 hours
- Without meters travel time is twice as unpredictable
- Crashes increased 26%

In the final analysis, the researchers of the ramp metering project determined the following two key statistics:

- Annual savings of 1,041 crashes (4 crashes per day)
- Estimated benefit to Twin Cities is $40M per year; a 15:1 cost-to-benefit ratio

**3.0 EXISTING CONDITIONS**

As previously described, the morning and evening peak periods experience high levels of congestion and incidents. An average drive in the morning commute from Pete's Highway to Airline Highway, which is almost 10 miles, can last 25 minutes with an average running speed of 24 MPH. The typical evening commute can take as long as 46 minutes with an average running speed of 11 MPH. It should be noted that these commute times do not consider the impacts of incidents.

Due to the high incident rate on the I-12 corridor, DOTD has taken a keen interest in collecting incident data. The accident data shown in Figures 1 and 2 are organized temporally and spatially along the corridor. The main findings of the data are that the accidents occur at the interchange locations and during the morning and evening commutes. The proposed ramp metering operations will be deployed at the locations where the majority of the incidents occur as well as operating during the time periods of the most frequent occurrences of incidents.

**Figure 1: Millerville Road to Juban Road, Eastbound Crashes by Time of Day**

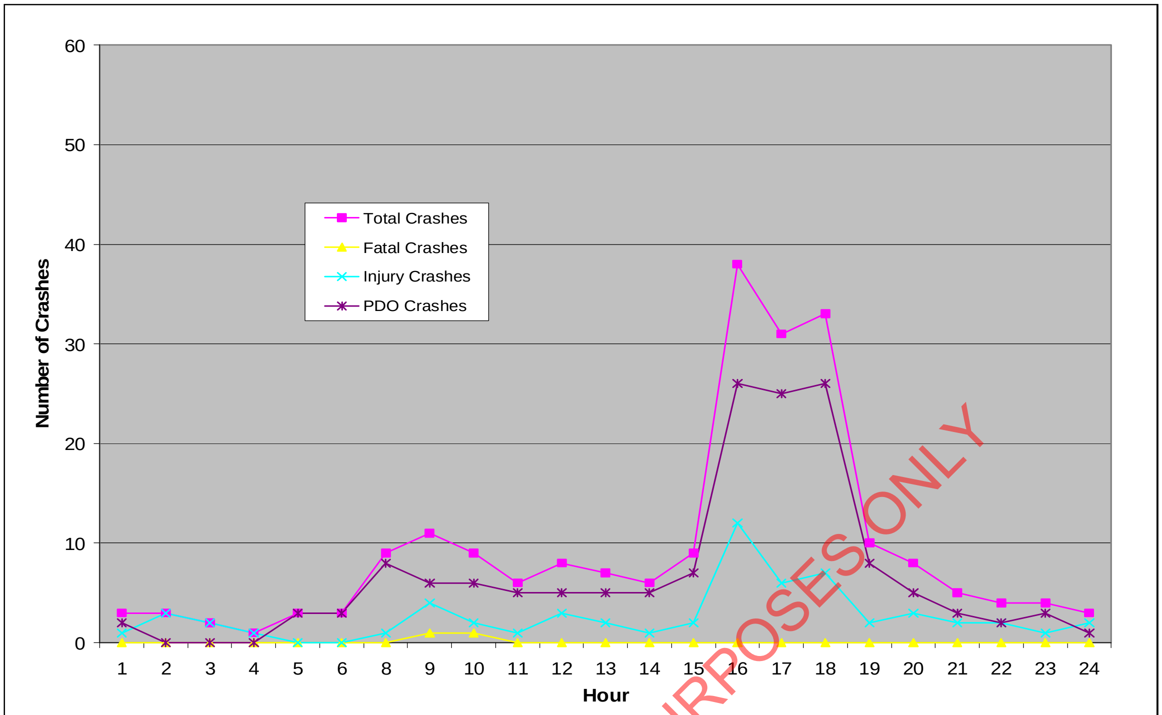
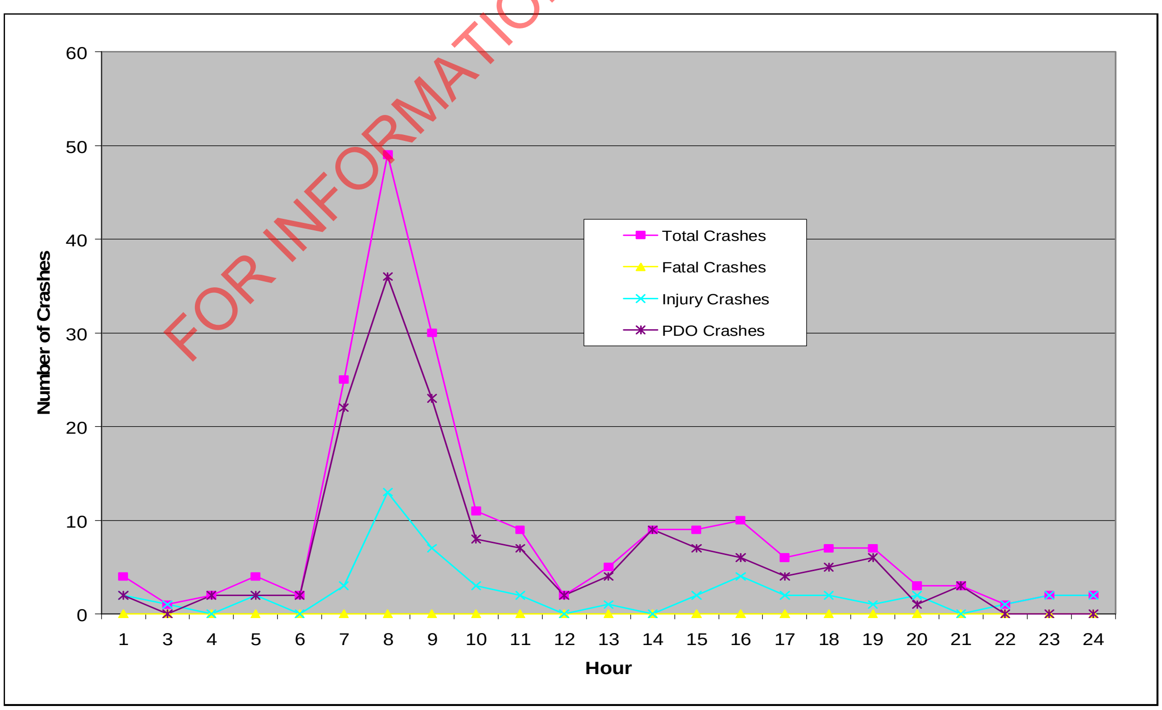
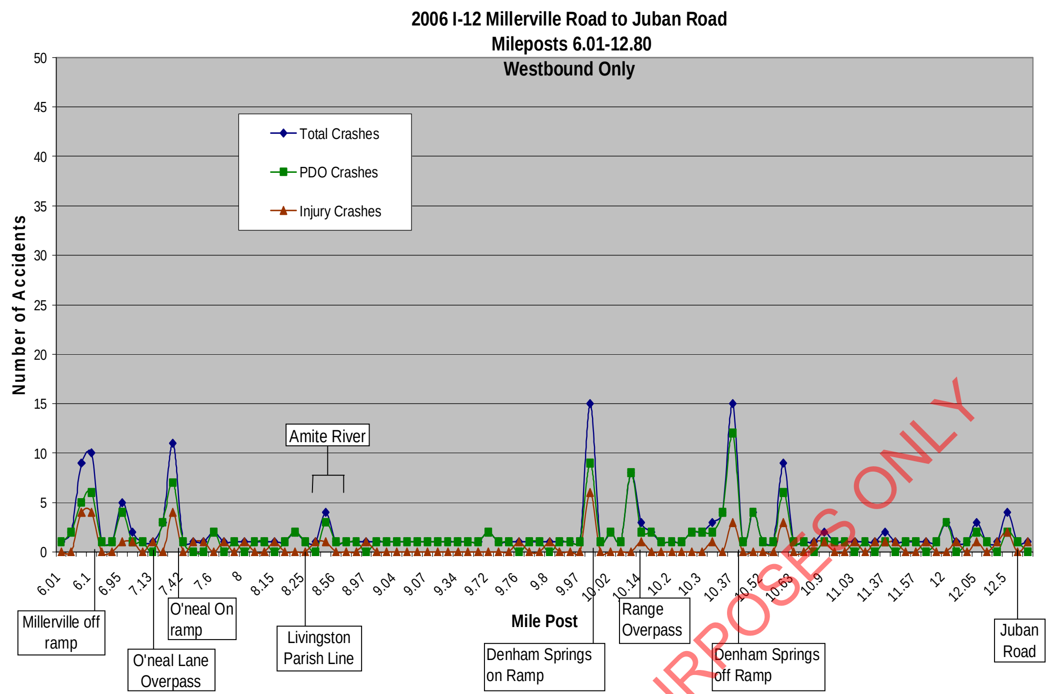




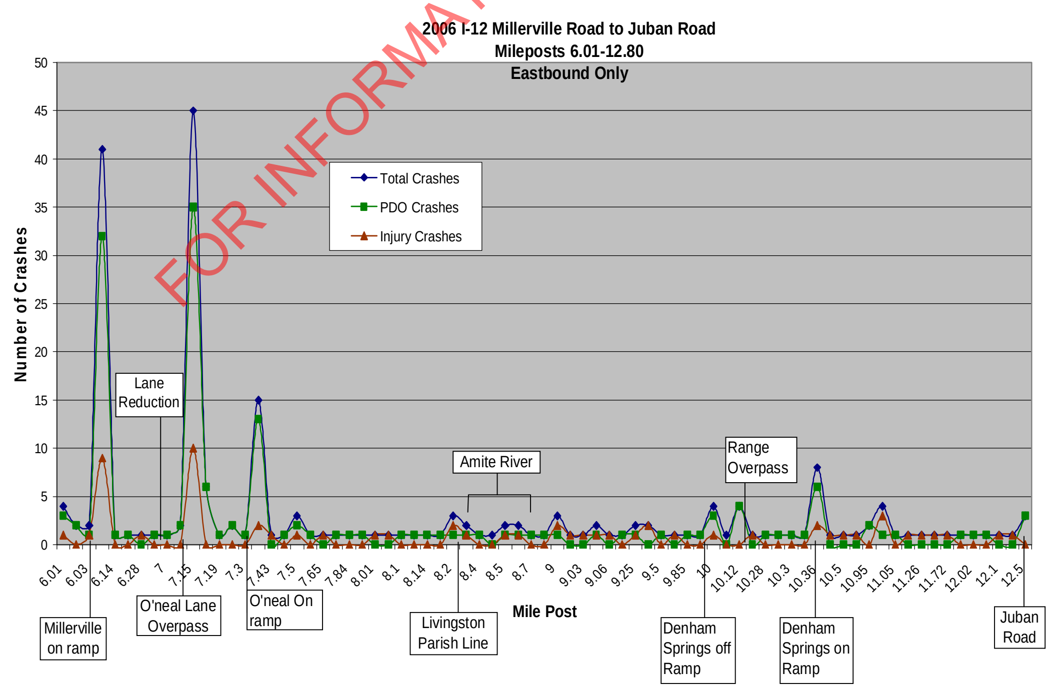

**Figure 2: Millerville Road to Juban Road, Westbound Crashes by Time of Day**



## Figure 3: Morning Peak Period Crash Data by Location




## Figure 4: Evening Peak Period Crash Data by Location



## 4.0 METHODOLOGY

The Measures of Effectiveness (MOEs) for I-12 during the AM and PM Peaks were developed using VISSIM as a microsimulation tool. The VISSIM model included the 5 interchanges on I-12 between Airline and Range as well as all nearby traffic signals. DOTD provided ABMB Engineers with a VISSIM model of I-12 to serve as a base model for the ramp meter study. ABMB verified the existing geometry in the field and calibrated the geometry in the model. Traffic counts for the interstate ramps were collected by DOTD and provided to ABMB Engineers. Mainline volumes for the interstate were taken from previous studies which included I-12. The nearby signal volumes were derived from a combination of existing studies and TSI's. The model was calibrated using travel times and queue taken in the field. The model was further calibrated based on comments from DOTD and ABMB staff that drive the corridor daily. The existing traffic conditions in the AM and PM were modeled with traffic volumes grown to the year 2010. The models were then run with ramp meters on the interstate on-ramps.



Ramp Metering Control

There are two types of ramp meter applications: *non-restrictive and restrictive*. Non-restrictive ramp metering consists of adjusting the meter timing to meet the demand so that traffic does not queue past the length of the entrance ramp. The benefit of non-restrictive ramp metering is that the spacing of vehicles entering the freeway is improved, which provides a safe merge operation at the freeway entrance and ultimately improves the reliability of the corridor.

Restrictive ramp metering is used to store vehicles on the ramp to control the number of vehicles entering the freeway. While providing the same benefits available through non-restrictive ramp metering, restrictive ramp metering reduces freeway demand by increasing delays for vehicles attempting to enter the freeway and ensures that the total entering traffic remains below its operational capacity.

In addition to non-restrictive and restrictive, ramp metering can also be managed as either fixed-time or responsive. Fixed-time ramp metering employs pre-determined time-of-day plans, whereas responsive ramp meters use controller logic to alter the ramp meter timings to let as many cars onto the interstate via the ramp as possible without causing a breakdown.

With the exception of Range Avenue in the AM peak period, this study evaluated fixed-time, non-restrictive ramp meter applications. Before the interchange located at Range Avenue was improved, queuing was experienced on Range Avenue. Now that the westbound merging lanes onto I-12 at the Range Avenue interchange have been increase to two lanes significant queuing occurs on the Interstate. In an effort to balance the queuing on the Interstate and Range Avenue, different levels of restrictiveness were tested at the Range Avenue interchange.

## Geometric Conditions

Since the study began before the "I-12 Design-Build" widening project, the project scope began with the existing geometry. However during the course of the study, the I-12 Design-Build project was "let" and the scope was expanded to include the six-lane cross-section.

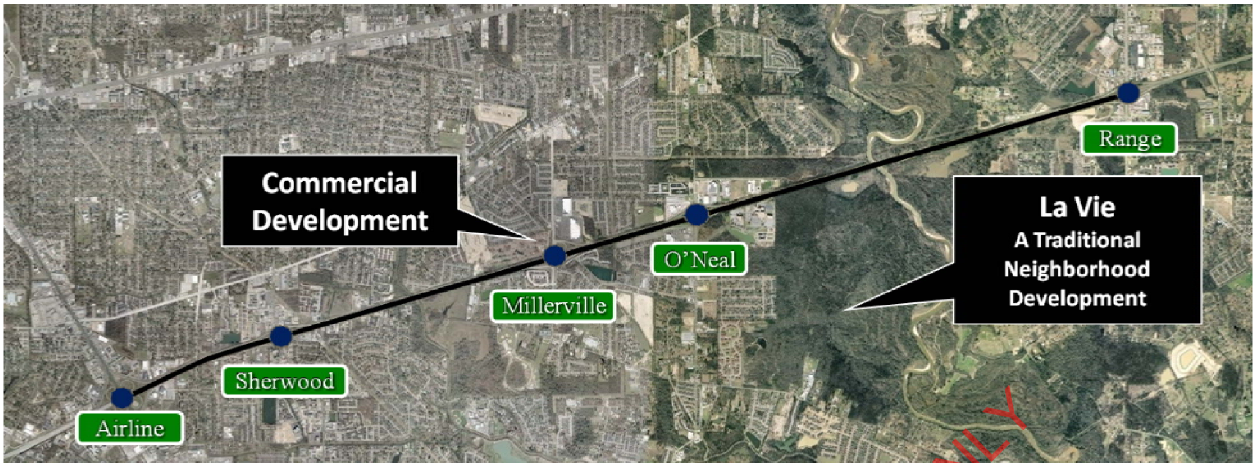
## Other Considerations

At the time of the study, two separate private parties had contacted DOTD to express their interest in developing near the Interstate system. DOTD requested that the two developments be considered in the study at the expense of the developer. The two proposed projects are as follows:

- A new westbound on-ramp for a commercial development at I-12 and Millerville.
- A new interchange and collector-distributor road system for La Vie, a traditional neighborhood development in the eastern edge of East Baton Rouge Parish, past O'Neal Lane.

The approximate locations of these developments are shown in Figure 5.

Figure 5: Proposed Developments




## 5.0 RESULTS

The reported metrics of the VISSIM model that were included in this report were travel time and speed. These results are shown in the Tables 1 through 4. They show two consistent results: the ramp meters increase running speed and decrease travel time.



Table 1: AM Peak Average Running Speed (mph)

| | No Ramp Meter | Ramp Meter | % change |
|---|---|---|---|
| 4-lane No Developments | 24 | 28 | 17.1% |
| 6-lane No Developments | 29 | 33 | 14.2% |
| 4-lane w/ Developments | 17 | 23 | 41.2% |
| 6-lane w/ Developments | 19 | 24 | 24.2% |

**Table 2: PM Peak Average Running Speed (mph)**

| | No Ramp Meter | Ramp Meter | % change |
|---|---|---|---|
| 4-lane No Developments | 11 | 13 | 18.3% |
| 6-lane No Developments | 13 | 14 | 11.1% |
| 4-lane w/ Developments | 18 | 20 | 11.2% |
| 6-lane w/ Developments | 21 | 21 | 1.9% |

**Table 3: AM Peak Travel Time (min)**

| | No Ramp Meter | Ramp Meter | % reduction |
|---|---|---|---|
| 4-lane No Developments | 24.9 | 21.3 | 14.6% |
| 6-lane No Developments | 20.8 | 18.2 | 12.4% |
| 4-lane w/ Developments | 36.0 | 25.5 | 29.2% |
| 6-lane w/ Developments | 31.4 | 25.3 | 19.5% |



**Table 4: PM Peak Travel Time (min)**

| | No Ramp Meter | Ramp Meter | % reduction |
|---|---|---|---|
| 4-lane No Developments | 45.7 | 38.6 | 15.5% |
| 6-lane No Developments | 37.9 | 34.1 | 10.0% |
| 4-lane w/ Developments | 27.9 | 25.1 | 10.1% |
| 6-lane w/ Developments | 23.4 | 23.0 | 1.9% |

In addition to the tabular results, spatial temporal speed contours were also developed. This type of graph was chosen to represent the results because they concisely show the relationship of three different sets of variables: distance, time, and speed. The contours consistently show a delay of the onset of congestion with the ramp meters turned on, as well as a less steep growth of congestion. This keeps queues from extending to additional interchanges.

The PM ramp meter contour also shows slightly higher speeds within queues, and the higher speed waves are allowed to propagate further back in the queue without interference from interchange on-ramps. This leads back to the concept of the smoothing out of the traffic entering the freeway.

**Figure 6: AM Spatial Temporal Speed Contour**

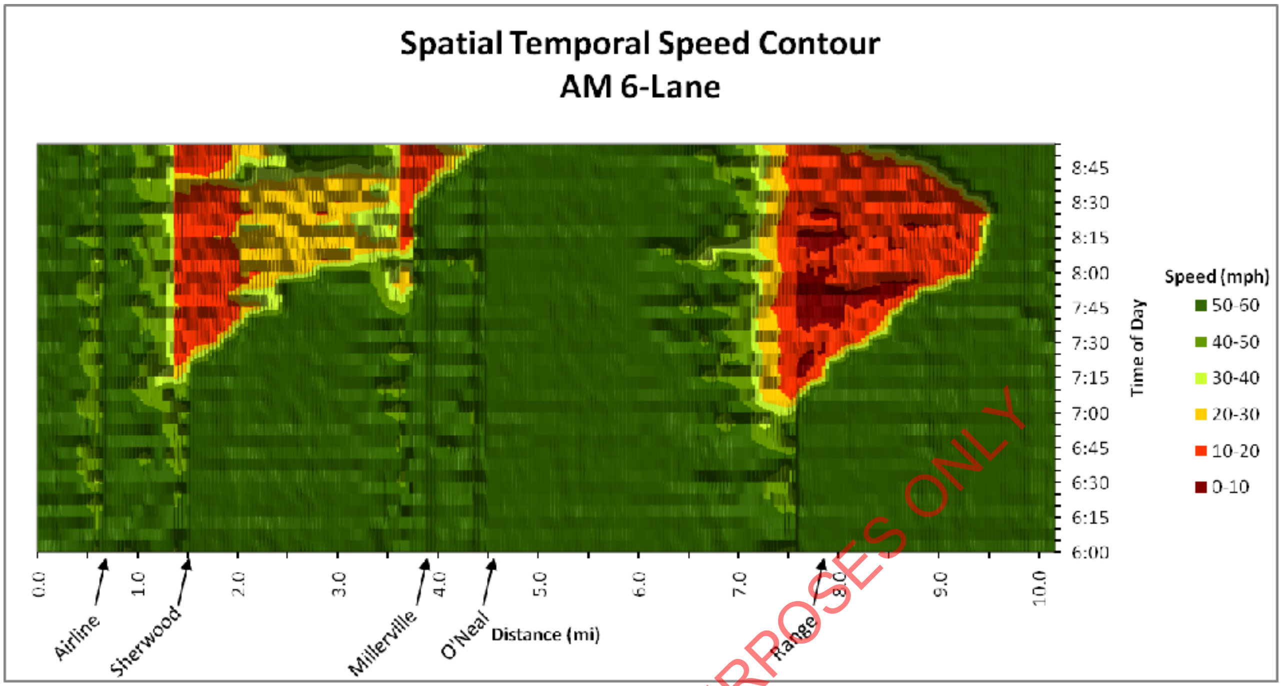



**Figure 7: AM Ramp Meter Spatial Temporal Speed Contour**

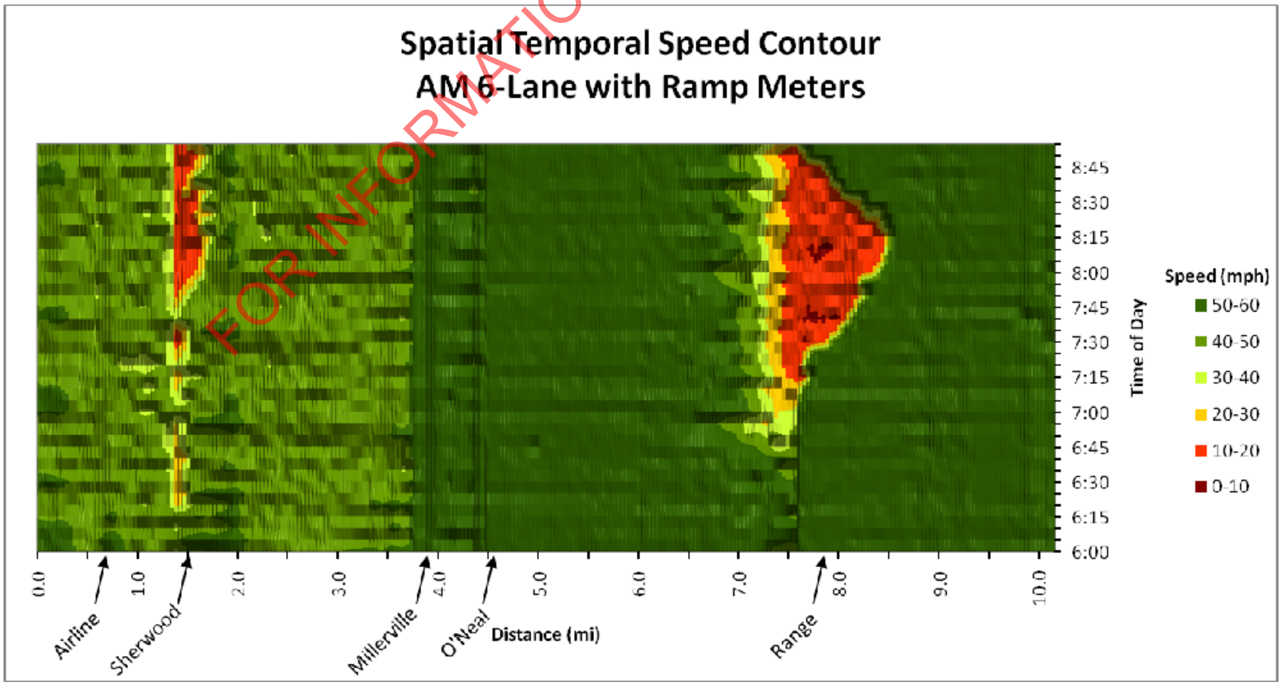


**Figure 8: PM Spatial Temporal Speed Contour**

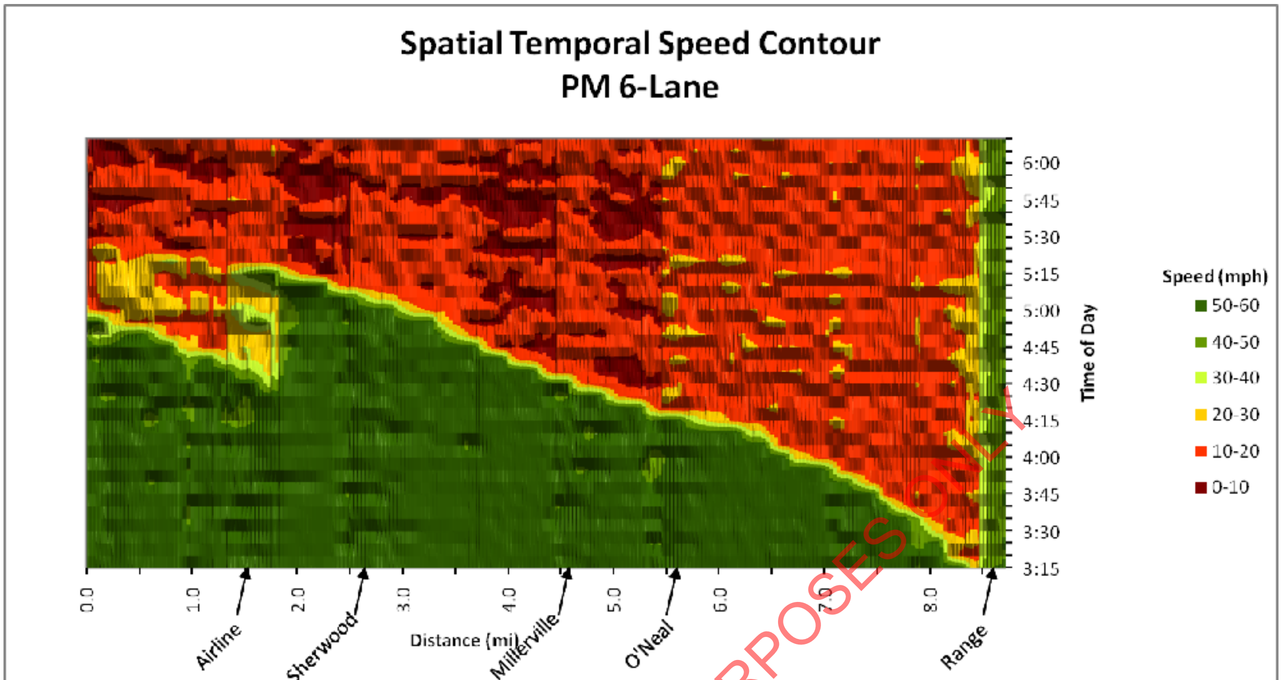
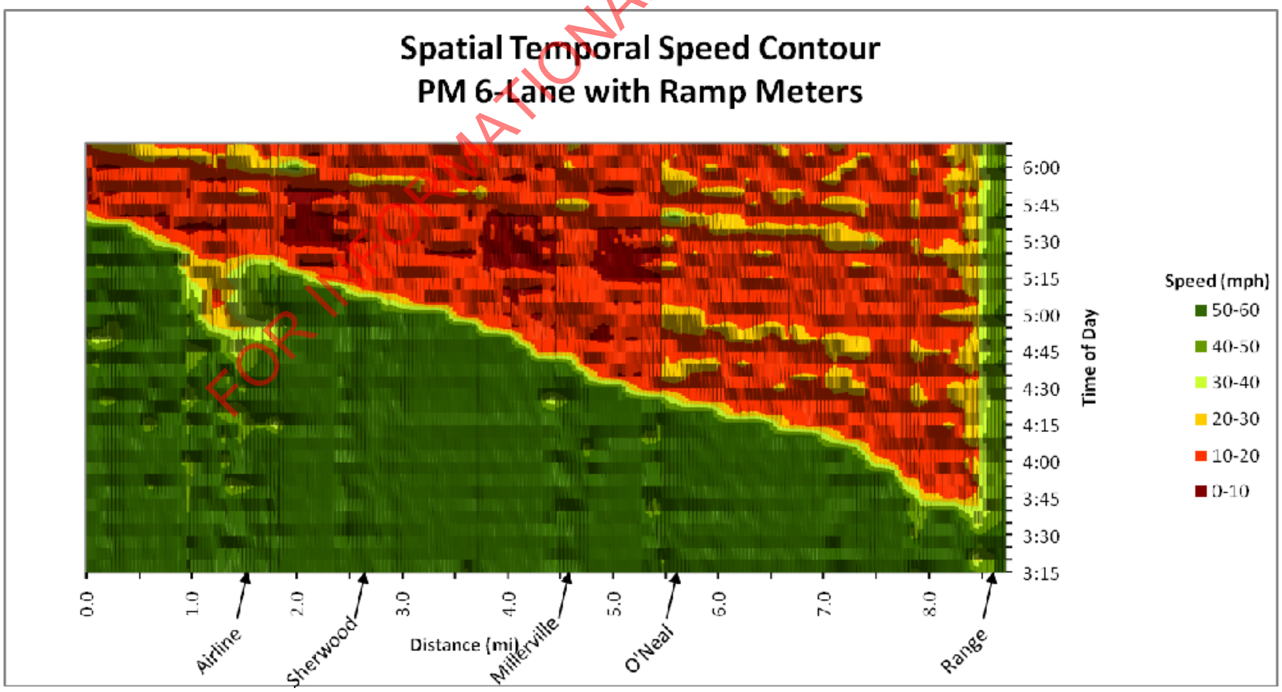



**Figure 9: PM Ramp Meter Spatial Temporal Speed Contour**



## 6.0 RECOMMENDATIONS

Based on the microsimulation modeling, the use of ramp meters has produced the expected results of decreased congestion and increased reliability. These findings are consistent with other ramp metering applications that were examined in the Literature Review. Therefore, it is recommended that ramp metering be implemented along the studied corridor as part of the I-12 widening project. The ramp meter project should be publicized as part of the traffic control efforts during the widening. This will provide DOTD a chance to monitor the operations of ramp meters in the field in order to determine any benefits and / or issues involved. Also, it is recommended that moderately restrictive ramp meters be used on the westbound on-ramp at Range Avenue to better balance the priority between the on-ramp and the Interstate. It should be noted that DOTD is now considering extending the current widening of I-12 past the Range Avenue westbound entrance ramp. This improvement will positively affect the bottleneck situation at the westbound merge point. This improvement was not included in the scope of work and, therefore, not modeled.

If the pilot program results in benefits of time-savings, safety, or reliability, DOTD should consider expanding the ramp meter program to include other locations.

# Appendix H

**Design Analysis**

TO No. 701-65-1052
FAP ITS-9906(549)

# I-12 ITS Field Devices
## Life Cycle Cost Design Analysis

| Center/Device | Location | Options | Pros | Cons | Lifetime (years) | Connection/Site Info | Project Principal Cost | Annual Cost | 5 Year Cost | 10 Year Cost | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ramp Meters | I-12<br>On Ramps | Pedestal Mounted Indications<br>Pre-Timed | -No mainline detection needed<br>-No communications to TMC required<br>-Simple hardware configuration | -Requires field adjustments to changing traffic conditions<br>-May result in over restrictive metering rates<br>-Not responsive to unusual conditions | 5 | Signal pedestal poles with sheet metal sign, 2-3 section signal heads, and advanced warning sign (cost per site) | Install Cost (16 sites) | Est. @ $1.4k/site | $1.4k/site for 5 years | $1.9k/Site for 2nd 5 years + replacement (inflation @ 3% /yr for 70% of the install cost) | * Replacement cost reduced due to reuse of hardware: conduit & pullboxes |
| | | | | | | $ 83,000.00 | $ 1,328,000.00 | $22,400 | $ 1,440,000.00 | $2,797,440 | |
| | | Overhead Indications<br>Pre-Timed | | | 5 | Single mast are with 2 sheet metal signs and 2-3 section signal heads (cost per site) | Install Cost (16 sites) | Est. @ $1.4k/site | $1.4k/site for 5 years | $1.9k/Site for 2nd 5 years + replacement (inflation @ 3% /yr for 48% of the install cost)* | * Replacement cost reduced due to reuse of hardware: mast arms, conduit, & pullboxes |
| | | | | | | $ 99,000.00 | $ 1,584,000.00 | $22,400 | $ 1,696,000.00 | $2,857,600 | |
| | | Pre-Timed with Actuation and Communications | -Provides low level of response to traffic conditions<br>-Ramp meter turns On/Off based on local ramp and conditions<br>-Lower Operating cost than Pre-Timed alone<br>-Can readily be upgraded to local responsive or system responsive<br>-Timing change can be remotely updated | -Higher capital and maintenance costs than purely pre-pretimed<br>-Increased maintenance<br>-Reactive vs. proactive<br>-Doesn't consider conditions beyond local ramp (i.e., not system based) | 5 | Same as overhead indications pre-time with the addition of 4 detection areas, a controller w/ actuation and fiber communications (cost per site) | Install Cost (16 sites) | Est. @ $2.5k | $2.5k/site for 5 years | $3.5k/Site for 2nd 5 years + replacement (inflation @ 3% /yr for 54% of the install cost)* | * Replacement cost reduced due to reuse of hardware: mast arms, conduit, pullboxes, & fiber comm. |
| | | | | | | $ 154,000.00 | $ 2,464,000.00 | $40,000 | $ 2,664,000.00 | $5,086,400 | |
| | | Local Responsive | -Better tailored to traffic conditions than Pre-Timed<br>-Lower Operating cost than pre-timed<br>-Adjusts to local ramp and mainline conditions<br>-Can run as pre-time and be upgraded to system responsive | -Higher capital and maintenance costs<br>-Increased maintenance<br>-Reactive vs. proactive<br>-Doesn't consider conditions beyond local ramp (i.e., not system based)<br>-Requires controller that allows logic based responsive adjustments | 5 | Same as pre-time with actuation and communications with the addition of a logic based controller (cost per site) | Install Cost (16 sites) | Est. @ $2.5k | $2.5k/site for 5 years | $3.5k/Site for 2nd 5 years + replacement (inflation @ 3% /yr for 56% of the install cost)* | * Replacement cost reduced due to reuse of hardware: mast arms, conduit, pullboxes, & fiber comm. |
| | | | | | | $ 165,000.00 | $ 2,640,000.00 | $40,000 | $ 2,840,000.00 | $4,833,600 | |
| | | System Responsive | - Better managed than Pre-Timed & local responsive<br>-Reduced operating cost<br>-Considers system wide conditions in adjusting metering plan<br>-Proactive (if forecasting is used in algorithm)<br>-Most benefit gained under heavy traffic demand relative to other options<br>-Typically less aggressive meter rate than local responsive | -Highest capital and maintenance costs<br>-Increased maintenance<br>-Requires responsive based controllers and centralized system to process and distributes adjustments.<br>-Removes human element<br>-Cost may not justify the limited benefit gained versus local responsive | 5 | Field hardware typically similar to that of the local responsive, but requires the additional centralized computer system, software, and communications medium. (Same as local responsive +$75k/ system) | Install Cost (16 sites) | Est. @ $5.0k | $5.0k/site for 5 years | $7.0k/Site for 2nd 5 years + replacement (inflation @ 3% /yr for 57% of the install cost)* | * Replacement cost reduced due to reuse of hardware: mast arms, conduit, pullboxes, & fiber comm. |
| | | | | | | $ 169,688.00 | $ 2,715,008.00 | $80,000 | $ 3,115,008.00 | $5,460,608 | |

# Appendix I

**Traceability Matrix**

| User Need ID | Description | Sys Rqmt ID | Description | Market Pkg | Sys Rqmt ID | Description | Market Pkg | Sys Rqmt ID | Description | Market Pkg | Sys Rqmt ID | Description | Market Pkg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All | These requirements apply to all needs | SysReq_25 | Communications shall conform to the following industry standard protocols:<br>- Gigabit Ethernet<br>- Fast Ethernet (copper)<br>- OSI Layer 2 and 3 | ATMS04<br>ATMS07<br>MC07 | | | | | | | | | |
| | | SysReq_26 | Communications network shall have a latency no greater than 7 milliseconds per switch. | ATMS04<br>ATMS07<br>MC07 | | | | | | | | | |
| | | SysReq_27 | Communications shall provide at a minimum the following fault information:<br>- Number retries before failure<br>- Delivery failure<br>- Unknown or corrupted protocol<br>- Device failed to respond | ATMS04<br>ATMS07<br>MC07 | | | | | | | | | |
| | | SysReq_28 | Communication shall provide at a minimum the following status information:<br>- Network status (available/not available)<br>- End device response (normal/not normal)<br>- Number of end devices<br>- End device addresses<br>- Protocol type | ATMS04<br>ATMS07<br>MC07 | | | | | | | | | |
| | | SysReq_39 | Communications shall have a bit rate error less than 10 (-12th). | ATMS04<br>ATMS07<br>MC07 | | | | | | | | | |
| | | SysReq_40 | There shall be communications connectivity between the following I-12 roadway field elements within Baton Rouge area and the Statewide TMC:<br>-CCTV cameras<br>-Ramp metering | ATMS04<br>ATMS07<br>MC07 | | | | | | | | | |
| All | These requirements apply to all needs | SysReq_35 | DOTD ITS Sections shall have support equipment to trouble shoot and maintain the following:<br>- Communications network<br>- Field equipment | ATMS04<br>ATMS07<br>MC07 | | | | | | | | | |
| Need_6 | Monitor and control of all ramp metering | SysReq_18 | I-12 roadway shall contain a ramp metering system (RMS) | ATMS04<br>ATMS07<br>MC07 | SysReq_19 | The ramp meter controller shall control the ramp meter advanced warning sign | ATMS04<br>ATMS07<br>MC07 | | | | | | |
| | | | | | SysReq_38 | Ramp metering system shall collect ramp detector data | ATMS04<br>ATMS07<br>MC07 | SysReq_20 | When activated, ramp meter system shall collect data from the following ramp detectors at a minimum:<br>- Stop bar detector<br>- Count detector<br>- Queue detector<br>- Main-line detectors | ATMS04<br>ATMS07<br>MC07 | | | |
| | | | | | SysReq_21 | The ramp meter controller shall provide the following status information at a minimum to the center.<br>- Unique Ramp Meter ID<br>- Location<br>- Time and date of the status report | ATMS04<br>ATMS07<br>MC07 | | | | | | |

| User Need ID | Description | Sys Rqmt ID | Description | Market Pkg | Sys Rqmt ID | Description | Market Pkg | Sys Rqmt ID | Description | Market Pkg | Sys Rqmt ID | Description | Market Pkg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | SysReq_22 | The ramp meter controller shall provide current reported state of the RMS, including:<br>- Fault status<br>- Current timing plan<br>- Loop configuration<br>- Time and date of the last timing plan<br>- Configuration change | ATMS04<br>ATMS07<br>MC07 | | | | | | |
| | | | | | SysReq_23 | The ramp meter controller shall provide fault information at a minimum to the center:<br>- Firmware faults<br>- Communication failure<br>- Power failure<br>- Detection failure<br>- Signal head indication failure | ATMS04<br>ATMS07<br>MC07 | | | | | | |
| | | | | | SysReq_2 | The ramp meter system shall display live video of the ramp meter signal indications | ATMS04<br>ATMS07<br>MC07 | SysReq_3 | The ramp meter system shall stream live video with less than 5 seconds of latency | ATMS04<br>ATMS07<br>MC07 | | | |
| | | | | | | | | SysReq_4 | The ramp meter system shall display live video at the user defined frames per second | ATMS04<br>ATMS07<br>MC07 | | | |
| | | SysReq_42 | The ramp metering system shall have the following modes of operation:<br>- Pre-defined fixed ramp metering rate with actuation<br>- Remote ramp metering control | ATMS04<br>ATMS07<br>MC07 | SysReq_43 | The pre-defined fixed ramp metering with actuation shall include:<br>- User defined metering rates<br>- User defined scheduler<br>- User defined actuation parameters | ATMS04<br>ATMS07<br>MC07 | SysReq_58 | The ramp meter shall operate the user defined timing plan during the user defined time of day. | ATMS04<br>ATMS07<br>MC07 | SysReq_59 | The ramp meter scheduler shall be programmed on the following basis:<br>- Minute<br>- Hourly<br>- Daily<br>- Weekly | ATMS04<br>ATMS07<br>MC07 |
| | | | | | | | | | | | SysReq_60 | The user defined ramp metering plan shall include:<br>- Number of phases<br>- Green indication time per phase<br>- Red indication time per phase | ATMS04<br>ATMS07<br>MC07 |
| | | | | | | | | | | | SysReq_56 | Ramp metering shall be suspended (ramp metering off) when the ramp queue reaches a user defined length. | ATMS04<br>ATMS07<br>MC07 |
| | | | | | | | | | | | SysReq_57 | Ramp metering shall resume operations from a suspended state when the ramp queue returns within the user defined length. | ATMS04<br>ATMS07<br>MC07 |
| | | | | | SysReq_61 | The pre-defined fixed ramp metering shall be operated with the following user defined actuation parameters.<br>- Vehicle presence time<br>- Stop bar presence time | ATMS04<br>ATMS07<br>MC07 | SysReq_62 | Ramp metering shall be suspended (dark indications) when vehicles are present in the queue detection zone for the user defined time. | ATMS04<br>ATMS07<br>MC07 | | | |
| | | | | | | | | SysReq_63 | Ramp metering shall resume operations from a suspended stat when the vehicles are no longer present in the detection zone at the stop bar. | ATMS04<br>ATMS07<br>MC07 | | | |
| | | | | | | | | SysReq_73 | The pre-defined fixed ramp metering shall be operated with the following user defined actuation parameters.<br>- Vehicle presence time<br>- Stop bar presence time | ATMS04<br>ATMS07<br>MC07 | | | |
| | | | | | SysReq_64 | The ramp metering system shall be remotely controlled from a ramp metering workstation co-existing with SteetWise Traffic Management System software (central system). | ATMS04<br>ATMS07<br>MC07 | SysReq_65 | The central system shall control the ramp meter schedule operations. | ATMS04<br>ATMS07<br>MC07 | SysReq_66 | The central system shall upload schedule changes to the selected ramp meter controller. | ATMS04<br>ATMS07<br>MC07 |
| | | | | | | | | | | | SysReq_71 | The central system shall upload timing changes to the selected ramp meter controller. | ATMS04<br>ATMS07<br>MC07 |
| | | | | | | | | SysReq_67 | The central system shall control the ramp meter manual override of the pre-timed actuated operations. | ATMS04<br>ATMS07<br>MC07 | SysReq_68 | The system shall turn off the ramp meter after the user executes the Graphical User Interface (GUI) command to terminate the ramp meter. | ATMS04<br>ATMS07<br>MC07 |
| | | | | | | | | | | | SysReq_69 | The system shall turn on the ramp meter after the user executes the GUI command to initiate the ramp meter. | ATMS04<br>ATMS07<br>MC07 |

| User Need ID | Description | Sys Rqmt ID | Description | Market Pkg | Sys Rqmt ID | Description | Market Pkg | Sys Rqmt ID | Description | Market Pkg | Sys Rqmt ID | Description | Market Pkg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SysReq_70 | The central system shall display the Ramp controller state status of the selected ramp meter controller using the systems GUI | ATMS04<br>ATMS07<br>MC07 | | | | | | | | | |
| | | SysReq_72 | The central system shall display the following status of the selected ramp meter using the central systems GUI:<br>- Fault status<br>- Current timing plan<br>- Loop configuration<br>- Time and date of the last timing plan<br>- Configuration changes | ATMS04<br>ATMS07<br>MC07 | | | | | | | | | |
| Need_9 | Field device status (meaningful health information about the field devices) | SysReq_21 | The ramp meter controller shall provide the following status information at a minimum to the center.<br>- Unique Ramp Meter ID<br>- Location<br>- Time and date of the status report | ATMS04<br>ATMS07<br>MC07 | | | | | | | | | |
| | | SysReq_22 | The ramp meter controller shall provide current reported state of the RMS, including:<br>- Fault status<br>- Current timing plan<br>- Loop configuration<br>- Time and date of the last timing plan<br>- Configuration change | ATMS04<br>ATMS07<br>MC07 | | | | | | | | | |
| | | SysReq_23 | The ramp meter controller shall provide fault information at a minimum to the center:<br>- Firmware faults<br>- Communication failure<br>- Power failure<br>- Detection failure<br>- Signal head indication failure | ATMS04<br>ATMS07<br>MC07 | | | | | | | | | |

# Appendix J

**FHWA Final Rule Compliance Report**

TheI-12 Ramp Metering Project's goal is to manage congestion on the I-12 Freeway between Essen Lane and Walker Rd. This project includes ramp metering and extended communications to manage congestion along the route during normal and abnormal conditions.

This Systems Engineering analysis report complies with the FHWA Final Rule CFR 940 part 11. The following is a compliance matrix that maps elements of the final rule to this SE document.

**Compliance with 23 CFR 940 part 11**

The following is the compliance matrix that maps the FHWA final rule to the section in this systems engineering analysis report.

| FHWA Rule Element | Section in this SEA Report that Addresses the FHWA Rule Element | Comment |
|---|---|---|
| (1) Identification of portions of the regional ITS architecture being implemented | Section 2 and Appendix A and B | |
| (2) Identification of participating agencies' roles and responsibilities | Section 3.3.1, Table 4 | |
| (3) Requirements definitions | Section 3.5 and 3.6 Tables 5-6 (Needs) Tables 7-9 (Requirements) | Needs and requirements |
| (4) Analysis of alternative system configurations and technology options to meet requirements | Section 4, Table 10, and Appendix H | Combined technical alternatives with procurement alternatives |
| (5) Procurement Options | Section 4.2, Table 10 | Combined technical alternatives with procurement alternatives |
| (6) Identification of applicable ITS standards and testing procedures | Appendix C, Table C1 | |
| (7) Procedures and resources necessary for operations and management of the system | Section 5 | |