

Intellegent TransportationSystems (ITS) Deployment Guide



March 2016

ILLINOIS STATE TOLL HIGHWAY AUTHORITY

The Intelligent Transportation Systems (ITS) Deployment Guide dated March 2016 replaces the December 2013 version.

Major Revision Highlights

- ITS Deployment Guide reformatted with new Section/Article numbering for commissioning section; eliminating “Part 1 / Part 2” format.
- Removed non-pertinent information from Sections 1, 2, and 3.
- Section 10 updated to reflect currently accepted technology.
- Section 11 replaces “Part 2” of the 2013 version of the ITS Deployment Guide.

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TERMS AND DEFINITIONS

All Electronic Tolling (AET): All Electronic Tolling is a system of tolling that does not incorporate manual cash lanes.

Alternating Current (AC): A form of electric power.

Active Traffic Management (ATM): Active Traffic Management is a toolkit of techniques for increasing peak capacity and smoothing traffic flows (see also Managed Lanes) that allow the agency to dynamically manage traffic flow and disseminate traffic information and guidance to the users of the system.

American Association of State Highway and Transportation Officials (AASHTO): AASHTO is a nonprofit, nonpartisan association representing highway and transportation departments in the 50 states, the District of Columbia, and Puerto Rico. It represents all five transportation modes: air, highways, public transportation, rail, and water. Its primary goal is to foster the development, operation, and maintenance of an integrated national transportation system.

Bluetooth™ Detection: These detection systems use Bluetooth™ technologies to detect anonymous MAC addresses (a “digital ID” on electronic devices) associated with mobile devices found in vehicles (such as phones, wireless headsets and handheld music players). One such system is BlueTOAD™, which can calculate travel time and road speed through analysis of subsequent detections. Data is archived for potential analysis of speed trends, origin-destination, route patterns, and trip length analysis.

Camera surveillance: Closed-circuit television (CCTV) cameras used to monitor traffic conditions, determine appropriate incident responses, and inform the public.

Chicago Metropolitan Agency for Planning (CMAP): CMAP is the official regional planning organization for the northeastern Illinois counties of Cook, DuPage, Kane, Kendall, Lake, McHenry, and Will. The Illinois Tollway operates within these counties. CMAP developed and now guides the implementation of [GO TO 2040](#), metropolitan Chicago's first comprehensive regional plan in more than 100 years.

Computer Aided Drafting and Design (CADD): Computer aided drafting is the creation of engineering or architectural construction plans through the use of computers and associated software (e.g., MicroStation). Computer aided drafting and design leverages design tools within CADD software to improve efficiency.

Construction Manager (CM): The Engineer or firm of engineers and their duly authorized employees, agents and representatives engaged by the Illinois Tollway to observe The Work to determine whether or not it is being performed and constructed in compliance with the Contract for Construction.

Customer Work Agreement (CWA): An agreement with a utility provider associated with obtaining utility service connections.

Design Section Engineer (DSE): The Engineer or firm of Engineers and their duly authorized employees, agents and representatives engaged by the Illinois Tollway to prepare the Plans, Special Provisions, and itemized Cost Estimates for a Design Section.

Design Corridor Manager (DCM): The Engineer or the firm of Engineers contracted by the Illinois Tollway to act as the duly authorized agent of the Chief Engineer to manage other DSE's, in accordance with the scope of the particular duties delegated to them by the terms of their Agreement.

Dynamic Message Signs (DMS): Electronic, remotely changeable signs that inform motorists of current traffic conditions, including travel times.

Electronic Toll Collection (ETC): Known as I-PASS, the Illinois Tollway's electronic toll collection system uses in-vehicle transponders and overhead gantry readers to automatically deduct tolls from instrumented vehicles.

Electronic Transaction Consultants Corporation (ETCC): The Illinois Tollway's current vendor for management and operation of the I-PASS electronic toll collection system.

Emergency Service Patrols: Illinois Tollway-owned and operated, or privately sponsored, vehicles dedicated to assisting disabled vehicles, detecting congestion, and responding to incidents (e.g., the Highway Emergency Lane Patrol or HELP Vehicles).

Federal Highway Administration (FHWA): Agency of the United States Department of Transportation that oversees the maintenance and improvement of America's roads and highways.

Geographic Information System (GIS): A system to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data.

Guide Drawings: A sample set of detail drawings available from the Illinois Tollway to aid the DSE in preparation of Contract documents. These drawings generally describe the preferred installation requirements of the Illinois Tollway for the preferred device being described. The Guide Drawings should be utilized in close coordination with the Guide Special Provisions. Guide Drawings are located on the Illinois Tollway website similar to Illinois Tollway Standard Drawings.

Guide Special Provisions: A sample set of specifications available from the Illinois Tollway to aid the DSE in preparation of contract plans. These special provisions outline technical requirements for device performance criteria, testing procedures, integration requirements, warranty requirements and other critical requirements to be met for the preferred device being described. The Guide Special Provisions should be utilized in close coordination with the Guide Drawings. Guide Special Provisions are only available by request from the Illinois Tollway.

Guide Special Provisions from past projects should not be carried forward to future contracts as the Illinois Tollway's preferred device or requirements may have changed between contracts. Only the latest Guide Special Provision shall be used by the DSE for each new contract.

Illinois Department of Transportation (IDOT): "IDOT is responsible for building and maintaining the state's non-tolled highways, supporting air, rail and public transportation projects. The Department also strives to encourage multi-modal transportation safety which enables the avenues of commerce and travel remain open and accessible to all of Illinois."¹

I-PASS: The Illinois Tollway's prepaid, electronic tolling system (see Electronic Toll Collection).

Intelligent Transportation Systems (ITS): The application of advanced electronic technologies and communications infrastructure in transportation to improve traveler information, increase motorist safety, speed incident response, enhance productivity, and reduce congestion; ITS must be explicitly integrated with operations to be effective.

Intermediate Power Distribution and Communication (IPDC) Facility: A purpose built building for providing a common location to obtain uninterruptible power service and communications for ITS deployments as well as normal power for roadway lighting.

Internet Protocol (IP): The method or protocol by which data is sent from one device or computer to another.

Light Emitting Diode (LED): A particular illumination technology utilized in Dynamic Message Signs for displaying information.

Magnetometer System: A magneto-resistive wireless sensor used for detecting ramp traffic data. This system has a 10-year battery life and is comprised of in-ground wireless sensors installed in the pavement surface that communicates to wireless transceivers mounted on roadside supports (generally roadway light poles). Its advantages are its wireless communication range and its high accuracy. Its major disadvantage is the need to install it in the roadway pavement and remove it during resurfacing or reconstruction. The Illinois Tollway currently has several SENSYSTM brand magnetometer systems in place.

Managed Lanes: Managed lanes are highway facilities or a set of lanes where operational strategies are proactively implemented and managed in response to changing conditions. The managed lane concept is where a set of lanes within the freeway cross section are separated from the general-purpose lanes. Principal management strategies may be categorized into three groups: pricing, vehicle eligibility, and access control.

Microwave Vehicle Detection System (MVDS): A technology that utilizes microwave radar for traffic detection. These units measure the reflection of microwave signals against moving vehicles to determine the volume, speed, and size of the vehicles. Two brands of side fired

¹ "2012 Annual Report". Illinois Department of Transportation, 2007

MVDS devices are most commonly deployed by the Illinois Tollway; RTMSTM and Wavetronix HDTM.

National Electrical Code (NEC): A regionally adoptable standard for the safe installation of electrical wiring and equipment in the United States.

National Transportation Communications for ITS Protocol (NTCIP): A family of standards designed to achieve interoperability and interchangeability between computers and electronic traffic control equipment from different manufacturers.

Network Integrator (NI): The Network Integrator is responsible for configuring new ITS equipment for use on the Illinois Tollway communications network ahead of Contractor installation and system testing.

Open Road Tolling (ORT): A combination of back office and roadside and overhead gantry electronic equipment and database applications that allows electronic toll collection to occur at highway speeds, eliminating mainline barrier plazas and reducing congestion.

Pan/Tilt/Zoom (PTZ): Camera operations that are typically used to describe the type of camera in question.

Portable changeable message signs (PCMS): Smaller, mobile message signs often used for work zones or near incident sites. A PCMS which can be remotely controlled is called a Full Matrix PCMS.

Project Manager (PM): Representative of either the Illinois Tollway or Design Section Engineer that is responsible for design components of an ITS project and coordinating with the other project managers.

Ramp Queue Detection: The application of strategically-placed vehicle detection along regularly congested ramps that are then linked to advance warning signs and/or traffic signals to reduce queues and improve safety.

Research and Innovative Technology Administration (RITA): A unit of the USDOT.

Request for Information (RFI): A question posed by the Contractor to the CM to provide clarification or further information about a design component. RFI responses often require assistance from the DSE.

Road weather information systems (RWIS): A field data collection system comprised of fixed roadside sensors that measure and report environmental and pavement conditions.

System Integrator (SI): The System Integrator develops software interfaces to new types of ITS hardware, performs integration testing to validate the correct operation of the new device type, then updates the production TIMS system to accept all future instances of the new device.

The SI also implements new TIMS software features in order to improve the Illinois Tollway's integrated operational approach toward traffic management.

The Work: The improvement described in the construction contract, including all References, authorized Change Orders, Extra Work Orders, and Supplemental Agreements.

Traffic and Incident Management System (TIMS): Computerized Central traffic management system housed in Illinois Tollway Headquarters that integrates and manages data from the above ITS tools to support the Traffic Operations Group.

Traffic Operations Center (TOC): The Illinois Tollway's central traffic management and coordination facility that houses the operators who control the collection and distribution of traffic data across the Illinois Tollway network and to outside agency and media partners.

United States Department of Transportation (USDOT): A federal Cabinet department of the U.S. government concerned with transportation.

Vehicle detection: Various technologies that detect the presence of vehicles and record their volume, speed, occupancy and size characteristics.

Vehicle Detection Systems (VDS): Detection systems utilized by the Illinois Tollway for various scenarios, including BlueTOAD™, RTMS™, SENSYS™, and Wavetronix™ brand equipment.

Virtual Weigh-in-Motion (VWIM): Vehicle detection and weigh scales that identify overweight trucks operating at speed to establish probable cause for a fine or removal from the roadway.

Web-based Program Management (WBPM): Web-based system for use on all Illinois Tollway projects for interpersonal correspondence and record keeping. DSE and CM only accessible resources may be found on this system as well.

1.0 INTRODUCTION

1.1 Deployment Guide Purpose

The purpose of this document is to serve as a tool for Illinois Tollway Design Section Engineer (DSE) and Construction Manager (CM) to help them develop Intelligent Transportation System (ITS) solutions that lead to design and implementation of successful ITS projects. The design portion of the deployment process is the focus of this guide. However, consideration is given to all stages of development and implementation due to the nature of Systems Engineering, which includes an iterative process with continuous validation/verification. This document is intended to present the Illinois Tollway preferences for the selection of appropriate ITS elements to be added to the existing Illinois Tollway ITS system. In concert with other Illinois Tollway manuals, this document will provide guidance to the DSE and CM about the ITS design and construction process, considerations that should be made during that process, and identify additional resources when further guidance is required.

This guide should be used in concert with other Illinois Tollway manuals, related reference materials, product installation and user manuals, and applicable industry standards.

It is critical that the DSE and CM understand from the beginning that ITS design and deployment is very different from traditional highway construction. While a roadway will still function as a cohesive unit with a variety of asphalt and concrete pavement, this is often not the case with ITS. ITS equipment (especially communications media and devices) must be compatible for the system to perform its functions properly. This requires planning, a thorough design, and a minimum of field changes. Beyond this, the DSE and CM are expected to consider all affected aspects of an ITS project before and during deployments. ITS elements are by nature interconnected and integrated. Unlike traditional road and bridge projects that are typically more segmented and modular, changes in one component of an ITS project may have a significant impact on another area (e.g., modifying communications hardware at an ITS device site may make it unable to transfer data back to the collection point). The integration of devices must be explicitly considered. As such, designers may need to consider elements outside the geographic limits of a particular project to ensure end-to-end functionality.

The Illinois Tollway's Traffic and Incident Management System (TIMS) is a tightly coupled combination of digital hardware and computer software integrated together through an Internet Protocol (IP) based wide area network, not unlike many other modern ITS systems around the world. TIMS has a unique architecture and, due to its existence alongside an electronic tolling system, must maintain a high level of security and limited access at all times. As a result of this architecture, there are many unique features and internal standards and safeguards involved in the selection and integration of new ITS elements into the system. New hardware device types and models must meet stringent performance requirements, and undergo extensive sample testing and integration before becoming a candidate for inclusion in the ITS Deployment Guide. Deviation from the options presented herein will be considered on a case by case basis. Extensive documentation must be provided as justification for any recommended deviation. Any recommended deviation must be reviewed and approved by the Illinois Tollway ITS Unit prior to execution in any Illinois Tollway construction contract.

This guide provides answers and explanations to many of the more common concerns that might be encountered in completing ITS projects for the Illinois Tollway and is an important tool for use during the design scoping process. It will help determine what design decisions will be the responsibility of the DSE, what decisions have already been made by the Illinois Tollway as part of pre-concept planning and what is expected of the DSE during the design effort. This will ensure that both parties (Illinois Tollway and DSE) effectively understand the level of pre-concept design to date, responsibilities, deliverables, and ultimate requirements for the successful deployment of ITS systems for the Illinois Tollway.

1.2 References

This ITS Deployment Guide does not provide ITS design or construction standards. These can be found in a series of other documents that should be used when developing ITS design deliverables or providing construction management services. These include manuals produced by the Illinois Tollway or Illinois Department of Transportation (IDOT), industry standard design manuals, and international standards.

Below is a listing of key Illinois Tollway reference materials that should be applied during ITS project design and construction. Additional forms, drawings, manuals, policies & guidelines, and specifications can be found on the Illinois Tollway website.

- *Design Section Engineer's (DSE) Manual* – provides information about the applicable administrative policies and practices, design guidelines, design process steps, and performance criteria for design section engineers on all Illinois Tollway design projects.
- *Roadway Design Criteria* – a guide to aid the engineer in the design of new facilities and rehabilitation of existing facilities for the Illinois Tollway, including the physical placement of ITS devices.
- *Structure Design Manual* – provides guidance for the design of Illinois Tollway bridges as well as overhead sign structures, retaining walls, and other structural elements involved in ITS design.
- *Geotechnical Engineer Manual* – describes soil boring requirements for Illinois Tollway structures.
- *Construction Manager's (CM) Manual* – provides procedures, expectations, and nomenclature for use by construction managers on all Illinois Tollway construction projects.
- *Roadway Traffic Control and Communications Manual* – a guide which defines how a combination of portable and fixed ITS elements are used in the active management of construction traffic, and how Smart Work Zones are implemented at the Illinois Tollway. This manual is commonly referred to as the “MOT Manual”.
- *ITS Labeling Guidelines* – provides minimum standards for the proper labeling of ITS infrastructure and equipment during construction and generation of as-built record drawings.

Below is a listing of key industry standard design manuals and standards that should be applied during ITS project design and construction. These include:

- *Systems Engineering for Intelligent Transportation Systems (FHWA)* – describes the manner in which systems engineering can be applied for planning, designing, and implementing ITS projects.
- *A Policy on Geometric Design of Highways and Streets (AASHTO)* – provides design controls and criteria for roadways and roadway elements, including signing and other ITS devices.
- *Roadside Design Guide (AASHTO)* – provides design criteria for roadside objects, including ITS devices.
- *The Manual on Uniform Traffic Control Devices (MUTCD), including the Illinois Update* – provides the standard for signs, signals, and pavement markings in the United States.
- *National Transportation Communications for ITS Protocol (NTCIP)* – standards for the transference of data between traffic management centers and ITS field devices, including DMS, RWIS, and CCTV cameras.
- *National Electric Code (NEC)* – describes installation methods for electrical cable, conduit, and equipment as well as fiber optic cable.
- *Motorola R56 Surge Protection and Grounding* – industry standard for communications equipment, infrastructure, and facilities grounding and surge protection.

Additional information can be found in the individual guide special provisions. The DSE should refer to the United States Department of Transportation (USDOT) Research and Innovative Technology Administration (RITA) website (<http://www.standards.its.dot.gov/>) to monitor the current status of applicable ITS standards.

Working knowledge of all of these reference materials is required for successful ITS design and deployment. Those engaged in ITS projects for the Illinois Tollway are expected to provide qualified staff for the execution of the design and/or deployment of ITS systems. Due to the range of technologies and the depth of potential resources, early planning and discussion with the Illinois Tollway during the design process is required to help avoid significant costs caused by issue resolution through field changes.

1.3 Roles and Responsibilities

1.3.1 Design Section Engineer/Construction Manager

The general roles and responsibilities of the DSE and CM are defined in the Illinois Tollway's *Design Section Engineer's Manual* (DSE Manual) and *Construction Manager's Manual* (CM Manual), respectively.

For ITS projects, the DSE's primary responsibilities are performed in the conceptual and detailed design stages, but the DSE continues to be involved during the construction stage. This involvement may include responding to requests for information (RFIs), developing construction changes, or coordinating with the CM.

For ITS projects, the CM's primary responsibilities are the construction administration and management, while ensuring the improvement is constructed in accordance with the contract requirements. For ITS projects the CM's role requires coordination between the Contractor and Illinois Tollway staff to successfully deploy and integrate new equipment. The CM is the Illinois Tollway's agent in the field to confirm that devices are properly installed, test procedures are followed, and that all equipment conforms to the test parameters along each step of the deployment. Where equipment fails to satisfy the test parameters, the CM must work with the Contractor to reconcile the point of failure.

1.3.2 Illinois Tollway Personnel and Support Staff

During both design and construction, the DSE and CM should consider the Illinois Tollway Traffic Operations Unit to be the customer. The Traffic Operations Unit is managed by the Traffic Operations Manager and includes the Illinois Tollway's Traffic Operation Center and its staff. The Traffic Operations Unit shall define project requirements, provide direction, and make final decisions about the project. Coordination with the Traffic Operations Unit throughout the project design and construction is critical to ensuring that constructed ITS elements are fully integrated into operations.

The Illinois Tollway Project Manager has numerous responsibilities beginning at project conception and ending with the completion of construction. All coordination shall be through the Illinois Tollway Project Manager.

Through the ITS project development cycle (defined further in Project Development Process Section and other related documents), several other Illinois Tollway departments might be engaged during a project containing ITS elements. Various sections within the Engineering and Information Technology (IT) departments play a larger role during the design stage; Traffic Operations and IT continue their participation during deployment. In addition, the Illinois Tollway Fiber Optic & Utilities Manager may be engaged during the project. In general, IT and other groups within the Illinois Tollway should be considered a source for technical expertise throughout the project development process and their involvement will be facilitated by the Illinois Tollway Project Manager.

The following is a summary of Illinois Tollway on-site support staff positions that currently assist the Illinois Tollway with ITS project delivery and operation:

Position
Program Management Office
General Engineering Consultant
Traffic Engineering Consultant
Fiber Optic & Utilities Manager
Network Integrator (NI)
System Integrator (SI)
Communications Tower Asset Manager

Table 1.1 Illinois Tollway Support Staff

Depending on the specific project, various resources may have more or less of a role. Tables 1.2 and 1.3 below outline some of the specific roles and responsibilities for Illinois Tollway staff (including on-site support staff and groups that participate in Capital Program Contracts) for ITS projects in the design, construction, and operations stages. Coordination with other Illinois Tollway groups and consultants will be as directed by the Illinois Tollway PM. However, it is still the responsibility of the DSE to become familiar with the roles and responsibilities as contained in these tables. The DSE/CM should only go to other groups after they have been directed to do so by the Illinois Tollway PM.

1.4 Deployment Guide Organization

This deployment guide is broken down into two primary areas. An overview of the Illinois Tollway's ITS project development process and universal deployment considerations are given in Sections 1.0 and 2.0. DSE guidance for developing Contract Documents for bidding and construction of ITS improvements and specifically for each of the ITS technologies is given in Sections 3.0 through 10.0.

1.4.1 Project Development Process

This section will detail the Illinois Tollway's process for originating, designing, and building an ITS project. Following the systems engineering process and a consistent quality assurance program, the Illinois Tollway first conceives an ITS project during its regular planning cycle or review of the extent of a major roadway construction project coincident with known or derived ITS needs. As discussed later in this document, there are some cases in which new ITS needs are directly created by roadway construction. After developing a pre-concept design that further defines the project, the Illinois Tollway solicits the participation of a DSE to perform the conceptual and detailed project design either as an ITS specific project or as part of a coincident roadway project.

Several facets of the detailed design process are universal across most Illinois Tollway ITS projects (e.g., system integration, equipment warranties). Once final Contract Documents have been created by the DSE and approved by the Illinois Tollway, the final documents are issued for bid by a Contractor. The DSE may provide support during the bid stage, as well as the construction stage that follows. The CM acts as the Illinois Tollway's agent during this process, verifying that the design requirements are met by the Contractor.

The DSE Manual shall be followed with regard to submittal requirements for ITS design stages and Contract Documents, including checklists of design considerations required at each "step" of the development process.

1.4.2 ITS Technologies and Site Design

The subsequent sections of this deployment guide provide general design guidance applicable to all ITS elements as well as cover the detailed design of the seven ITS technologies listed below that are currently utilized by the Illinois Tollway:

- Mainline Detection.

- Ramp Detection.
- Closed Circuit Television (CCTV) Cameras.
- Dynamic Message Signs (DMS).
- Portable Changeable Message Signs (PCMS).
- Road Weather Information Systems (RWIS).
- Virtual Weigh-in-Motion (VWIM) Stations.

The principles used in each of these technologies should be reviewed for applicability when applied to any new technologies.

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Project Dev. Stage	Illinois Tollway Department	Group	Role	Responsibilities
Design	Engineering	(varies by project)	Project management	- Day-to-day oversight ITS design stage - Act as liaison between DSE and other Illinois Tollway departments
		Traffic Operations	Design support	General design oversight and coordination
		Land Acquisition	Coordination	Coordinate right-of-way or easement purchase
		Environmental	Design support	Coordinate impacts in environmentally sensitive areas
		GIS Services	Design support	Provide geographic data
		Incident Management	Design support	Coordinate traffic control and maintenance of traffic
		Permits and Utilities	Coordination	Provide utility location information
		Roadway Maintenance	Design support	Provide maintenance access requirements
		Road Electric	Design support	Provide power source information, maintenance access requirements
		Fleet Maintenance	Design support	Provide requirements for rolling stock ITS items
		Fiber Optic & Utilities Manager	Design support	- Provide fiber optic cable location information - Review fiber optic Contract Documents
		General Engineering Consultant	Design support	Review ITS Contract Documents for general engineering components (e.g., structures)
		Program Manager	Design support	Review ITS Contract Documents (capital improvement projects only)
		Traffic Engineering Consultant	Design support	Review ITS Contract Documents for traffic issues
		Communications Tower Asset Manager	Design support	Review tower equipment installation documents
		Construction	Design support	Review ITS Contract Documents and coordinate project phasing and construction efforts
		System Integrator	Design support	Review impact of introducing a new ITS devices into TIMS network.
		Network Integrator	Design support	Review ITS Contract Documents for communications network integration
	ITS Technical Team	ITS Deployment Engineer	Design support	Review all DSE presentations and submittals
		Network Integrator	Design support	
		General Eng. Consultant	Design support	
		Program Manager	Design support	
	Information Technology	Information Technology	Design support	- Review tower equipment installation documents - Review any changes needed to the Illinois Tollway IP network or Firewalls
	Inspector General	Toll Audit	Design support	Review adjustments to cash lane cameras
	State Police	D-15	Design support	Provides operational input for device locations
	Administration	Security	Design support	Review adjustments to security cameras
	Procurement	Purchasing	Design support and coordination	Assist with procurement of items that may be considered O&M
	Finance	Risk Management	Oversight	Oversee Contractor insurance and bonding

Table 1.2 Illinois Tollway Roles and Responsibilities – Design Stage

Project Dev. Stage	Illinois Tollway Department	Group	Role	Responsibilities
Construction	Engineering	(varies by project)	Project management	- Day-to-day oversight ITS construction stage - Coordinate with CM to resolve issues - Inspection reports - Follow-up with punch list items
		Traffic Operations	Construction support	General construction oversight and coordination
		Network Integrator	Construction support	Configure IP network devices including field switches, digital cameras, IP Relays, DMS Controllers, etc.
		Information Technology	Construction support	Participate at the Pre-Installation meeting for tower applications
		Asset Manager	Construction support	Provide identification for installed ITS devices
	ITS Technical Team	ITS Deployment Engineer	Construction support	Support CM review of construction submittal, RFIs and review field test results or reports
		General Engineering Consultant		
		Program Manager		
	Inspector General	Toll Audit	Construction support	Assist with adjustments to cash lane cameras
	Administration	Security	Construction support	Assist with adjustments to security cameras
Operation and Maintenance	Engineering	Traffic Operations	Operator	Add new field ITS devices, operate and test the system, including burn-in testing
		Asset Manager	Operations support	ITS asset management and tracking
	Information Technology	Information Technology	Operations support	Provide IP network monitoring and troubleshooting
	Inspector General	Toll Audit	Operator	Operate cash lane cameras
	Administration	Security	Operator	Operate security cameras

Table 1.3 Illinois Tollway Roles and Responsibilities – Construction, Operations & Maintenance Stages

2.0 PROJECT DEVELOPMENT PROCESS

2.1 Illinois Tollway ITS Project Development – A Systems Engineering Approach

Designing and constructing complex ITS systems involves many unpredictable parameters, multiple interested parties, and ever-evolving technologies – all of which can increase the inherent technical risk to the project. To reduce this risk, the FHWA promotes the use of the systems engineering process. Systems engineering is defined as “an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem.”

Systems engineering requires a high level definition of functional requirements in the earlier stages of defining project requirements, generally carried out by Illinois Tollway staff when programming improvements. The DSE then refines the improvements and develops contract requirements for construction. During construction the CM oversees the installation of ITS assets, validating that contract requirements are met to satisfy the functional needs identified by the Illinois Tollway at the start of the development process. Upon construction completion, the Illinois Tollway continues to evaluate the performance and operational needs for the life cycle of the technology.

2.2 Planning and Pre-Concept Design

Pre-concept design may be performed by the Illinois Tollway, DCM or the DSE depending on the nature of the project. On Illinois Tollway ITS projects, the Illinois Tollway is responsible for developing the initial planning and pre-concept design in which various project alternatives are analyzed. A DCM may provide pre-concept design for larger projects with multiple design sections. This is not traditionally part of a DSE Contract as a thorough pre-concept design is needed to adequately scope the final design phase.

The result of the planning and pre-concept design is typically the basis for a Scope of Services negotiated with a design firm for execution. For ITS projects, the Scope should include the following parameters, at a minimum:

- Project name, limits, and other contractual details necessary to formulate an effective bid.
- Project goals and objectives.
- Proposed ITS applications.
- Design tasks to be performed by the DSE.

Design section project goals may occasionally be generalized without identifying specific ITS applications or deployment locations. Larger projects with DCM oversight of multiple design sections may necessitate the DSE coordinate design objectives through the DCM. The DCM may be responsible for the planning and pre-concept design rather than the Illinois Tollway for such projects.

It is important to note that the Illinois Tollway is responsible for maintaining consistency with the regional ITS architecture when developing ITS projects.

2.3 Concept of Operations

A concept of operations describes how a proposed system is intended to work from the perspective of system users. It might include the identification of roles and responsibilities, operational scenarios, or general procedures for system operation. The ITS technologies described in this deployment plan will fall under the operational control of Traffic Operations or another Illinois Tollway department/group and should be addressed in operational concepts developed beforehand by those groups. For instance, operational concepts for vehicle detection, ramp queue detection, CCTV cameras, dynamic message signs, and portable changeable message signs are all functionalities under the umbrella of the Traffic and Incident Management System, and, as such, are addressed in the TIMS Concept of Operations.

2.4 System Requirements

The identification of system requirements is a critical step in any ITS project. This identification of system requirements must build from the goals and objectives identified by the Illinois Tollway in the Pre-Concept Design. It is critical to the success of ITS projects that the requirements are created from, and are very specifically referenced back to, these goals and objectives. This documentation of traceability is important in addressing design changes and field changes.

2.5 Conceptual Design (High Level Design)

Concept of Operations and Systems Requirements are developed by the Illinois Tollway. Occasionally the Illinois Tollway may engage consultants for master planning that could involve pre-concept design, concept of operations, or system requirements – which are not traditionally part of a DSE Contract.

The DSE must meet with the Illinois Tollway to discuss the pre-concept design, Concept of Operations, and System Requirements before project scope development or commencing any detailed project development. Everything provided to the DSE leading up to the project scoping is considered pre-concept design, unless otherwise identified by the Illinois Tollway prior to project scoping. The pre-concept design may be a variable aspect of the scoping process. For example, the Illinois Tollway may identify VWIM or DMS locations, but not mainline detection or CCTV locations in which only high level requirements are provided (e.g., full system coverage, ½ mile spacing, etc.). The general intent is for the DSE to have a clear idea of the level of design completed as part of the pre-concept phase and accurately scope and deliver the remaining design effort.

The starting point for the DSE's work should be determined as part of the project scoping process. The Concept Design shall be predicated by a Functionality Plan as further described in the DSE manual. Depending on the nature of the project and the progress of the pre-concept design, the Functionality Plan and Concept Design submittals may be modified from requirements established in the DSE manual or this guide.

Typically, the Conceptual Design for ITS projects includes site selection, field verification, coordination with other Illinois Tollway departments and outside agencies, and coordination with adjacent or overlapping Contracts. The DSE shall hold workshops with Illinois Tollway departments prior to submitting a Functionality Plan or Design Concept Report as outlined in the DSE manual or identified in the DSE's Scope of Services. At these workshops, the DSE shall present the master plan or conceptual design to the Illinois Tollway for comment and/or acceptance prior to the commencement of detailed design.

Illinois Tollway ITS device names are developed by the ITS Unit and follow a common nomenclature. The device names should be referenced in contract documents to ensure consistency when transitioning from construction to operations:

- Roadway number (###).
- First letter of roadway direction (X).
- Milepost number (###.#).
- Equipment type/ITS device designator (XXX).
- Plaza (# or ## or ###).
- First letter of signal type (X).
- Port number (analog camera).
- IP address 4th octet (digital camera).

ITS device designators are as follows:

- RTS = Mainline Detector.
- RQD = Queue detector.
- QDR = Queue detector repeater.
- CAM = CCTV camera.
- DMS = Dynamic message sign.
- PCMS#'s = Portable changeable message sign.
- VWIM = Weigh-in-motion station.
- RWS = Road weather information system.
- WXP = Pavement sensor.

Examples:

- Analog Example: 088E134.3CAM56A27
- Digital Example: 355S003.3CAM99D39

During Conceptual Design the DSE should exercise engineering judgment and not simply duplicate what the Illinois Tollway provides from the Pre-Concept stage or from past similar projects. The DSE should incorporate system requirements developed through the systems engineering process with an ultimate goal of meeting the Illinois Tollway's stated goals and objectives from the Pre-Concept stage. Additionally, it is incumbent on the DSE to research any new advances in technology for applicability or be fluent in the capabilities and limitations of the prescribed technologies if they are required for the project. This may lead to additional

requirements or modifying existing requirements. In all cases, the DSE shall bring these issues to the Illinois Tollway PM who will provide guidance.

The DSE shall review available guide specifications and drawings available through the Illinois Tollway website or WBPM, determining which ones apply to the project. While the guide special provisions document numerous materials, construction, testing, and warranty requirements for the various ITS technologies contained herein, they are not to be regarded as standards. The DSE should use these requirements as a starting point for discussion with the Illinois Tollway departments/groups, and then adapt them to current Illinois Tollway requirements, technology updates and the specific field conditions of the project. The DSE may request an example contract specification or detail drawing as a “starting point” for any pay items lacking guide documents.

2.5.1 Site Selection

Site selection describes high-level ITS device layout. Record plans, aerials, and software packages such as Google Earth may be used to identify potential device field locations based on locations identified by the Illinois Tollway during the Pre-Concept design phase of the project. While this phase of the design process is high-level, the DSE can determine device interval spacing, offsets, design and posted speeds, clear zone requirements, ease of maintenance, and utility locations. Following initial approval of the high-level layout from the Illinois Tollway, the DSE shall verify the field device locations and determine if modifications should be considered (see Conceptual Design Section below).

The DSE must coordinate with the Communications Tower Asset Manager at locations requiring modifications to existing Illinois Tollway communications towers before the Illinois Tollway will permit the installation of devices on Illinois Tollway owned towers. The Contract Documents will require the Contractor provide a structural analysis of the tower, to be reviewed for approval by the Communications Tower Asset Manager prior to construction. This ensures that tower conditions at the time of construction, rather than design, are feasible for the proposed improvement and Contractor’s means and methods. If the Communications Tower Asset Manager does not approve the proposed work, the work shall be cancelled from the contract and an alternate improvement discussed with the ITS Unit.

While specific examples of considerations regarding site selection and design are mentioned in this guide, ITS work incorporates civil infrastructure and must be carefully coordinated with other disciplines.

When presenting the site design (concept plans) the DSE must provide sufficient detail that gives clear direction to the contractor (station/offset, alignments, etc.) while allowing flexibility for field conditions where needed. Schematic presentations should be limited to system level information only, such as communication diagrams.

2.5.2 Field Verification

The DSE must conduct a field review of potential ITS device sites as part of the Conceptual Design stage. During this phase of the design process, the DSE shall verify the viability of the

initial site selection, and identify any potential conflicts, potential power sources and communications linkages. Potential conflicts could include topography, access/maintainability, Right-of-Way restrictions, and power or communication issues. Adjustments to the locations, if necessary, shall be made at this time to minimize or eliminate these potential conflicts. The DSE should also obtain general location information including GIS latitude and longitude information for the ITS devices and elevation information for sites. All latitude, longitude, and elevation information shall be consistent with Illinois Tollway standards.

The DSE shall take photos of proposed locations for each ITS device, correlating to proposed locations shown on the concept drawings, as well as locations of any existing fiber optic backbone, existing handholes and existing power sources utilized for the proposed design.

2.5.3 Coordination with Other Illinois Tollway Departments and Outside Agencies

Before submitting the conceptual system design to the Illinois Tollway PM, the DSE must review the field verified locations with any related Illinois Tollway departments and outside agencies, such as the Illinois Department of Transportation (IDOT) or county departments of transportation (see Table 2.1), to ensure the selected locations will not conflict with any existing infrastructure. The DSE must also coordinate the operational requirements of the ITS devices, such as availability of communications and power, with the proper Illinois Tollway departments. This coordination should be carried out with Traffic Operations approval and participation.

Coordination Issue	Illinois Tollway Department/Outside Agency
Communications	Fiber Optic & Utilities Manager
Wireless Path Analysis	Traffic Operations, Road Electric, outside agencies
Power	Permit Engineer, ComEd
Wetlands	Environmental
Traffic Signals	IDOT, local county/municipality
Structure Attachments	Structures, Information Technology, Communications Tower Asset Manager
CADD Linework	GIS Services
Site Access	Roadway Maintenance, Road Electric
Soil Conditions	Design or Construction
Traffic Control	Roadway Maintenance

Table 2.1 Illinois Tollway Department Coordination

2.5.4 Coordination with Adjacent/Overlapping Projects

Many Illinois Tollway ITS projects will be designed and deployed independently from other construction projects. It is incumbent on the DSE to coordinate the efforts of such ITS Contracts with any current or planned Illinois Tollway or outside agency projects during the conceptual design stage to identify and resolve any scheduling or constructability conflicts with other Contracts, or to explore potential coordinated design and construction. The DSE and Illinois Tollway PM are required to monitor all of the various Construction Contracts under development in or near the ITS project area and work with the Illinois Tollway PM/CM for assistance with all coordination efforts. If conflicts are identified for proposed ITS device sites (e.g., power, communications), the DSE must reevaluate the placement of the ITS device and develop alternate solutions.

2.5.5 Utility Coordination

Utility coordination for ITS device sites includes:

- 1) Identifying conflicts with existing utilities; locating new ITS devices accordingly.
- 2) Making arrangements for new power sources, where necessary.
- 3) Making arrangements for communications to transmit recorded data to the Illinois Tollway's Traffic Operations Center.
- 4) Identifying safe accessibility points for maintenance.

Existing Utilities

The DSE is responsible for obtaining all available utility information and including it in ITS design plans. The Roles and Responsibilities Section identifies Illinois Tollway personnel (e.g., Permits and Utilities, Fiber Optic & Utilities Manager) that should be consulted to obtain existing underground utility information. Wherever possible, ITS sites should be adjusted to avoid existing utilities where conflicts are discovered.

New Utilities - Power

There are five options for obtaining power to Illinois Tollway ITS sites:

1. Intermediate Power Distribution and Communication (IPDC) Facility
 - a. It is preferred that electrical power to ITS sites is obtained from an IPDC wherever possible. IPDC deployment may either be included in the overall ITS concept for design or as an existing installation.
 - b. All existing installation shall be evaluated to determine if sufficient capacity exists for the proposed additional loads. If capacity is insufficient, the DSE shall provide recommendations for modification of the IPDC for the additional loads.
2. Existing utility service
 - a. Where possible, existing electric utility service provided for an ITS device being removed can be utilized for a new device, provided that there is sufficient capacity for the additional load.
3. Roadway lighting controller
 - a. Where no existing electrical service exists (IPDC or utility) and where new utility service or IPDC deployment is prohibitive, the DSE shall consider the use of existing roadway lighting controllers in the vicinity of the proposed ITS device for obtaining electrical power.
 - b. For such installations where an existing roadway lighting controller is utilized, the DSE shall verify that sufficient capacity exists for the proposed additional loads.

- c. The DSE shall note on the plans that any circuit utilized within a roadway lighting controller for the purpose of powering ITS devices. This circuit shall be from the portion of the bus which is not controller via the photocell (24 hours available power), and the subject circuit labeled for the ITS device.
4. New utility service
 - a. A new electric utility service connection may be considered for remote ITS deployments where IPDC deployment are NOT included in the project scope or where no other existing installations exist for obtaining electrical power.
5. Solar
 - a. For locations where connection to IPDC or electrical utility service connections are impractically far away, solar power may be considered.
 - b. Solar should always be regarded as the last acceptable option for permanent deployments, and only where the cost of AC grid power is prohibitive.
 - c. The DSE shall provide a cost estimate for solar versus new utility service connections and discuss these options with the Illinois Tollway before commencing either design.
 - d. Solar might be considered for temporary deployments in construction zones where utility service power is disrupted or unavailable due to construction operations. Where temporary solar power is utilized, the design shall accommodate the conversion to permanent utility service power.

Utility service connections would be provided by Commonwealth Edison/Exelon (“ComEd”). For new standalone services, the DSE shall do an initial analysis by consulting ComEd, with the final power source finalized during construction. Project schedules may dictate that Customer Work Agreements (CWA) be executed by the DSE to ensure availability of power at time of construction. Otherwise, the CWA will typically be filled out by the Contractor and CM, with DSE consultation only.

During construction the CM shall closely monitor the Contractor’s schedule for new utility service connections, coordinating with the utility or Illinois Tollway as necessary to ensure the ITS device is deployed in a timely fashion to satisfy operational requirements of the new system.

New ComEd service can be established by calling 1-866-NEW-ELEC. The DSE should be prepared to provide the following information when calling:

- Project Location - Interstate name and mile marker, distance from cross street or adjacent address (e.g., I-355 MM 29.8, 60’ South of Army Trail Road or 1966 W. Army Trail Road Addison, IL).

- Customer name/address/phone (i.e., Illinois State Toll Highway Authority, 2700 Ogden Ave., Downers Grove, IL 60515-1703, (630) 241-6100, fax (630)241-6100).
- Tax ID number for the Illinois Tollway (to be provided by the Illinois Tollway PM).
- Design Section Engineer contact information.
- Service characteristics (ampere, single phase, multi-phase, upgrade, revision, etc.).
- Date service is needed.

Once this process begins, ComEd will assign an engineer to assist with identifying power service. The ComEd engineer will provide forms specific to the service being requested.

Communications

Different Illinois Tollway ITS devices utilize different communications approaches:

- New deployments of any permanent ITS device should incorporate fiber optic communications, except as directed by the Illinois Tollway prior to project scoping.
- Communication to existing mainline detection devices largely use cellular telephone (the Illinois Tollway has contracted with Verizon to communicate via a third party contract with the State of Illinois). The Contractor and the Illinois Tollway will be responsible for adding any subsequent proposed cellular deployments to the system over the cellular network, which includes configuring the modems and coordinating with the Illinois Tollway to complete the communication link. While some existing mainline detection devices employ cellular communication, continued use of cellular communications should generally be considered for deployments to be replaced within a 3-year period.
- Portable changeable message signs (PCMS) primarily use cellular communications. Cellular service for PCMS is arranged on a Contract-by-Contract basis.
- Communications with ramp queue detection stations will be performed via wireless or direct links to the Illinois Tollway's fiber optic network depending on proximity to the fiber and general cost-benefit analysis.
- CCTV cameras, dynamic message signs, some detection sites, and weigh-in-motion stations all communicate data to the TIMS using the existing Illinois Tollway fiber optic network. Linkages between these devices and the Illinois Tollway network should be made at ramp and mainline toll plaza buildings via typically short fiber runs in conduit.
- Road weather information systems (RWIS) transmit weather and pavement condition data to the TIMS over dial-up telephone or cellular modem.
- Any other field devices shall have their communications defined in the System Requirements or High-Level Design phase.

2.6 Detailed Design

Conceptual design for ITS projects is followed by the detailed design stage, which encompasses the Preliminary, Pre-Final, and Final Design phases. During detailed design, the DSE is responsible for developing Contract Plans, Specifications, and cost estimates for construction of

the ITS Contract. The detailed design process for each of the ITS technologies is included elsewhere within this deployment guide.

2.7 Design Submittals

ITS design submittals must follow the documented process as described in the Illinois Tollway's *DSE Manual*. The DSE shall comply with the requirements that apply to each ITS project, as described in their Scope of Services. This includes submittals at the Conceptual (30%), Preliminary (60%), Pre-Final (95%), and Final Check (100%) design phases.

2.8 Bid and Construction Support

Bid and construction support by the DSE must follow the documented process as described in the Illinois Tollway's *DSE Manual and/or CM Manual*. While bid and construction support is typical to all projects, whether they be ITS Contracts or road and bridge Contracts, there are several unique items that the DSE and CM for ITS Contracts should plan to address. These include requests for information (RFIs) and shop drawing reviews for technology that is continually evolving, coordination with numerous Illinois Tollway and outside agency departments, coordination of adjacent and overlapping projects, and interfacing with existing ITS devices.

It is important to note that ITS technologies change at a rapid pace to the point that obsolescence might occur in the time span between the design and construction stages of an ITS Contract. This may result in shop drawings and submittals that do not match the Contract Documents, but are valid nonetheless. The CM and DSE shall coordinate with each other and the Illinois Tollway to resolve these situations quickly.

For ITS Contracts, it is important that any revisions to the Contract Documents during the bid and construction stages be carefully reviewed for potential impact on other related systems. Where a traceability matrix has been developed, changes must be tracked back through the matrix to determine their impact on the goals and objectives.

Upon completion of an ITS Contract, the CM, DSE, or Contractor may be requested by the Illinois Tollway to assist with the review and/or preparation of as-built drawings. These drawings may be based on the original Contract Drawings, but will include any field changes or change orders implemented during construction. In some instances the Contractor will be required to produce original as-built drawings where none currently exist. DSE's must ensure the special provisions clearly state the expectations for as-built drawings and system documentation to be developed by the Contractor. The CM must ensure as-built and system drawings are delivered per the requirements of the Contract.

Another critical item of concern to the DSE and the CM is the Contractor's reports of testing, calibration or other field adjustments required to ensure the accuracy of the information generated by the new, modified or relocated ITS equipment. The CM witnesses tests and calibration activities specified by the DSE in the Contract Documents. The DSE may need to clarify any questions the CM may have regarding the testing, or consult with the CM regarding the interpretation of the test results.

2.9 Operations and Maintenance

As part of the design process, the DSE must consider how the operation and maintenance of the ITS devices will impact the design. The Illinois Tollway has established a maintenance process for each type of ITS equipment now in its inventory, including the management of manufacturer warranties. Standard warranty requirements are specified in the applicable special provision for each type of equipment. If a new type of ITS equipment is proposed by the DSE, the Illinois Tollway may require the DSE to build upon the TIMS Concept of Operations to develop specific requirements for how the ITS devices are to be operated and maintained if it has not already been developed by the Illinois Tollway as part of the Pre-Concept planning phase, as well as measures and considerations for the initial installation of the devices. These include system integration, system testing and acceptance, asset management, and warranty requirements, each of which are discussed in detail below. The DSE must develop the new special provision detailing all of these requirements in addition to the functional and environmental performance of the equipment.

Likewise, the CM should take into account operations and maintenance aspects of the ITS installations (e.g., accessibility, maintenance personnel safety) before approving device locations and equipment installations.

In all cases, the appropriate chain of command must be followed, as illustrated below in Figure 2.1.

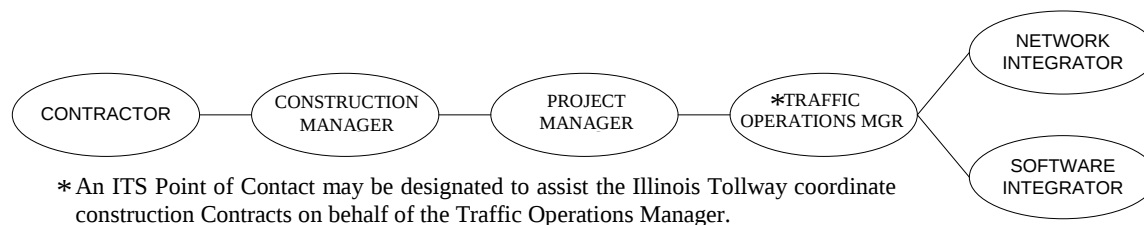


Figure 2.1 Illinois Tollway ITS Project Notification Chain of Command

2.9.1 System Integration

System integration involves configuring proposed ITS devices and introducing them into the Illinois Tollway network and its Traffic and Incident Management System. System testing and acceptance is performed to confirm that new ITS devices function properly, transmit data in the format and at the accuracy level that is required, and that this data is properly received by the Illinois Tollway network and TIMS. System integration and system testing/acceptance for Illinois Tollway ITS projects occur in a logical process and are the responsibility of the contractor including proper and timely coordination with the Illinois Tollway.

In contracts that require a Contractor to provide ITS equipment, the Contractor is required to provide the ITS equipment installed, tested and burned in for 30 days or more. The Illinois Tollway has invested in a wide area network. The core components of this network are already installed and operational. As such, most Contracts will be construction “extensions” unless otherwise scoped. The Illinois Tollway’s wide area network is highly regulated by the Illinois Tollway IT Department in conjunction with Traffic Operations/ITS needs.

The “plug and play” integration of new ITS elements (not new types of equipment) into the Illinois Tollway’s wide area network is easily accomplished due to the following process:

- Only pre-approved ITS Equipment types may be included.
- Only IT Department approved equipment manufactured by Cisco Systems Inc. may be deployed and attached to the Illinois Tollway digital network.
- All network components including switches and network peripherals requiring configuration must be delivered to the Illinois Tollway prior to their installation in the field. Upon receipt, the Illinois Tollway Network Integrator will assign IP addresses, perform other network configuration work, test the configured units, and will affix required identifying labels which uniquely specify the ITS Element name and location where each component is to be installed in the field.
- The Contractor is notified that network configuration work is complete, and is to pick up the configured components from the Illinois Tollway Central Administration building and install them in the field in the correct locations.

Because of the extensive nature of this process to add new technology, the Illinois Tollway has decided to “freeze” the technologies approved for deployment until further notice (unless otherwise identified in the DSE’s scope of work).

Where new types of ITS Equipment are approved the process is much more involved. The steps taken by the Illinois Tollway to evaluate new technology may be up to a 12 month process and are as follows:

- New ITS technologies are evaluated by the Illinois Tollway for performance benefits vs. costs of acquisition and maintenance as well as for compatibility with the Illinois Tollway’s highly secure wide area network architecture.
- The one-time cost of integration of a new type of ITS equipment is not insignificant, and must be estimated, funded and implemented. Implementation includes extensive system compatibility and performance testing in a bench environment as well as in the field environment by the Illinois Tollway’s SI and NI.
- The Illinois Tollway ITS Change Control Board must approve the change to TIMS software to support the new ITS Equipment Type.
- The Illinois Tollway IT Department Change Control Board must approve any change affecting the broader wide area network including any firewall changes.
- The approved changes must be successfully installed in the production build of TIMS software.
- A new guide drawing and special provision must be written, approved and published for use by the DSE.

2.9.2 Network Integration

The NI maintains “Network Communication Diagrams and Communication Details” for all roadside ITS equipment installed on the Illinois Tollway Right-of-Way. The DSE must request a

copy of the relevant Network Communication Diagram sheets covering the project's construction limits from the NI by sending an email containing your Contract number, roadway and mileposts at all limits of construction. The DSE shall include these sheets as an appendix to the 60%, 95% and 100% construction plans. These sheets document the logical connections between existing ITS Elements within the contract limits. The NI will review the Network Communication diagrams for project impact after the 30% design conference, and inform the DSE of any expected impact to toll plazas, maintenance facilities or any other Illinois Tollway facilities or equipment within or nearby the construction limits. If work is needed at an affected plaza or facility, then the NI will provide the DSE with a list of needed equipment, and the DSE shall incorporate that list into a "Communication System Upgrade" special provision. The Contractor's responsibility is limited to furnishing the listed equipment to the Illinois Tollway in a timely manner. The NI will then install and integrate it into the wide area network as it is needed to facilitate the successful "plug and play" operation of the new ITS Equipment to be installed later by the Contractor.

The NI has the capability (along with the IT Department) to remotely monitor ITS Equipment in the field and determine whether it is communicating through the wide area network. The TOC operators can verify that the data is being received at the TOC, and that the ITS equipment in the field appears to be functioning properly. But neither the TOC nor the NI can determine whether a new ITS device has been properly installed, calibrated and aligned. When a new ITS device has been installed, and is not communicating, then the Contractor and the CM must resolve the issue in the field by checking for proper workmanship, stand-alone operation, the absence of any fault indications, and the matching of all of the equipment labels inside the unit (and on the pole if a digital camera) with the site location.

When corrective actions are taken in the field, the CM may contact the TOC directly to verify whether the problem has been corrected. This should not be done during rush hour periods, as the TOC is busy managing peak traffic. If there is a significant traffic incident at any time, the TOC may likewise be unavailable to respond until after the incident has been cleared.

At the end of the Contract, after the new ITS Equipment has been successfully tested, then the NI will update the Illinois Tollway's Network Communication diagrams and the changes will be reviewed and approved by the ITS Change Control Board, adding them to the master ITS network documentation database.

2.9.3 Testing and Acceptance

An Illinois Tollway ITS device is not considered accepted until it has undergone complete testing, including burn-in, as documented by the CM. Each required test is detailed in the testing sections of the special provision for that particular type of ITS Equipment.

Factory Acceptance Test

For the most complex ITS Elements, such as Full Color Dynamic Message Signs, the Illinois Tollway shall require a factory acceptance test be performed on each unit prior to shipment from the factory to the field site. This is to allow much of the complex functional testing to be performed in a laboratory environment instead of in an uncontrolled, highway work zone. The details of the Factory Acceptance Test, where required, will be provided to the DSE in the special provision for the equipment. Factory Acceptance tests are formal tests which must be witnessed by the CM. The Illinois Tollway usually assists the CM during this test due to its complexity.

Field Install and Test

For each ITS Equipment type, the special provision defines the requirements for field testing as well as the testing related submittals. A test data sheet form with instructions may also be included in the special provision. Test plans and Test Reports should be reviewed by the CM and the Illinois Tollway ITS engineering team during construction.

The Contractor should perform dry runs of the field tests to ensure that a majority of the sites will pass on the first attempt. If a configuration problem is found during the dry run by the Contractor, the CM shall be notified. The CM then notifies the project team, following the chain of command for notification (Figure 2.1). The NI will be expected to correct the configuration problem only if the proper unit is installed in the correct location and the configuration has not been changed since handover to the Contractor.

The Standalone/Local Field Test shall comprise the Contractor verifying that all site equipment has been installed, connected and configured properly and can be operated as intended from the site. Prior to connection with the rest of the system, the Contractor shall ensure that all components of the location function appropriately after installation. The Standalone/Local Field Test must be witnessed by the CM and test results recorded on a Test Plan data sheet which is to be signed off by both the Contractor and the CM. A Test Plan (i.e. set of test procedures) should be included in the Contract Special Provisions for each given ITS element.

System Test

Upon passing the Standalone/Local Field Tests, the Contractor shall submit, in writing, notice of devices that have completed the test and are ready for integration to the CM. The CM shall forward the device list through the appropriate chain of command to the TOC Manager (Figure 2.1).

The TOC Manager will contact the NI to verify that the device is communicating to the Illinois Tollway Central Administration Building. If it fails, the Illinois Tollway PM will notify the project team, and the CM will notify the Contractor, who will address the problem. If it passes, the Illinois Tollway PM will inform the project team and the device will progress to the next test.

Next, the TOC operator will add the new ITS devices to TIMS and test them. If a device fails, the TOC Manager will inform the project team. The TOC Manager will provide the Illinois Tollway PM with details of the problem, for the CM to coordinate with the Contractor for resolution. This could be poor video quality, slow PTZ, blank video, traffic data coming from the

wrong lane, or no data at all from a lane. If the device passes the test, the TOC Manager will inform the project team and written notice will be given to the Contractor by the CM and the burn-in period will begin.

Burn-In Period

The requirements of the burn-in period are described in the Special Provisions. In general, the burn-in period allows the Illinois Tollway to monitor the operation of the device over an extended period of time and a variety of conditions. Potential issues with the installation or equipment that may not have been noticed during the brief start-up testing may present themselves during this time. In general, the burn-in period shall demonstrate full monitoring capabilities of the device from the TIMS Center via the installed/existing communications channels as well as the functionalities of the standalone test and troubleshooting/diagnostics for a predefined period (30-days for all devices except dynamic message signs and weigh-in-motion stations, which require a 60-day burn-in period).

The burn-in starts once the Illinois Tollway has approved the “end to end” system test of the ITS equipment unit.

The Contractor shall maintain a date and time stamped log of all failures occurring during the burn in period, and what was done to correct each problem. The burn in clock is stopped each time a failure occurs, and is either reset to zero or restarted where it stopped when the problem is corrected. The reset or extension of the burn in period is defined in the Contract Special Provisions for the device in question. The Contractor must demonstrate that the failure was successfully corrected for the burn in period to commence and final acceptance ultimately granted.

2.9.4 Asset Identification

The Contractor is required to provide the Illinois Tollway asset management documentation including model number and serial number of each serialized components part of their as built documentation. The asset identification should be listed on the warranty documents provided. Information required as part of the asset management process includes, but is not limited to, the following:

- ITS device identification.
- Model and serial number of the device.
- Latitude/longitude (within 10 meters) of the final installation/elevation based on Illinois Tollway standards.
- IP address.
- Firmware version installed.
- Warranty information.
- Site photos including a general site photo and equipment cabinet photos.

2.9.5 Warranty

Warranties are for equipment only and the manufacturer’s labor associated with repairing the equipment, but not for labor needed in the field to remove and replace the equipment. The

physical replacement of equipment will be done by the Illinois Tollway or the Illinois Tollway's Maintenance Contractor.

Warranty requirements shall be documented in the Contract Special Provisions (or as found in the guide special provisions as applicable). For most equipment, the standard equipment manufacturer's warranty will be transferred to the Illinois Tollway upon Contract closeout. For some equipment (DMS, VWIM) an extended warranty will be required and defined in the Special Provision. Additional aspects of the Contractor's work will be covered by surety, as further described in the Illinois Tollway Supplemental Specifications to IDOT Standard Specifications.

2.10 Maintenance of ITS During Construction

The disposition of existing ITS must be considered as part of any Construction Contract. This will generally fall into one of two categories: conflicts with general road and bridge construction (e.g., widening projects) or allowance for continuous maintenance of devices within a construction zone. Because Illinois Tollway operations relies on ITS to manage traffic in construction zones, continuous availability of the equipment is a critical component that must be accounted for in Contract Documents.

2.10.1 Construction Conflicts

Any type of construction has the potential to impact the existing ITS deployment. Impacts to ITS may result from any or all of the following:

1. Impacts to the source of power and power lines feeding the device.
2. Impacts to the source of communications (plazas) or the communications cables feeding a device.
3. Impact to the device (pole/foundations).

2.10.2 Existing System Verification

The Illinois Tollway will provide all available as-built drawings, system drawings, and inventories available. However, the availability and accuracy of all information varies. The DSE should develop a clear understanding of the information available for the existing system during scoping and include effort to field verify information as appropriate. Contract Documents must clearly identify existing locations and to the extent possible, underground infrastructure supporting power and communications.

2.10.3 Mitigation Plan Development

ITS conflict mitigation may be done as part of an advance contract to the main roadway contracts or as part of the main roadway contracts with interim completion dates. In both cases, the intent is to allow for relocated or new equipment to be operational prior to the first major stage changes to allow monitoring and management of the work zone. As part of the overall design process, the DSE shall coordinate closely with roadway and other civil infrastructure designers to identify

impacts to any of the above and design mitigation measures as appropriate. These may include, but are not limited to any or all the following:

- Temporary relocation with permanent relocation to follow.
- Permanent relocation.
- Temporary wireless (cellular) communications.
- Temporary solar power.
- Portable equipment to supplement existing equipment or extended outages of equipment.

The Illinois Tollway's general design requirement is to maintain the existing functionality of the ITS equipment in the construction corridor. Depending on the extent of the construction, location and level of existing ITS deployment; the Illinois Tollway may direct additional devices be deployed to cover the construction zone. This direction will be provided at scoping as part of the pre-concept design or general design criteria (system requirements).

New ITS equipment deployed for work zone management may be done through a combination of applications such as temporary locations with solar power and wireless communications on wood poles, or permanent locations such that the Illinois Tollway can receive a permanent benefit if construction operations allows. It is the DSE's responsibility to identify the most appropriate design solution to meet the functionality required by the Illinois Tollway's system requirements in an economical fashion.

Temporary locations may utilize wood poles; however, use of metal poles (new or existing) on helix foundations is an option as well due to the relative ease of installation and removal of those foundations.

2.10.4 Maintenance

In addition to mitigation of any impacts and conflicts with existing ITS, the Illinois Tollway must be able to maintain the existing system when required. These may include routine maintenance or specific repairs or replacement to address a particular operational issue. This maintenance may be addressed through multiple means depending on the nature of the construction project.

Illinois Tollway Maintenance – The Illinois Tollway typically maintains the existing system through a combination of Illinois Tollway forces and support Contractors. As the long term operators and maintainers of the system, this methodology is often the best solution to maintenance needs. The Illinois Tollway will typically retain the right to maintain its equipment within the construction zone. As part of Contract Documents development, appropriate provisions should be included to ensure the Illinois Tollway is provided access to the work zone in a timely manner in order to affect repairs. Alternate methodologies as discussed here should be considered to mitigate construction coordination issues such as site access and disruptions to construction operations.

Contractor Provided On-Call Maintenance – Contractor provided on-call maintenance can be used to supplement Illinois Tollway forces when needed. Contracts may include special

provisions and pay items that allow a Contractor to respond on an on-call basis when determined most efficient by the Illinois Tollway. The Illinois Tollway retains the general responsibility for the equipment except when the Contractor is actively responding to a call. This may be employed as part of a dedicated ITS Construction Contract or may be included in a general Construction Contract. It should be noted that coordination issues may still exist if a dedicated ITS contract (which includes the ITS maintenance) overlaps with a general Construction Contract. The DSE should consider which application is best and may need to coordinate with other designers to ensure appropriate provisions are included in a general roadway Contract to allow for access by other Contractors.

Maintenance Transfer – The Illinois Tollway may transfer maintenance of the ITS within the construction zone to the Contractor, in which the Contractor would be solely responsible for the continued operation of the equipment for the duration of the Contract. This methodology is typically not employed. The DSE must discuss this methodology at the 30% design meeting with the Illinois Tollway if it is to be considered. Due to the complexity of the system, Contractors – even specialized ITS Contractors – are typically not qualified to adequately maintain the system in its entirety. Additionally, a significant amount of time and resources may be required to complete all site inspections required for a maintenance transfer to the Contractor and then back to the Illinois Tollway. As such, the Illinois Tollway will not typically transfer all maintenance responsibility as part of construction, however, it may be considered based on Contract and location.

The DSE should evaluate the general impact of a construction project on the existing ITS in the area. Based on the potential impact, duration of the project, and other project specific considerations, the DSE, in consultation with the Illinois Tollway, should select the appropriate methodology for ensuring the system can be adequately maintained during construction.

3.0 GENERAL DESIGN GUIDANCE

This section addresses general design principles that may be applicable to all types of equipment. The DSE should consider the guidance provided in this section along with specific device information provided in subsequent sections in order to design the most optimal system. The general principles in this section are based on the concept of balancing the functionality of a particular device (i.e., what is it supposed to do, how does it support the concept of operations and system requirements) with the physical limitations of the constructability and maintainability of that device. This section also addresses a specific consideration for collocation of equipment when balancing these three primary design principles.

While typical examples are provided to illustrate these points, the DSE must recognize that every project and design element is unique in terms of location, types of deployments, and project goals. It is incumbent upon the DSE to identify specific design considerations and solutions in the context of guidance in this section and the manual as a whole.

3.1 Functionality

First and foremost, the intended functionality of the equipment must be accommodated. The DSE must understand the overall goals and objectives of the Illinois Tollway's traffic and incident management strategy and specific project goals and objectives and other information presented in the system requirements or pre-concept designs provided by the Illinois Tollway to ensure the design of the system effectively supports each as applicable. These are clearly stated in the Illinois Tollway's concept of operations and system requirements. The DSE will need to validate these as part of the design process in order to translate them into a detailed system design.

For example, a CCTV camera must be able to effectively view the intended area of the roadway. If the view is significantly obstructed by other infrastructure or other off system features (building, billboards, trees, etc.) then its functionality (use) is minimized. While constructability and maintainability concerns often impose significant constraints on where a foundation and pole can be located, the intended functionality must take precedence as the higher weighted item of the three. But all three criteria are important. In some cases, the DSE may need to specify an additional camera and shift their locations in order to satisfy all constraints. A camera that is not maintainable is not an acceptable solution.

Consideration should be given to adding device locations to achieve the required functionality through multiple sites in order to accommodate constructability and maintainability concerns. This might occur around major interchanges where multiple overpasses may obstruct camera views and steep slopes and retaining walls will constrain where physical infrastructure can be installed and accessed.

3.2 Constructability

ITS installations are deployed within the context of a typical high speed, limited access highway. Integrating ITS infrastructure into this type of facility has a number of challenges such as:

- Conflicts/integration with other civil infrastructure including barrier walls, retaining walls, sound walls, drainage features, signage, and other private utilities. Very often the best location for a particular device may not be feasible due to conflicts with other elements. The DSE must evaluate these constraints to best optimize the location in terms of what can actually be constructed. The DSE must also consider the staging of a particular project. If ITS installations are being deployed as part of a larger roadway Contract, ensuring ITS locations don't conflict with final roadway features as well as construction operations is critical. It must be understood that "schematic design" using aerial photography as base mapping is typically not sufficient. As with any roadway project it is most desirable to work from topographic survey with all proposed elements tied to specific control points. Because underground features are often unknown or at best approximated, flexibility for CMs and Contractors to field adjust within certain tolerances should be included where appropriate.
- Proximity to Power and Communications – A significant cost of ITS deployment is connection to power and communications (fiber optic cable). The DSE must consider the source of power and communications and balance these against the best functional location.

Using the camera example, if power and communications are both located on one side of the roadway, it is preferable to place the camera on the same side to minimize conduit and cable runs and eliminate expensive directional boring under the roadway. This is typically not an issue if the camera is located on a tangent section of roadway. If the camera is being placed on a horizontal curve, the better functional location (i.e., best view) is typically on the high side of the curve (closer to the point of intersection). If this does not coincide with the location of power and communications, the DSE will have to make a determination on the most appropriate design solution to balance the two.

3.3 Maintainability

It is important to consider how a site will be maintained following deployment. Maintenance will typically consist of two primary activities:

1. Access by technicians on foot to a ground/pole mounted equipment cabinet.
2. Access by technicians to pole or truss mounted equipment via standard lift trucks or material handling lift truck.

Access to a particular site will be needed on a regular basis for both routine maintenance (cleaning, adjustments, etc.) and repairs. Ease of access for both technicians and vehicles must be considered and limitation of specialized equipment such as longer reach lift trucks or need for lane closures.

A typical bucket truck is able to reach a camera mounted 50 feet above the shoulder when located laterally up to 20 feet from the shoulder. The DSE should consider the effect of slopes on both the functionality and maintainability. Steep slopes may reduce the overall height of the camera above the roadway as well as make access on foot difficult. The DSE shall review the maintenance work area immediately adjacent to the ITS device to ensure a maintenance technician is able to access and work on the ITS device. The Illinois Tollway's Guide Drawings and Special Provisions generally consider site maintenance with such features as maintenance pads and railings, however, the DSE must be aware of site conditions and adjust details or add further detail as needed in order to provide safe and reliable access (as well as providing the Contractor sufficient detail for any location specific designs not covered by typical drawings).

A specific and recurring example of balancing constructability and maintainability is the requirement for roadside obstructions (clear zone) versus maintenance. As a fixed object, equipment poles and cabinets must be either shielded (i.e. guardrail, concrete barrier) or located outside the clear zone. This may result in the concern of the added construction cost of barrier versus the reduced maintainability from increasing equipment offsets to beyond the clear zone. These increased offsets may compound the general constructability/maintainability balance issue by impeding maintenance access due to ditches or noise abatement walls.

3.4 Collocation of Devices

In addition to balancing the three general design constraints of functionality, constructability, and maintainability, the DSE should also consider collocation of devices where practical as another part of design optimization.

The cost of power and communications connections, along with the long term cost of maintenance represents a significant portion of the life cycle costs of ITS equipment. Collocation provides the following benefits to offset these costs:

- Consolidation of equipment limits the costs of separate power and communications feeds.
- Consolidation of equipment reduces maintenance costs by consolidating routine maintenance site visits and reduces the equipment maintenance and/or replacement costs through shared equipment (network switches, power distribution and conditioning equipment, etc.).

The DSE shall consider collocation of devices where practical while balancing the functional needs for different types of devices.

Where optimal coverage of two different devices results in separation of up to several hundred feet, consideration should be given to design revisions to move one or both such that they can be collocated on a single pole. It should be noted that the specific distance from what is considered the optimal location is not specific design criteria. Individual site characteristics such as horizontal and vertical geometry, proximity of ramps or overpasses, and general site constraints related to constructability and maintainability will all factor in the ability to optimize collocation possibilities. The DSE must use good engineering judgment and the overall goals and objectives of the individual devices and the system as a whole when considering collocation potential.

Because the Illinois Tollway’s individual design criteria related to CCTV camera coverage and mainline vehicle detector coverage, it is typical practice to always collocate a CCTV camera with a side-fire microwave vehicle detector and vice versa. The incremental cost of adding a camera or detector to a pole is minimal compared to the overall cost of all power, communications, and structural support infrastructure. This may result in some overlap in coverage or denser coverage, however, system redundancy is an added benefit. Often the greatest amount of overlap will be the result of complex areas such as major interchanges or other significant geometric changes. Excessive redundancy should be considered and avoided. This is typically left to the judgment of the DSE and will be reviewed as part of concept or preliminary plan reviews by the DSE and Illinois Tollway.

The Illinois Tollway’s Guide Drawings and Special Provisions generally address device collocation by standardizing cabinet layouts and designs such that devices can easily be added or removed from a particular location with minimal change to cabinet designs.

3.5 Intermediate Power Distribution and Communication (IPDC) Facilities

As with the collocation of ITS devices, Intermediate Power Distribution and Communication (IPDC) Facilities provide for common locations to obtain uninterruptible power service and communications for ITS deployments as well as normal power for roadway lighting. The IPDC may be considered a “mid-level” architecture that generally consists of a small building with power and communications infrastructure between field devices and electrical utility company/third party leased communication lines. This “mid-level” architecture is Illinois Tollway owned and facilitates more rapid deployment of new assets.

The ITS designer shall closely coordinate with other designers for roadway improvements impacted by the IPDC site consideration. The DSE shall consider the following items when coordinating IPDC design requirements:

- Area for maintenance vehicle parking and access.
- Site grading and IPDC building placement must accommodate clear zone requirements wherever feasible.
 - o Drainage design considerations must be given for providing level grading within and otherwise open drainage design with ditches. Additional culverts may be required to partially close the ditch drainage in the vicinity of the IPDC.
- The IPDC locations shall be spaced to optimally service both lighting and ITS deployment needs of the entire corridor, including those portions outside of the design section limits, as further defined in the guide drawings or directed by the Illinois Tollway.

The DSE shall refer to Guide Drawings and Special Provisions for overall equipment requirements and site considerations.

3.6 ITS Labeling Guidelines

The DSE shall be made aware of the ITS Labeling Guidelines, available on the Illinois Tollway website. The DSE should consult the ITS Labeling Guideline to include labeling for the following cabling and equipment via the Contract Documents, as coordinated with Illinois Tollway ITS:

1. ITS cabinet/equipment racks.
2. Communications/network equipment.
3. Fiber termination shelves.
4. Fiber optic and copper cables (backbone & drop).
5. Fiber optic and copper patch cords.
6. Copper patch panels.
7. Copper building entrance terminals.
8. Ground bus bars.
9. Bonding conductors.
10. Terminal panel boards.
11. Field/site space.

The CM should review the Contractor's "labeling plan" for conformity to the Illinois Tollway's ITS Labeling Guidelines prior to the start of construction of any cabinet, rack, raceway, cable or wire requiring labeling per the Standard.

3.7 Guide Drawings, Special Provisions, and Reference Documents

As described in various sections above, a number of Guide Drawings and Special Provisions are available. The DSE shall be responsible for final development of all details and special provisions for use in the Contract Documents. All referenced manufacturers, models, and functional requirements of any equipment specified or shown shall be verified by the DSE to be commercially available and meet the intended functional requirement of that piece of equipment as specified or shown in the guide document. Any equipment found to be obsolete or incapable of meeting the intended functional requirement should be identified by the DSE to the Illinois Tollway and an alternate component presented for substitution.

3.7.1 System Testing and Acceptance

System testing and acceptance procedures are more thoroughly discussed elsewhere in this document.

The guide special provisions more fully describe the requirements for system testing and acceptance of a given device to be deployed. It is critical to the overall success of the Illinois Tollway's Traffic and Incident Management Program to receive accurate, reliable data. To that point, the CM should take special care during the testing and acceptance period to ensure that systems have been installed correctly and are accurately reporting data and clean video imaging. Should results fall outside the specified accuracy of a device; the Contractor will be required to make adjustments and the testing repeated.

3.7.2 Structure/Support

Refer to Guide Drawings and Special Provisions for any required structures or supports (e.g. poles). Breakaway devices are allowed for flashing beacon only. All other ITS devices shall be considered non-breakaway and be located well outside the clear zone or in areas shielded by guardrail, barrier wall or other shielding method.

Except where explicitly governed by Illinois Tollway provided guide drawings, the DSE must perform a structural analysis of any pole and foundation required; considering existing soil conditions as well as the size and location of the elements to be installed on poles, which may include solar panels, cameras, detection units, and equipment cabinet.

The final location of the equipment pole and foundation should be checked for clear zone requirements. ITS equipment should be installed well outside of the clear zone where feasible. For locations where right-of-way is restricted and the ITS equipment detector is not located well outside of the clear zone, installation of new guardrail may be considered if alternate equipment locations are infeasible. The DSE should refer to the Illinois Tollway's Traffic Barrier Guideline and AASHTO's Roadside Design Guide for more guidance.

3.8 Topographic Survey

A topographic survey is required for each deployment site, for every device deployed along the roadside. The survey allows for a cross-sectional view of the site to determine the appropriate functional parameters may be met (i.e. proper detector mounting height is achievable) and provide data for clear zone calculations. Additionally, potential design flaws (such as drainage, grading, and maintenance access for vehicles and technicians) must be evaluated. For widening and reconstruction contracts, additional topographic survey generally will not be required.

Cross sections should be surveyed at a staked location for the proposed equipment and roughly 25 feet on either side of the staked location. In the event that the staked location is determined to be unacceptable during latter design stages, the two adjacent cross sections would serve to identify alternate possibilities. These secondary cross sections also provide a "check" of the data collected at the primary location, and can help to identify drainage areas, etc.

A full cross section of the roadway (i.e., from right-of-way to right-of-way) may be required where the functional limits of the ITS device are reached (i.e. the width of the area to be detected (from detector to far travel lane) approaches the detection limit or exceeds 10 lanes of traffic for mainline detection).

Where the considered technologies include wireless communications, radio or cellular, potential line-of-sight issues should be further investigated and surveyed as necessary.

The survey should also include locations of existing power and communication (fiber) drops. Soil borings should be conducted where foundation designs are required.

3.9 Communications

As discussed previously the collocation of devices will consolidate the number of communication feeds required for a group of equipment. This will reduce the number of splices made to the Illinois Tollway's fiber optic network, improving quality (introducing fewer failure points) and more prudent use of the available fibers.

The preferred communications media is fiber optic. There are two types of fiber optic cables utilized by the Illinois Tollway for ITS; single mode (SM) and multi-mode (MM). New deployments shall utilize single mode fiber optic cables, except where required to connect to existing multi-mode fiber optic cables or as necessary to comply with equipment communication requirements.

There are several different types of fiber optic cable deployments within the Illinois Tollway right-of-way; equipment cables, lateral cables, backbone cables, distribution cables, and third party leased cables. Most designs will only require inclusion of equipment and lateral cables. Backbone cables may be included where major construction, reconstruction, or rehabilitation work is undertaken. Other types of deployments are generally not included within the ITS scope of work and not further discussed in this manual. Below is a discussion of the common type of cable deployed for ITS work.

- Equipment cables are specific to the devices deployed for connecting individual components within the system deployed or for connecting the system to the lateral cable. These cables may be small strand count fiber optic cables that have been terminated or jumper cables connecting the equipment. For example, Dynamic Message Signs generally use 6-strand MM fiber optic cable to communicate between the controller and the sign (with MM jumper cables as appropriate), but use SM jumper cables to connect the controller to the SM lateral cable for Traffic Operations Center communication.
- A lateral cable is utilized to connect a ITS deployment site to a backbone cable. This cable is a smaller strand count, general 6- or 12-strand cables, of a material type compatible with the backbone cable. New deployments should be SM, except where connecting to legacy MM cables. Where legacy MM cables are encountered the lateral cable may be "home run" to a primary communications network connection (such as to a plaza) or consideration given to replace the legacy MM with new SM fiber optic cable architecture.
- A backbone cable is a large count strand cable utilized to connect the field devices to a primary communications network connection, typically located at Toll Plazas. Some sections of the Tollway contain an ITS backbone fiber with ample capacity for new connections. Otherwise, the ITS field device may be required to connect to an IT backbone fiber with limited capacity for connecting ITS field devices. The appropriate connection points to an existing backbone cable, or the need to provide a new dedicated backbone fiber cable must be coordinated with the Tollway Fiber Optic and Utilities

Manager during pre-concept or concept design stages. New backbone cable deployments generally utilize 144-strand single mode fiber optic cables.

For any design that might use communications media other than Illinois Tollway fiber, a compelling case must be made with a cost analysis to justify using alternative approaches. The cost analysis shall be provided by the DSE to the Illinois Tollway at the Conceptual Design meeting. The cost to create a fiber optic cable connection between the new camera and the nearest network access point must be estimated (trenching/boring, handholes, transceivers, etc.). The cost of alternate approaches being considered must also be estimated (i.e. wireless line of sight, radio equipment, install). Included in this decision must be the reliability of the approaches (the TIMS operators/manager will have relevant experience with the various types).

Wireless cellular communication deployments may be considered for use within work zones where physical communication connections would be disrupted by construction activities. Permanent deployment of cellular communications is discouraged and must be coordinated with the Illinois Tollway ITS Unit.

Wireless radio communications for permanent deployment between an ITS site and a primary network connection shall not be considered.

Where ITS devices rely upon wireless communications between subcomponents, the DSE must consider line-of-sight needs, signal range, and communication path between the subcomponents.

The optional use of non-preferred communications should be presented by the DSE at the Concept Submittal (30% design) for approval by the Illinois Tollway ITS Unit. Detailed design of the approved final communications media should be given in the Preliminary Submittal (60% design). Any use of a wireless modem shall be researched by the DSE to ensure compatibility with the local cellular service provider before it is included in the Contract Documents. During construction, the Contractor will coordinate with the Illinois Tollway to arrange and assume the cost of the cellular service. The Contractor is responsible for providing a functioning ITS deployment that transmits data to TIMS.

Any communication requirements specific to a type of ITS technology utilized by the Illinois Tollway is further discussed further below in each section addressing that particular ITS technology.

4.0 MAINLINE DETECTION

4.1 Introduction

Mainline detection is used to provide presence indication and measurements of traffic volume, lane occupancy, speed, and limited vehicle classification. Non-invasive detection technology shall be used for mainline detection. MVDS stations utilize a traffic detector that does not require saw cutting the pavement for the installation of cables to communicate with the device. Mainline detectors are typically located along the roadside at or approaching areas where speeds tend to fluctuate such as interchanges, ramps, and toll plazas, as well as at predefined spacing along the mainline of the Illinois Tollway system. The former placement favors accurate detection of incidents, while the latter placement enhances accurate calculation of travel times.

Data collected by mainline detection is transmitted back to the Illinois Tollway's Traffic and Incident Management System (TIMS), providing real-time traffic information to Illinois Tollway traffic managers and the public.

4.2 Placement

Mainline detector placement and spacing is typically defined during the Pre-Concept stage and finalized during Conceptual Design. The spacing is determined based on congestion levels typically experienced along the particular segment of roadway being detected. For example, along urban or regularly congested sections, ½-mile to 1-mile spacing may be utilized, with rural or uncongested areas employing 3-mile spacing. Intermediary spacing of 1½ to 2 miles would be used for transitional areas. The detector spacing should provide the Illinois Tollway's Traffic Operations Center with sufficient density of traffic data to detect incidents and congestion levels as well as calculate travel times throughout the system. The detector spacing shall be coordinated with the Illinois Tollway during the scoping stage of the Contract for the given context of the Contract limits.

MVDS detectors provide presence indication and measurements of volume, occupancy, speed, and classification for at least 12 separate lanes. The MVDS manufacturer claims of detection from up to 250 feet away from the detector location have proven difficult to attain. A desirable limitation of 220 feet is recommended for a practical design. Detectors should generally be located no more than 50 feet from the edge of the nearest travel lane. If the width of the roadway at the proposed detection site exceeds the detection zone distance limits, or if there is a substantial grade difference between opposing directions of travel, two detectors may be necessary to capture all lanes. Detectors placed opposite one another should be offset by 20 to 30 feet to avoid crossing detection zones.

4.3 Description of Types/Models

The Illinois Tollway's preferred detection technology may be found as described on the Guide Drawings and Special Provisions. Future Contracts may consider other technology options available at the time of scope development. The final detector selection to be deployed at each location must be justified by the DSE or DCM, and is subject to Illinois Tollway approval at the Concept Design (30%) stage. If there is no Illinois Tollway "historical data" available, then the

DSE or DCM must provide quantitative accuracy and reliability data from other highway transportation agencies.

Any alternate technology the DSE wishes to bring forward for consideration should be discussed with the Illinois Tollway staff in the initial phases of design to determine to what extent alternatives should be considered.



Existing Deployments

Much of the existing mainline detectors deployed along the Illinois Tollway are RTMS™ model G4 devices. Newer deployments have installed Wavetronix™ SmartSensor or RTMS™ SX-300 devices. These units are typically mounted on a road-side pole located outside of the clear zone or shielded by otherwise warranted guardrail. This configuration results in limited, traffic disruptions during installation or maintenance, if at all. This configuration also allows for mitigated disruption during construction, often times only requiring recalibration of the units for shifted lanes of traffic.



To a lesser degree, the Illinois Tollway has existing deployments of Sensys™ magnetometer systems, primarily deployed along ramps rather than mainline. This system uses small (3x3x2 inches) magneto-resistive sensors (installed flush in the pavement) and packet radio technology to collect and distribute vehicle presence and movement data. The magnetometer system uses a non-replaceable battery pack, with an average life of 10 years (estimated) as the power source. While the magnetometer system does not require saw cutting the pavement for the installation of communication cables, a degree of pavement intrusion is required to install the sensors as well as for replacement once the sensor reaches its end of service life.



4.4 Design Considerations

The Pre-Concept stage will typically identify the inclusion of mainline detection or not, providing a general basis for the number and locations of detectors (e.g. specific milepost locations or general density, such as ½-mile or 1-mile spacing). Any further studies required by the DSE to determine optimum spacing requirements of the mainline detectors would be part of the scoping discussion between the Illinois Tollway and DSE before commencing the Contract. At a minimum, the DSE should maintain the extent of the existing coverage for any proposed designs.

The DSE is responsible for selecting and finalizing conceptual mainline detector sites, including conducting initial field verification of those sites for feasibility.

What follows is the detailed design stage. This stage includes data collection, site design, system integration, system testing and acceptance, and the definition of equipment warranties.

4.4.1 Field Investigation

A site visit shall be conducted as part of the data collection process to document all pertinent aspects of the proposed site. Site visits for detector stations should take into account the following site characteristics, at a minimum:

- Detection zone – maximum number of travel lanes and distance from the detector to the outer edge of the farthest travel lane (multiple detectors should be applied for detection zones exceeding these parameters).
 - The DSE shall consider the maximum number of detection zones a particular device is capable of producing, compared to the number of travel lanes a given site contains.
- Topography – flat area suitable for detector pole foundation installation and future maintenance.
- Access – clear path to the detector site from the mainline, both for construction and future maintenance (avoiding ditches, steep slopes, and outside lane barrier walls).
- Clear zone – locate obstructions well outside of clear zone or sufficiently shield devices as determined by a barrier warrant analysis (refer to the Illinois Tollway Traffic Barrier Guideline for further information).
- Obstructions – structures near the site (e.g. median barrier walls, overhead cantilevers, bridges, large highway signs, light poles, and underground/overhead utilities). Close proximity may cause interference with detectors employing radar technology.
- Sunlight – direct view of southern sky (for solar powered sites).

Once a detection site has been investigated and all potential conflicts have been resolved, the detector pole location should be staked and marked for surveying. When possible, the surveyor should participate in site staking to resolve any issues before the next stage of data collection. A full cross section of the roadway is required for analyzing each site, with careful consideration given to design constraints of other disciplines (such as drainage headwalls, grading, and sign placement) in the immediately vicinity of the detection site.

4.4.2 Site Design

Site design involves the placement of detector components at the site, taking into account the functionality, constructability, and maintainability of the installation. The result of this stage is Contract Documents for competitive bidding.

The site plan for each mainline detector deployment shall define the location of all associated components including: the detector assembly (detector pole, sensor, cabinet, cabinet equipment), pole foundation, power source and associated infrastructure, any civil work necessary to access the site for construction or maintenance, grounding and lightning protection, and a maintenance of traffic plan.

5.0 RAMP DETECTION

5.1 Introduction

The Illinois Tollway deploys vehicle detectors at ramps of both system and service interchanges and both exiting and entering ramps based on the functional need. These functional needs include the following:

5.1.1 Vehicle Counts

Where tolling plazas are not present, the Illinois Tollway may deploy vehicle detectors for the purpose of recording vehicle counts and classification by lane for general planning and traffic engineering purposes. These may be deployed for either entrance or exit ramps on both service and system interchanges.



5.1.2 Queue Detection

Ramp queue detection is the process of detecting vehicles that queue up to a critical point along an Illinois Tollway exit ramp as a result of capacity constraints at the ramp terminal (typically a signal controlled intersection). When a critical queue is detected, the system activates alerts and potentially implements traffic remedies to reduce the queue or provide advance warnings to motorists approaching that ramp. Ramp queue detection is intended to reduce delay and increase driver safety by detecting queue backup before it reaches the mainline lanes and creates a potentially hazardous condition.

The Illinois Tollway may apply ramp queue detection in three non-exclusive ways:

- Mainline warning operation – This method includes sensors on the ramp to detect a queue and communication with driver warning systems upstream of the ramp. The warning system may include an existing DMS, a DMS proposed as part of the queue detection and warning system, or a static sign and flasher. If this system is deployed, the DSE will have to consider guidance provided as part of the DMS section and general sign design practices.
- Queue reduction – This method includes an interconnection between the queue detection system and the local traffic signal at the ramp terminal. Upon detection of a queue, a priority signal is provided to the traffic signal controller which will implement a timing plan to reduce or flush out the queue. If this system is deployed, the DSE will have to coordinate with the local agency with jurisdiction over the traffic signal system to design the appropriate interconnects between the Illinois Tollway system and the signal controller.

- **Illinois Tollway Alert** – This method includes deployment of the detection system only. The Traffic Operations Center will receive notification of a queue and may implement mitigation measures through coordination with local Roadway Maintenance resources for deployment of PCMS or “shadow” truck with PCMS boards attached.

As part of the Pre-Concept design provided to the DSE and project scoping, the Illinois Tollway will direct which system is to be implemented as part of the project.

5.1.3 Wrong-Way Detection

The Illinois Tollway is evaluating the need for detecting wrong-way entry onto the system. Specific direction and guidance will be provided as part of the scoping process should the Illinois Tollway pursue wrong-way detection deployment.

5.2 Placement

The varied functional uses for ramp detection and variety of technologies that may be deployed factor into the placement of the detector. Prior studies may have been done by the Illinois Tollway when determining the need for providing ramp detection. The DSE shall consult with the Illinois Tollway to determine if prior studies are available or whether the DSE should perform the needed studies to refine the ramp detection needs (all of which shall have been discussed as part of the Scoping process). Once the type of technology and general location has been determined the DSE shall follow the manufacturer recommendations for placement and proximity to the travel lanes. Following are placement considerations for deployment of ramp queue detection.

5.2.1 Ramp Queue Detection Devices

The most important detail in configuring the ramp queue detection site is the placement of the vehicle detector to identify the queue. The location should be determined based on the observed maximum queue lengths and the allowable frequency of pre-emption that would result from ramp queues that are detected for systems that will employ traffic signal interconnection. For systems that will be warning only systems, consideration should be given to allowing detection of a queue and implementation of an appropriate response. For example, it may be desirable before the queue reaches a critical point (i.e., extended to conflict with mainline traffic) such that the Traffic Operations Center can actively monitor the queue and deploy resources if needed.

Depending on the communications type used at each site, a radio and radio antenna, may need to be mounted to each ITS device. ITS devices include the vehicle detector, the advanced static warning sign or DMS, the traffic signal controller cabinet, and any necessary repeaters. Mounting details for these components may be found in the guide drawings found on the Illinois Tollway’s website, if available.

Discussed below, there are a variety of placement options depending on the purpose of the ramp queue detection site type:

- Advanced static warning sign alert system.
- Extended green time system.
- Queue flush system.

5.2.1.1 Advanced Static Warning Sign Alert System

If advanced warning of a queue is to be provided by a DMS, typical design practices for a DMS should be followed while ensuring the DMS location provides adequate distance between its location and the ramp for drivers to react to the message.

If an advance static sign with flashers is used as a warning device, communication to the flashers must be designed. The advanced static warning sign alert system refers to a system where a vehicle detector collects and transmits traffic data which is sent to a central information hub (such as TIMS). TIMS would then process the data and determine the presence of a queue or not. Upon detection of a queue, a signal is sent back to the field from the TOC to activate the warning flasher. This communication will be done over the Illinois Tollway's network, but will be executed via a contact closure to activate the flasher. The DSE will be responsible for this "last mile" design from the point of presence of the Illinois Tollway network to the flashers. This may be done by bringing fiber and network communication directly to a cabinet at the flasher or by using wireless technologies (if approved by the Illinois Tollway) between the nearest Illinois Tollway network switch (e.g., a nearby camera) and the sign/flasher assembly. This element of the design must be developed by the DSE as part of the Concept Plan development.

5.2.1.2 Extended Green Time System

The extended green time system works with the off-ramp traffic signal to change the signal timing plan to allow for additional green time for the off-ramp movements. This additional green time helps disperse the queue, freeing up capacity on the ramp. The placement of the vehicle detector in this configuration depends on many factors including, length of the maximum queue, traffic signal cycle length, traffic signal phase length, and adjacent traffic signal operations. The DSE needs to ensure that the additional ramp-phase green time provides adequate opportunity to free up storage space on the ramp and should investigate the effect of the additional green time on the surrounding roadway and intersection network.

5.2.1.3 Queue Flush System

A queue flush system is designed based on the goal of completely flushing the off-ramp queue once the queue backs to a designated length, allowing enough green time to flush a predetermined length of queue. Again, the placement of the vehicle detector is a key element in the design of the ramp queue detection sites.

Communication with a traffic signal controller will be a simple contact closure signal sent to the controller to indicate an event. The Contractor and local agency will then connect to the appropriate input on the controller and develop the alternate timing plan. It is anticipated that

actual development of timing plans would be done by the local agency; however, depending on the terms of the Inter-Governmental Agreement, it may be the responsibility of the Illinois Tollway – and therefore the DSE – to develop timing plans for local approval. This element should be defined during project scoping.

5.3 Description of Types/Models

The Illinois Tollway may use different technologies depending on the specific purpose of the ramp detection project: ramp counts only, queue detection only, or combination. Some technologies are more suited to free-flow traffic conditions and ramp counting versus congested traffic conditions associated with queue detection. The Illinois Tollway is regularly evaluating the performance of different detection technologies for specific applications and developing the associated Guide Drawings and Special Provisions. In general, the Illinois Tollway’s goal is to utilize a single detection technology for all functions.

Ramp detection may be accomplished via non-intrusive side-fire radar (similar to mainline detection) or through in-pavement wireless detectors. The Illinois Tollway will provide direction on preferred technologies and application of appropriate special provisions and guide drawings as part of the pre-concept design documents provided as part of the scoping process. This section generally addresses functional needs and considerations as opposed to specific technology applications and considerations related to the design process. However, the DSE should be aware of the differences in technologies and potential impacts on specific design components. For example, the “last mile” communications design will differ between bringing fiber all the way to a microwave vehicle detector versus wireless hopping to a nearby communications point on the fiber for in-pavement wireless detection.

Where side-fire radar is appropriate, refer to mainline detection above for further guidance as applicable. Illinois Tollway Guide Drawings and Special Provisions provide specific design requirements for wireless connections associated with in-pavement wireless detectors.

5.4 Design Considerations

For ramp detection projects, the planning and Pre-Concept stage of design will typically identify the ramps for system deployment, type of operation (i.e., counts, queue flushing, ramp queue warning, etc.), and technologies to be used. The DSE will be responsible for determining device and infrastructure locations and conducting initial field verification of the sites.

Ramp detection and its potential three functional uses represent a specific application of collocation of devices as discussed in general previously above. Ideally, all three functions could be accommodated with a signal detector deployment at one specific location on the ramp. This will not always be the case. If multiple needs are required as part of the pre-concept design or engineering study, consideration should be given to balancing each need with the various constraints of deploying a functional solution for each need. As queue detection has generally more constraints with regards to placement of detectors, the detailed design guidance of this section focuses primarily on that function as opposed to traffic data collection. The latter function should always be considered during the design phase.

Typically, ramp queue detection sites are placed in areas where the design of the off-ramp does not provide adequate storage for the high demand of exiting vehicles. These locations cause potentially hazardous conditions to the through traffic on the adjacent Illinois Tollway facilities as off-ramp traffic queues extend beyond the length of the exit ramp and into the high-speed through lanes. Ramp locations that have a history of traffic backing onto Illinois Tollway facilities have usually necessitated the implementation of ramp queue detection.

Once the need and location for ramp queue detection has been identified, the detailed design stage follows. The detailed design process includes data collection, site design, system integration, system testing and acceptance, and the definition of equipment warranties.

5.4.1 Field Investigation

A field investigation of the site(s) allow for the DSE to understand any issues that may impact the design or the communication of the ITS components of the ramp queue detection site.

As described above, ramp queue detection sites might include several devices that transmit information and activate alarms when ramp queues build. Information collected during the field investigation for the ramp queue detection site includes, but is not limited to:

- Ramp length – measurement of ramp length, including number of lanes, turn bays, presence of shoulders.
- Speed limit of Illinois Tollway and ramp facilities.
- Maximum queue lengths – counting of the number of vehicles in the queue over the course of several traffic cycles during the peak period(s). Other methods of determining queue lengths may be used to as directed or approved by the Illinois Tollway PM, including the Highway Capacity Manual methodology, traffic simulation tools, or using CCTV to view maximum queue lengths.
- Ramp volumes and Illinois Tollway facility volumes – the volumes will be used to evaluate available storage, queue lengths, and flow rates.
- Detector site – refer to mainline detection section above for field investigation considerations for the placement of the detector.
- Static warning sign site – roadside topography, construction and maintenance access, sunlight (for solar powered sites), viewing angle, competing signage, line-of-site to detector or repeater site(s).
- Repeater site(s) – roadside topography, access, presence of guardrail, sunlight (for solar powered sites), line-of-site to detector and warning sign.
- Traffic signal cabinet site – line-of-sight or presence of available conduit to detector.
- Inventory of all signal control equipment at the ramp intersection with the local roadway network.
- Intersections surrounding the proposed site that may be impacted by queue reduction operations.
- Existing traffic patterns of vehicles exiting the ramp to the local roadway network.

The DSE should take photographs of pertinent field conditions based on the items noted above (e.g., traffic signal cabinet, ramp lines-of-sight). The photos can be revisited throughout the design process to remind the DSE and others involved with the site design of any outstanding issues not otherwise documented.

The DSE should also verify any additional information regarding the ramp queue detection site with Illinois Tollway Maintenance staff. Existing conditions and anecdotal information that may be available from Maintenance staff should be reviewed and documented.

5.4.2 Traffic Signal Coordination

If the ramp detectors are to be connected into an adjacent traffic signal controller cabinet, significant coordination with the local traffic agency is required. Design of the system must adhere to any requirements included in the inter-governmental agreement (IGA). The IGA may be in place when design begins or may be developed by the Illinois Tollway and the local agency in conjunction with the design process. The DSE will assist the Illinois Tollway in providing any specific technical or design information that is to be included in the IGA. An interagency agreement should be in place before design of a ramp queue detection system is initiated. The most common agencies operating signals along the Illinois Tollway include:

- Illinois Department of Transportation, Districts 1, 2, and 3.
- Cook County Highway Department.
- DuPage DOT.
- Lake County DOT.
- McHenry County DOT.
- Kane County DOT.
- Will County DOT.

6.0 CLOSED CIRCUIT TELEVISION CAMERAS (CCTV)

6.1 Introduction

Closed-circuit television (CCTV) cameras are deployed to provide visual coverage of the roadway for monitoring incidents and congestion. Coverage generally means the ability to clearly identify the number and type of vehicles and the presence of drivers or passengers in the vehicles, as well as to read standard sized hazardous materials placard on commercial trucks. The existing visual coverage of the Illinois Tollway system, as determined by the TOC Manager for quality of the existing coverage, shall be the basis for initial selection of new CCTV locations within the limits of the construction project. The goal for new projects will generally be to design for 100% visual coverage (full camera coverage of the roadway, including underpasses) with high definition (HD) cameras; either full replacement of existing systems or “filling in the gaps” for rehabilitation type Contracts where existing infrastructure will be maintained.



Roadway cameras are able to be panned, tilted, or zoomed (PTZ) which allows operators to see up to a mile (or more with HD cameras) of the roadway from a single camera depending on horizontal and vertical curvature or other obstructions. Criteria for reading a HAZMAT placard will generally govern the required camera spacing for up to 100% visual coverage. The DSE shall consult with the ITS Unit to determine the proper spacing of the camera technology specified in the guide documentation. Additional studies may be required of the DSE should new technology be evaluated as part of their scope of work, to determine the optimal spacing required for up to 100% visual coverage.

Cameras assist operators, and ultimately emergency responders with detecting, confirming, and managing incidents, construction zones, congested areas, and special events. Cameras are used by roadway maintenance to view and assist in the management of snow and ice removal operations. Cameras are also used by engineers to monitor construction zones and traffic control measures.

Illinois Tollway traffic cameras are shared with other road transportation management centers through the Lake Michigan Interstate Gateway Alliance website <http://www.TravelMidwest.com>. Traffic snapshots taken in 5 minute intervals at key locations are available to the public on the Illinois Tollway website <http://www.illinoisIllinoisTollway.com> and on the LMIGA website.

Additionally, CCTV cameras are used in secure areas of the Illinois Tollway system to monitor toll plazas, currency locations, network and computer rooms, and other sensitive locations. While not specifically used for traffic and incident management, because security cameras share the same communications infrastructure, and Illinois Tollway ITS has the responsibility for their maintenance, Illinois Tollway ITS engineering projects often address these cameras as well.

6.2 Placement

For CCTV projects (or projects that include CCTV cameras) the concept stage of design will typically identify the communications technologies to be used and general locations for the camera in order to achieve the ultimate design goal up to 100% visual coverage of the Illinois Tollway System. Additional capability is the ability to read the hazard placard attached to commercial vehicles up to 1000-feet away. Presently, the Illinois Tollway has determined the optimal spacing to be a ¼ mile radius (½ mile spacing between cameras). The DSE shall consult with the ITS Unit to determine the proper camera spacing for their Contract. Additional studies may be required of the DSE should new technology/functionality be evaluated as part of their scope of work, to determine the optimal spacing required for up to 100% visual coverage using the new technology.

CCTV cameras are typically installed either on dedicated camera poles (e.g., 50 feet high pole) or on Illinois Tollway owned communication towers (which range from 100 feet to 300 feet high).

6.3 Description of Types/Models

The Illinois Tollway deploys full PTZ cameras along the roadside and at other locations where full PTZ capability is needed. In some locations the Illinois Tollway deploys fixed cameras for tolling purposes. All ITS cameras shall be PTZ cameras. All new fixed or PTZ cameras deployed in the field shall be digital IP cameras which have been pre-tested and integrated with TIMS. The DSE should consult with the Illinois Tollway for the latest guidance and evaluation results during the concept phase of each project to determine the suitability of the camera guide specification for meeting their project goals. The remainder of this section provides additional detail on the CCTV camera.

6.4 Design Considerations

The DSE is responsible for selecting conceptual CCTV device sites and conducting initial field verification of those sites. When plotting the camera coverage the DSE shall review the guide special provisions to determine the minimum specifications to be met by the camera manufacturer. The DSE shall develop and implement a methodology for confirming required camera coverage as part of the Concept (30%) design, to be reviewed and approved by the Illinois Tollway, and submit support calculations or information with the Preliminary (60%) design. The DSE should also gather information, either from the Illinois Tollway or outside agencies, about the existing infrastructure in the project area. A key element is the availability and proximity of Illinois Tollway fiber optic cable and power locations, and the ability to extend them as needed given budgetary limitations versus the performance benefits of fiber.

For tower mounted cameras, the cable length distance from the video power junction box in the plaza/tower building to the camera must be considered. Any deployment where that cable length exceeds 330 feet will require an Ethernet extender device, as well as a power-over-Ethernet injector to power the extender device. The guide specifications and drawings provide for the required design elements for this condition. The DSE shall make known in the plans what locations trigger this requirement.

6.4.1 Field Investigation (Camera Pole Installations)

A site visit shall be conducted as part of the data collection process to document all pertinent aspects of the proposed site. Site visits for CCTV locations should take into account the following site characteristics, at a minimum:

- Sight distance and field of view – the primary factor in placing a camera is maximizing the view of the roadway. While some concessions can be made to accommodate roadside features or proximity to communications or power, all decisions should be weighed against the field of view of the camera. A common example is proximity to power on a horizontal curve. Generally, cameras should be placed on the outside of the curve, i.e., closer to the point of intersection of the horizontal curve. If power is available from the opposite side of the road, the extra cost of boring under the road to connect to the power is justified to maximize the view of this camera. In a situation where the camera is placed on a tangent section of roadway, all things being equal, it would be appropriate to move a camera to the opposite side of the roadway to minimize the cost to connect to power.
 - The DSE shall review conceptual camera locations for compatibility with alternate roadway alignments refined during concept design, both vertical and horizontal. Refinements to the camera locations shall be made to ensure full camera coverage is maintained.
- Access – clear path to the CCTV site from the mainline, both for construction and future maintenance:
 - Ease of equipment access: What will be required to install the foundation, pole, and camera (e.g., regular bucket truck or large truck with outriggers)? Will the installation be accessible year-round (i.e., with snow and ice present)? Are permits or other authorization needed for off-system (i.e., local route) access?
 - Lane/shoulder closures: What type of roadway closures will be required to construct and/or maintain this site (e.g., if only night time lane closures are allowed this will increase costs)?
 - Power and communications: proximity/alternatives?
- Clear zone – sufficient right-of-way to locate the camera pole well outside of the clear zone or to shield exposed devices as supported by a barrier warrant analysis (refer to the Illinois Tollway Traffic Barrier Guideline for more information).
- Obstructions – structures near the site (median barrier walls, overhead cantilevers, bridges, large highway signs, underground/overhead utilities, noise walls).
- Elevation – higher elevations (on embankments) are preferable for both view distance and wireless communications (if utilized), however this must be balanced against ease of maintenance. Higher embankments will typically result in greater offsets requiring bucket trucks with greater reach (both horizontal and vertical) or possibly require maintenance from off of Illinois Tollway right-of-way.

Once a CCTV site has been investigated and any potential conflicts have been resolved, the camera pole location should be staked and marked for surveying. When possible, the surveyor should participate in site staking to resolve any issues before the next stage of data collection.

6.4.2 Field Investigation (Tower Camera Installations)

Tower cameras provide a superior view to standard pole-mounted cameras and, as such, are preferred locations. The DSE should always determine if there are existing Illinois Tollway communications towers within the project area and use the Conceptual Design to discuss inclusion of a tower camera. If it has been determined that a tower camera should be part of the Contract, the DSE must take the following steps.

First, the DSE should contact Illinois Tollway Information Technology (IT) to obtain specifics of the tower(s) in question from the Illinois Tollway tower database. The database can be utilized to determine the current loading on the tower along with location of equipment. If IT confirms that sufficient capacity is available, the DSE must include a tower structural analysis requirement in the special provisions for each tower where a new camera will be installed as coordinated with the Communications Tower Asset Manager (see Table 1.1). Refer to the guide special provisions for more information.

While guide drawings represent a typical lattice tower, each tower is unique. DSEs should visit the site with Illinois Tollway IT to determine any needed revisions or additions to the guide drawings as well as determine basic installation issues such as camera mounting heights, building entry, etc. Illinois Tollway IT must review all tower details and specifications.

6.4.3 CCTV Camera

The CCTV camera can be mounted on a new pole or existing structure, generally as high as possible to maximize sight distance. The standard height of new poles for CCTV location is 50 feet; with the camera itself usually mounted near the top of the pole. Pending the offset of the pole, this height is accessible by maintenance personnel using a Tollway ITS Maintenance bucket truck. The DSE shall consider the impacts of slopes to ensure this when selecting locations. Alternate locations or pole heights should be considered if the elevation above pavement is less than 40 feet, due to sight line limitations of lower mounting heights. Additional pole height above 50 feet may be necessary to obtain proper sight distances, but this should be approved by the Illinois Tollway as maintenance of the cameras at taller mounting heights might not be possible from Illinois Tollway maintenance vehicles.

All pole mounted CCTV cameras shall be accessible using a bucket truck.

Mounting cameras onto fixed base light poles (i.e. non-breakaway poles) or sign structures should be considered a last resort to installing the camera on a standalone pole. Light poles are not designed to accommodate the needs of a camera deployment and may result in poor video quality due to excessive deflection from wind loading.

Tower-mounted cameras are typically installed as high on the tower as possible. Existing equipment mounted on the tower will dictate the allowable mounting height. If installed on a

tower, the camera must be mounted on the roadway side of the tower leg, away from dishes and antennas that will impede view. A corner mount may also be required based on roadway alignment.

7.0 DYNAMIC MESSAGE SIGNS (DMS)

7.1 Introduction

A dynamic message sign (DMS) is a large electronic sign that displays a wide range of timely, accurate, and useful information to passing motorists. A DMS is deployed, typically overhead, at a fixed location, unlike the smaller portable changeable message signs (PCMS) discussed elsewhere. The displayed messages are modified from a remote location, the Illinois Tollway's Traffic Operations Center (TOC) located at the Illinois Tollway Central Administration Building.

The signs are used to provide real-time, en-route traveler information to motorists in order to affect motorist behavior and improve traffic flow and operations. Information displayed on the signs may cause motorists to choose alternate routes, or even alter their destinations, in cases of heavy congestion or other poor traffic conditions. A DMS may inform motorists of both planned and unplanned incidents, and may be programmed to automatically display specific messages under certain conditions. The signs typically display travel times to select interchanges or destinations, and are also used to inform motorists of congested locations, incidents, construction or maintenance activities, special events, road conditions, severe weather, and child abduction alerts.

DMS installations must be located in a manner that integrates the dynamic messaging with any static signage required along the corridor. Static guide signs alert the driver of an upcoming interchange, located in a manner to provide ample time for making any necessary lane changes. DMS messages provide the driver information regarding incidents or travel times for making a decision to change routes or not. Spacing the guide signs and DMS too closely will result in information overload and sign clutter, diminishing the driver's ability to make decisions in a timely manner. As such, both static and dynamic signage must be approached holistically to ensure general visibility and sufficient separation is provided to avoid these pitfalls.

A full-matrix DMS is composed of a matrix of equally-spaced individual light-emitting diodes (LED). These LEDs are illuminated to act as pixels that form alphanumeric characters and/or graphic images in order to display a message to drivers. Typical messages contain two or three short lines of text. Longer messages can also be displayed by transitioning between two shorter messages within short time intervals, so long as a driver at the prevailing speed could still read and comprehend the entire message.

All DMS in service prior to 2014 on the Illinois Tollway provide amber colored text only. All new DMS signs procured by the Illinois Tollway shall be capable of generating full color text and graphics.

Lane control use signs are smaller dynamic message signs with a highly specialized purpose and position over the roadway. These signs are only used to implement an operational concept called Active Traffic Management (ATM). ATM is not currently planned throughout the Illinois Tollway system, but rather will begin with the easternmost portion of the I-90 corridor. Lane control use signs must be discussed with the Illinois Tollway prior to inclusion in any Contract.

7.2 Placement

The general location of DMS should follow recommendations given in Pre-Concept design. The type of DMS to be deployed will affect the ability of the DSE to establish finer placement options. A barrier warrant analysis will generally identify the recommended location of DMS supports and foundations. Control cabinets and CCTV camera location requirements are further discussed in the design considerations, and are dependent on the type and location of DMS being deployed.

7.3 Description of Types/Models

There are two types of DMS that the Illinois Tollway is either currently using or proposed for possible use on the system. The types have different sizes, mounting characteristics, deployment costs, and other advantages or disadvantages, as described below. Refer to the Guide Drawings and Special Provisions for more detail.

7.3.1 Type 1

- Description – These signs are the large (nominally 8 feet x 28 feet), overhead truss-mounted signs that are typically deployed about 2 miles upstream of major system to system interchanges. The signs are capable of displaying three line messages using larger alphanumeric characters. Incident information and travel times to select interchanges or major destinations are typically displayed.
- Advantages – Maximum visibility due to size and mounting locations centered over roadway; can display larger amounts of information; fixed location and dedicated communications minimizes time needed to distribute information to motoring public. These signs can be maintained from the interior of the sign (“walk-in” sign housing) without closing main line traffic lanes below the sign.
- Disadvantages – Higher costs due to large size and mounting requirements; installation will require lane closures (catwalks allow maintenance to be performed with shoulder closures); fixed location limits deployment flexibility.



7.3.2 Type 2

- Description – Type 2 signs are smaller than Type 1 signs, and should be able to display a three line message but with fewer alphanumeric characters (shorter messages). They are typically deployed upstream of major traffic generators such as high volume exits to arterials or major



destinations. They can also be deployed upstream of recurring incident areas such as exit ramps that develop queues that may impact mainline traffic. These signs are often mounted on the side of the road or in the median (and may be cantilever or butterfly mounted on a pole), and are often used to display more location-specific information than Type 1 signs.

- Advantages – Lower costs for sign and mounting; less disruption to traffic for installation and maintenance (may only require shoulder closure).
- Disadvantages – Smaller size and off shoulder/off center mounting limits the visibility and length of messages; fixed location.

7.4 Design Considerations

Pre-Concept design will include the selection of general locations, sign types, and mounting configurations, if applicable. The DSE is then responsible for proceeding with Conceptual Design, which includes detailed site selections and initial field verifications, and final design. The detailed design stage includes data collection, determination of power and communications requirements, site design, system integration, system testing and acceptance, and the definition of equipment warranties. The site plans should include all overhead signing and any ground mounted guide signs within ½ mile upstream or downstream of the proposed DMS location so the Illinois Tollway may review the DMS in context of the other signing.

7.4.1 Field Investigation

A site visit shall be conducted as part of the data collection process to document all pertinent aspects of the proposed site. In general, site visits for DMS stations should take into account the following site characteristics, at a minimum:

- General location – The DSE should evaluate proposed DMS sites against the TIMS Concept of Operations and system requirements defined in the Pre-Concept and Conceptual Design stages. In general, the DMS should be two (2) miles in advance of any decision points (depending on the general area; rural/urban, other interchanges, etc.), but other features of the area between the sign and decision point should also be taken into account (e.g. other exits to potential diversion routes or lack thereof).
- Sign visibility – Identify objects or topography that may present obstructions to drivers' views of the proposed DMS installation and determine whether the obstructions can be reasonably mitigated. This includes, but is not limited to, overpasses, other signage, horizontal or vertical curvature. The sign should be visible for a minimum of 1000 feet.
- Topography – Determine whether the location is suitable for the necessary foundation and structural systems, for installation and maintenance activities.
- Safety and clear zone – Locate DMS equipment and structural supports well outside of the clear zone or shield exposed devices as supported by a barrier warrant analysis (refer to the Illinois Tollway Traffic Barrier Guideline for more information).
- Obstructions – Identify physical features near the site that have potential to interfere with the placement, operation or maintenance of the DMS including guardrail or barrier walls, overhead cantilevers, bridges, large highway signs, underground/overhead utilities, trees, etc.

- Accessibility to power and communications – Determine whether connections can be made to existing power and communications sources and the extent of any additional utility work that would be required. For solar-powered DMS, ensure clear visibility of the southern sky.
- CCTV coverage – The front side of every Type 1 and Type 2 DMS should be visible from an Illinois Tollway CCTV camera. A new camera should be included in the installation if an existing one cannot be used. DMS visibility is limited by the horizontal view angle (“cone of vision”) of the DMS specified. Therefore, particular attention shall be paid to ensure the CCTV is located well inside of the DMS view angle.

7.4.2 Message Sign

The DMS should be mounted in accordance with the type of sign being used. Refer to the Guide Drawings and Special Provisions for more detailed information. Signs mounted along the roadside may need to be turned at a slight inward angle towards the roadway, and utilize LEDs that provide a wider cone of vision to ensure maximum visibility and legibility. The size of the sign, distance from the travel lanes, speed of traffic, number of lanes, roadway curvature, and any obstructions should be considered when determining the mounting location of the sign.

For displaying location-specific information, the sign should be placed far enough upstream from the decision point for the motorist. Ideally, for any DMS installed on the Illinois Tollway, signs should be placed at least two (2) miles upstream from the decision point or next downstream interchange. The characteristics of the roadway in the area will impact this distance. The DSE should consider various traffic operations considerations to determine the appropriate upstream distance for the sign. In addition to the time to comprehend a message, make a decision, and possibly complete a lane change, a motorist may also be contending with other traffic operations constraints such as varying speeds, narrow shoulders, incidents, and other signing. Additionally, the critical decision point may be upstream of the major landmark. For example, a potential diversion route may be in advance of a major system interchange. As such the motorist must be able to make all decisions and change driving behavior prior to the potential diversion route.

In order to maintain proper separation of guide signs, DMS deployed on the Illinois Tollway should be located at least 800 feet from the nearest guide sign.

For vehicles on the Illinois Tollway traveling at freeway speeds, it is preferable to have a visibility distance of at least 1000 feet for a DMS. Keep in mind that curves or hills may hide a DMS, impacting the location and visibility requirements. Consideration should be given for the DMS to be located farther away from the decision point so that there will be enough time for the motorist to read and act upon the message.

After the DMS has been located in the field, the DSE shall verify that the sight distance is greater than the required visibility and legibility distances. After a sign is staked, photos at various distances (e.g. 200, 500, 800, and 1000 feet) should be taken for review by the Illinois Tollway.

7.4.3 Cabinet

The cabinet for each DMS site shall house power and communications components for the site. Typical cabinet characteristics are described further in the guide drawings.

For DMS deployed on the Illinois Tollway, cabinets should be installed outside the clear zone, approximately 100 feet upstream of the DMS, or as shown on the guide drawings. The location shall allow a person at the cabinet to view the sign when performing maintenance or testing. Cabinets should be fully accessible in any weather conditions.

7.4.4 Communications

The type of communication for each DMS site shall be single mode fiber optic, or as determined by the Illinois Tollway. For Type 1 and Type 2 DMS, communications should be provided through the Illinois Tollway's fiber optic network. The DSE should consult with the Illinois Tollway's ITS Communications Plan and/or Record Fiber Plans (provided by the Illinois Tollway) when selecting and designing the communications system, including the proposed utilization of existing and/or new communications drops.

7.4.5 CCTV

A CCTV camera should be provided in conjunction with Type 1 and Type 2 DMS installations if an existing Illinois Tollway CCTV camera within 300 feet to 500 feet of the sign cannot be used to view the front of the sign. Information on CCTV camera system design is provided elsewhere. Refer to the guide drawings for typical camera location in advance of the sign. However, the DSE will have to consider the location of the sign (including both edges of pixels), the location of the camera, and the cone of vision of LEDs for the sign to be sure the camera will be able to clearly see all pixels on the sign face.

8.0 PORTABLE CHANGEABLE MESSAGE SIGNS (PCMS)

8.1 Introduction

A portable changeable message sign (PCMS) is a traffic control and traveler information sign, typically mounted on a trailer or a truck, which can be dispatched on short notice to the required location to display messages that can be modified electronically either on-site or remotely. A PCMS is typically deployed for a limited time at one or more locations at which traffic control must be modified in response to unusual changes in traffic conditions caused by construction, maintenance, traffic incidents, or special events.

There are three general types of PCMS displays: modular, continuous line matrix, and full matrix. Each display type has a different level of flexibility in the type and length of message that can be displayed.

For Illinois Tollway projects, there are two primary PCMS applications; 1) Maintenance of Traffic (MOT), typically on approaches to work zones, or 2) for supplementing or replacing traffic and incident management. Depending on the application, the PCMS will either be IDOT-compatible or Traffic and Incident Management System (TIMS)-compatible.



MOT applications are typically one or two IDOT-compatible PCMS positioned on approaches to a work zone and used solely by the Contractor. These signs can use any of the three display types mentioned above (refer to the IDOT Standard Specifications for Road and Bridge Construction, Section 701). TIMS-compatible signs may also be used for MOT applications, but additionally include the provision that operators in the TIMS Traffic Operations Center (TOC) can access the PCMS in an emergency. TIMS-compatible PCMS are only full matrix displays and include additional communications and certification requirements (refer to the guide special provisions for more detail). Adjacent Construction Contracts should be coordinated to avoid unnecessary overlap or duplication.

PCMS used to supplement or replace traffic and incident management must only be TIMS-compatible PCMS units. Traffic and incident management applications are for use by TOC operators only and may not be operated by Contractors. If a DMS is to be taken out of service for an extended period of time a PCMS may be utilized as temporary mitigation. Consideration should be given to providing a PCMS on each side of the road (and staggered) to enhance visibility as the PCMS is more limited than an overhead DMS (e.g. for heavily congested routes

with more than 3 lanes of traffic). Information on DMS usage when considering a PCMS for temporary replacement is provided elsewhere.

The DSE is responsible for identifying the number and location for each type of PCMS for a given project. Typical MOT applications (IDOT-compatible PCMS) do not require Illinois Tollway ITS coordination. Only TIMS-compatible PCMS need to be coordinated through Illinois Tollway ITS.

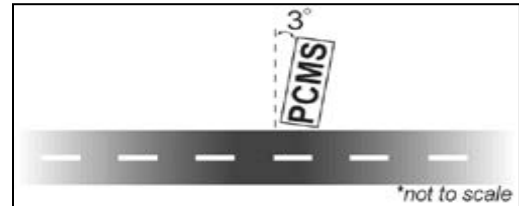
8.2 Placement

When utilized for MOT, the PCMS is one component in a system of devices to manage traffic through a work zone. As such, the functionality of the PCMS in proximity to heightened decision making is critical. Proper placement of the PCMS is imperative to providing travelers timely information to act on. The PCMS must be highly visible and to function as intended.

If possible, the PCMS should be placed closest to the lane for which the message applies. The PCMS normally is placed on or just outside the shoulder. Care should be taken not to place the PCMS so far off the roadway that the PCMS is not in the motorist's cone of vision long enough to read the message. Factors that change the motorist's cone of vision are:

- Distance the PCMS is placed from the side of the road.
- Number of lanes.
- Roadway curvature.

In addition, the PCMS should be placed on level ground and turned 3 degrees toward the roadway from the perpendicular edge of the roadway to reduce glare.



PCMS applications are discussed elsewhere in this deployment guide for temporarily replacing permanent DMS installations.

Refer to the Roadway Traffic Control and Communications Manual and Illinois Tollway Standard Drawings – Section E for MOT applications of PCMS. The CM and Contractor are ultimately responsible for determining the optimum location of PCMS for MOT. There should be a minimum spacing of at least 1,000 feet between PCMS units or between a PCMS and an arrow board. Multiple PCMS units in series should be placed on the same side of the roadway.

After the PCMS has been located in the field, the CM shall verify that the sight distance is greater than the required visibility and legibility distances.

8.3 Description of Types/Models

The Illinois Tollway pre-approves specific PCMS devices for use on its system. Refer to the Guide Drawings and Special Provisions for further information on the types and models for the specific application considered.

8.4 Design Considerations

PCMS required for Illinois Tollway construction or maintenance projects should be specifically identified in the maintenance of traffic items required in the Contract Documents. Recommendations made by the DSE for specific numbers, types and locations of PCMS for a Contract will be transmitted to Traffic Operations for review and comment.

Recommended locations and messages should be fully described in the maintenance of traffic plan.

8.4.1 Field Investigation

A site visit shall be conducted as part of the data collection process to document all pertinent aspects of the proposed site. Site visits for PCMS stations should take into account the following site characteristics, at a minimum:

- Sign visibility – Identify objects that may present obstructions to drivers' views of the proposed PCMS installation and determine whether the obstructions can be reasonably mitigated.
- Topography – Determine whether the planned location for each PCMS is accessible both during and after construction.
- Clear zone – AASHTO's Roadside Design Guide references a study that found impacts into portable concrete barriers were more likely to result in serious injuries than impacts into trailer-mounted devices themselves, and that concrete barriers should not be erected solely to shield a trailer-mounted device. As such, location of PCMS in an area shielded from errant vehicle should only be considered if the shielding barrier is required for some other purpose and in relative proximity to where the PCMS is required. Refer to the Illinois Tollway Traffic Barrier Guideline, Illinois Tollway Standard Drawings – Section E, and AASHTO's Roadside Design Guide for further information.
- Obstructions – Identify physical features near the site that have potential to interfere with the placement, operation or maintenance of the PCMS including median barrier walls, overhead cantilevers, bridges, large highway signs, underground/overhead utilities, etc.

8.4.2 Communications

Communications requirements are stated in the Contract Documents, generally through wireless means. If the quantity of TIMS-compatible equipment is specified, no substitution will be allowed for those items. When specified, TIMS-compatible signs listed in the Contract Documents shall be designed to communicate with the Illinois Tollway's TOC. Refer to the guide special provisions for more information.

9.0 ROADWAY WEATHER INFORMATION SYSTEMS (RWIS)

9.1 Introduction

Roadway weather information systems (RWIS) are used by Illinois Tollway personnel to monitor weather conditions along the Illinois Tollway System. The availability of RWIS allows Illinois Tollway operators to notify motorists of expected and on-going weather that may affect roadway, sight, or driving conditions. In turn, DMS messages can be displayed to warn motorists of hazardous conditions and to adjust their speed and driving habits accordingly. Illinois Tollway Roadway Maintenance staff also use the data to determine necessary roadway treatments for snow and ice conditions.



Older installations of RWIS utilize sensors placed in/under the pavement, which may encounter construction conflicts for both rehabilitation and reconstruction contracts due to this sensor placement (if not planned for replacement). The current standard utilizes a non-intrusive sensor technology, mitigating construction conflicts for the pavement rehabilitation or reconstruction.

9.2 Description of Type/Model

At present, the Illinois Tollway's preferred device for RWIS is manufactured by VAISALA. The unit is ordered in several different parts and model numbers depending on requirements. In the future, other technology options may be applied on the Illinois Tollway for RWIS locations. This section provides additional detail on the RWIS Station.

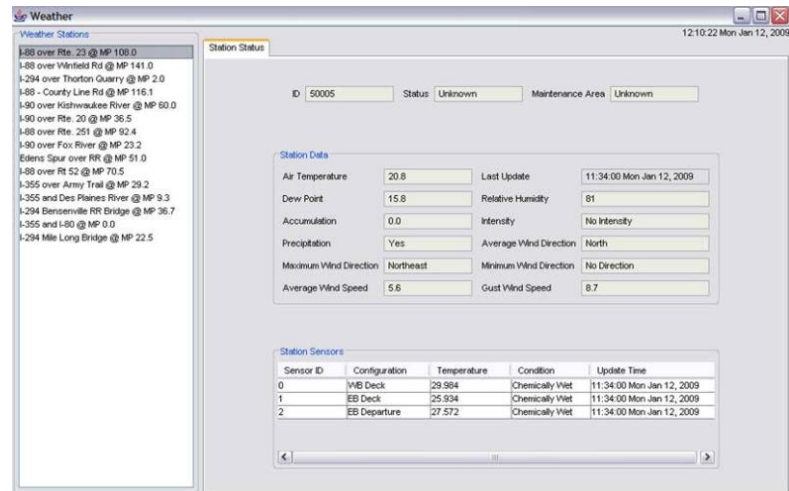
An RWIS station includes a tower structure that can include the following equipment:

- Tower structure for equipment mounting.
- Tower mounted cabinet for remote processing unit.
- Atmospheric sensors.
- Subsurface sensors.
- Snow and stream level sensors.
- Non-intrusive roadway sensors.

The DSE shall coordinate the RWIS deployment with VAISALA to ensure any unique characteristics or requirements of the site being designed are adequately detailed and specified, minimizing potential conflicts that may arise during construction.

A guide specification for the VAISALA RWIS is available. At a minimum, the following information should be available from the RWIS station:

- Air temperature.
- Dew point.
- Accumulation.
- Precipitation.
- Intensity.
- Relative humidity.
- Average wind direction.
- Maximum wind direction.
- Minimum wind direction.
- Average wind speed.
- Gust wind speed.



9.3 Collocation

RWIS stations generally do not provide the same collocation benefits for consolidation of power and communication that other ITS devices may afford. The standard RWIS tower does not accommodate traditional CCTV camera mounting requirements. However, consideration should be given to evaluating non-standard CCTV camera placement at RWIS sites where visual confirmation of weather conditions outweighs these drawbacks. Fiber optic communications would be required and the tower evaluated for suitability of the CCTV camera mounting. Prior to co-locating any equipment on the RWIS station, the DSE should present recommendations for Illinois Tollway approval, noting all non-standard aspects of the proposed design.

9.4 Design Consideration

For RWIS projects (or projects that include RWIS stations) Pre-Concept design will typically identify the technologies to be used, general locations, and potential weather related issues for the devices. Weather related issues may pertain to specific data that is required by the RWIS to determine hazardous conditions such as potential flooding from a nearby stream or a low lying section of roadway prone to fog conditions. The DSE is then responsible for refining the RWIS station sites and conducting initial field verification of those sites for conceptual design.

What follows is the detailed design stage. This stage includes data collection, site design, system integration, system testing and acceptance, and the definition of equipment warranties.

9.4.1 Field Investigation

A site visit shall be conducted as part of the data collection process to document all pertinent aspects of the proposed site. Site visits for RWIS locations should take into account the following site characteristics, at a minimum:

- RWIS placement – RWIS sites are generally selected for the ability to monitor weather conditions for the overall Illinois Tollway system as well as critical locations that have high numbers of accidents in inclement weather. Therefore, the proximity to bridge

decks and horizontal or vertical curves that can be hazardous in inclement weather should be viewed as key locations. The Illinois Tollway may provide similar placement in the Pre-Concept design. In general, RWIS stations should be placed as far from potential roadside splashing and snowplow removal operations to prevent sensors from becoming dirty or disabled. There is no minimum distance between RWIS station locations, however current locations are typically spaced 10 to 30 miles apart. If the RWIS station is being located to detect specific problems (as determined by the Illinois Tollway) then the DSE should work closely with the RWIS vendor to determine the best location of the station.

- Sensor placement – Fog from a river or lake rises up versus normal fog which drops down. Therefore, the height of the fog sensor should be placed to determine the vehicle type that it will impact first. For example, if fog is rising up from a stream, but the sensor is placed for fog dropping down and to be sensed at semi driver eye height, the motorists in cars could be experiencing fog conditions some time before the sensor begins to warn the operators. The general recommendation for measuring wind speed is to measure 30 feet from the ground surface. Therefore, the RWIS station should be located such that the wind speed sensor can be mounted approximately 30 feet above the roadway surface.
- Topography – The location of the RWIS station requires a flat area suitable for the station foundation installation and future maintenance of the site.
- Access – A clear path to the RWIS site from the mainline, both for construction and future maintenance (avoiding ditches, steep slopes, and outside lane barrier walls) shall be provided. The site should be accessible during all weather conditions (i.e., snow, ice). Shoulder closures for maintenance should be minimized if possible. Evaluate off-system options as required, determining what permits or authorizations are required.
- Technician access – The site should be accessible to a technician on foot. The station must be installed away from any potential areas of standing water. Be cognizant of potential slope issues for a technician approaching the device or at the device. Due to the sensitive nature of the RWIS measurement devices, frequent maintenance and calibration is to be expected and should be considered in site placement.
- Clear zone – Locate the station well outside of the clear zone or shield as supported by a barrier warrant analysis (refer to the Illinois Tollway Traffic Barrier Guideline for more information).
- Obstructions – The location of the RWIS station should avoid structures near the site (i.e., median barrier walls, overhead cantilevers, bridges, large highway signs, underground/overhead utilities).

Once a RWIS site has been investigated and any potential conflicts have been resolved, the RWIS location should be staked and marked for surveying. When possible, the surveyor should participate in site staking to resolve any issues before the next stage of data collection.

9.4.2 RWIS Station

The general goal of RWIS location siting is to maximize the coverage of the roadway conditions within the capabilities of the RWIS station. It is important to take into account the intended use of the RWIS station when siting the location. The site plan for each RWIS deployment shall define the location of all RWIS associated components and may include the following: the station assembly, atmospheric sensors, pavement sensors, CCTV camera, pavement/ground

sensors, stream sensor, snow depth sensor, foundation, power source and associated infrastructure, any civil work necessary to access the site for construction or maintenance, grounding and lightning protection, and a maintenance of traffic plan.

The DSE shall coordinate site specific conditions with the RWIS manufacturer (VAISALA) to layout and design the RWIS station for optimal deployment. Final design should be reviewed by VAISALA to ensure the RWIS station layout may be constructed to perform most effectively.

9.4.3 Non-Intrusive Roadway Sensors

Two (2) pairs of non-intrusive roadway sensors shall be implemented. One pair will be utilized for bridge approach pavement while the second pair shall be used for the bridge deck. Each pair of sensors is comprised of one sensor for measuring water, ice, and snow present on the roadway and one sensor for a remote alternative to measuring road surface temperature.

9.4.4 Ground Sensors

Ground sensor design typically consists of a single subsurface sensor that can be placed in close proximity of the tower at a depth of 18 inches. This sensor will need to be marked so that future maintenance can be provided.

9.4.5 Communications

All new RWIS installations will utilize “RWIS On-line” so that all stations will communicate via cellular modem and future fiber optic cable to the RWIS server. All new RWIS stations shall be supplied with a cellular modem and the ability to connect to the Illinois Tollway fiber optic cable network. To allow for all of this functionality, the RWIS enclosure will need to be large enough to withstand equipment expansion in the future (refer to the guide drawings for details). The cellular modem specification should be obtained from VAISALA. If possible, a Verizon wireless compatible modem should be specified as this is the state standard. Refer to the guide special provisions for more information.

Additional consideration for fiber optic communications should be given if other ITS devices are collocated with the RWIS station. Refer to the Communications sub-section for any devices collocated with the RWIS station.

10.0 VIRTUAL WEIGH-IN-MOTION (VWIM) STATIONS

10.1 Introduction

Virtual weigh-in-motion (VWIM) is the process of measuring the dynamic tire forces of a moving vehicle and estimating the corresponding tire loads of the static vehicle. Gross vehicle weight of a stopped highway vehicle is due only to the local force of gravity acting upon the composite mass of all connected vehicle components, and is distributed among the tires of the vehicle through connectors such as springs, motion dampers, and hinges. Highway VWIM systems are capable of estimating the gross weight of a moving vehicle as well as the portion of this weight, called load, that is carried by the tires of each wheel assembly, axle, and axle group on the vehicle. Illinois Tollway VWIM stations typically include VWIM sensors, loop detectors, controller cabinet, roadside observation pad and lane display subsystem, and a downstream enforcement area. Refer to the guide drawings for a typical layout of these components for the two forms of VWIM used by the Illinois Tollway.

The Illinois Tollway constructs VWIM stations to provide the Illinois State Police with a tool to identify potentially overweight vehicles. The VWIM System includes a display of the lane and type of overweight infraction that immediately conveys this information to a State Police vehicle on the observation pad. The State Police can then pursue the potential overweight vehicle, direct it to the enforcement area, and weigh it on static, certified scales. The VWIM station thus serves to establish “probable cause” of an overweight vehicle. The overall goal is to protect Illinois Tollway infrastructure and maximize pavement life.

VWIM sites should only be considered where recommended in Pre-Concept design. New deployments of VWIM are generally at the request of Illinois State Police.

10.2 Placement

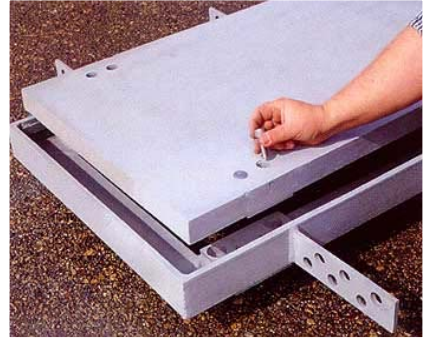
VWIM site locations will generally be identified in the Pre-Concept design if required. Site selection and finesse of the VWIM system will require coordination with other civil design elements of the corridor, Illinois Tollway entry/exit points, and preference of the Illinois State Police. Placement options are further discussed in the Design Considerations section below.

10.3 Description of Types/Models

There are differing technologies utilized for VWIM applications at both existing and newly reconstructed roadways. Refer to the Guide Drawings and Special Provisions for more information about applications on the Illinois Tollway system.

Bending Plate

This type of VWIM system has been utilized at existing VWIM sites. This system uses plates with strain gauges attached to the underside. As a vehicle passes over the plate, the system records the strain measured by the strain gauge and calculates the dynamic load. The static load is estimated using the measured dynamic load and calibration parameters that account for the influences to that the static weight, such as vehicle speed and pavement/suspension dynamics.



If not properly maintained, pavement damage may occur which could impact safety and operations. Future installation of bending plate systems is not anticipated.

Piezo Quartz

These VWIM systems use Piezo quartz sensors to detect a change in voltage caused by pressure exerted on the sensor by a vehicle's axles. The Piezo sensors may be encapsulated in an epoxy-filled metal channel, usually made of aluminum. Four (4) sensor modules (each typically ~ 30 in long) are connected in an in-line assembly to span a single lane. Two such assemblies are installed per lane for optimum performance.



As a vehicle passes over the Piezo sensor, the system records the electrical charge created by the sensor and calculates the dynamic load. The static load is estimated using the measured dynamic load and calibration parameters.

Load Cell

This type of VWIM system uses a single load cell with two scales to detect an axle and weigh both the right and left side of the axle simultaneously. As a vehicle passes over the load cell, the system records the weights measured by each scale and sums them to obtain the axle weight. This system is not anticipated to be deployed for Illinois Tollway VWIM applications.



10.4 Design Considerations

For weigh-in-motion site projects (or projects that include VWIM), Pre-Concept design will typically identify the enforcement function, required design life and accuracy performance level, and general potential locations for the station. The DSE is then responsible for selecting the conceptual weigh-in-motion station sites near the pre-concept locations and conducting initial field verification of those sites. The DSE should select the most applicable technology for the given site improvements and make a recommendation to the Illinois Tollway for approval. Factors that should be considered in determining the VWIM location include:

- Pre-concept design locations determined by the Illinois Tollway, as discussed during the scoping of the design section (refer to Project Development Process section found elsewhere in this design guide).
- Must capture the heaviest truck movements.
- Must minimize opportunities for trucks to bypass the site (via an alternate route).
- Location of major truck destination in relation to enforcement areas and possible routing issues (e.g. is an enforcement area past a major interchange or exit that will result in trucks having to double back or take a long reroute to go to the original destination).
- Must be relatively flat and straight (discussed below).
- Minimize number of lanes (when near a lane drop).
- Must safely accommodate the roadside observation pad (where State Police vehicles are positioned).
- Must provide adequate distance for the State Police to overtake violators and pull them over at a safe enforcement area.
- Must provide for an enforcement area located an ideal minimum of 2 miles downstream of VWIM site.
- Must minimize time to replace sensors on high volume corridors.
- Must consider site drainage when selecting technology to be used.
- Location of a Illinois Tollway owned or off-system private certified scale that may be used by State Police.
- Prior to Concept Design submittal, engage the State Police for general site selections and high level design considerations (Illinois Tollway traffic operations may assist with this coordination, but is the responsibility of the DSE to execute).

What follows is the detailed design stage. This stage includes data collection, site layout, system integration, system testing and acceptance, and the definition of equipment warranties.

10.4.1 Field Investigation

A site visit shall be conducted as part of the data collection process to document all pertinent aspects of the proposed site (both the VWIM station including roadside observation pad and the downstream enforcement area).

In general, a site should first be selected for the desired downstream enforcement area, with input from State Police. The enforcement area should be located a minimum of two (2) miles from the observation pad and should include lighting and camera coverage. The Illinois Tollway's

preference is to use an existing facility such as a toll plaza or maintenance area. If such an area is not available, site investigations should be performed to consider the same accessibility, safety, size, and drainage as with the roadside observation pad, as well as electrical/communications links for any new cameras or lighting.

The enforcement area is significantly larger than the VWIM scale area, typically allowing State Police to weigh three (3) semi-trailer trucks on level ground at the same time. Enforcement area location requirements are often more difficult to meet than those of the VWIM scale area. The enforcement area requires roughly 1,500 feet of relatively flat terrain with sufficient ROW width and safe access to and from the Illinois Tollway mainline. Once the desired location for the enforcement area has been determined, site selection for the VWIM scale shall occur by evaluating locations a minimum of two (2) miles upstream from the enforcement area. It is important to consider both the VWIM system sensor area and the enforcement area as a single system. The two locations must be well coordinated, since initial weighing at speed and static weighing downstream must work together for the system to work well.

In order for any VWIM system to perform properly, an adequate operating environment for the system's sensors and instruments must be maintained. VWIM sensor performance can be degraded by less-than-ideal site conditions, even if the VWIM system sensors, instruments, and algorithms are capable of high-quality performance. During site visits for the VWIM stations, the following site conditions (or better) are required if the VWIM sensors are to perform optimally (these conditions shall be validated by the DSE based on the Guide Drawings and Special Provisions for the most current technologies considered):

- Horizontal alignment — The horizontal curvature of the roadway lane for a minimum of 200 feet (preferably 500 feet) in advance of and 100 feet beyond the VWIM system sensors shall have a radius not less than 5700 feet measured along the centerline of the lane for all types of VWIM systems.
- Longitudinal alignment (profile) — The longitudinal gradient of the road surface for 500 feet in advance of and 300 feet beyond the VWIM system sensors shall not exceed 2% (with no vertical curves).
- Cross slope — The cross-slope (lateral slope) of the road surface for 200 feet in advance of and 100 feet beyond the VWIM system sensors shall not exceed 3%.
- Lane width and markings — The preferred maximum width of the paved roadway lane for 200 feet in advance of and 100 feet beyond the VWIM system sensors shall be 12 feet.
- Surface smoothness — To allow reliable VWIM performance the surface of the paved roadway must be smooth for a distance of 500 feet in advance of and 300 feet beyond the VWIM system sensors before installation and maintained in a condition such that a 6-in. diameter circular plate 0.125-in. thick cannot be passed beneath a 20-foot long straightedge, as further described in the guide drawings or special provisions. Pavement replacement should be specified as necessary to achieve these requirements.
- Access — Identify a clear path to the VWIM site from the mainline, both for construction and future maintenance (avoiding ditches, steep slopes, and outside lane barrier walls).

- Safety and clear zone – Identify existing guardrail or other barrier protection, or the need for new barriers to be installed to protect the VWIM equipment and State Police observation vehicles.
- Obstructions – Identify physical features near the site that have potential to interfere with the placement, operation or maintenance of the VWIM station including guardrail or barrier walls, overhead cantilevers, bridges, large highway signs, underground/overhead utilities, trees, etc.
- Accessibility to power and communications – Determine whether connections can be made to existing power and communications and the extent of any additional utility work that would be required.
- Adequacy of location for controller cabinet – Determine whether the site is in an adequate location for the VWIM controller cabinet. The site should not be subject to runoff or to standing water. It should be accessible with a clear line of sight to the sensors. It should also be in a location that cannot be hit by a vehicle leaving the roadway and that can be serviced easily and safely.
- Traffic conditions – Determine whether the site is in a location that provides an area with generally free flow traffic conditions with a minimum of stop and go or slow moving traffic and lane changing.
- Adequate drainage – Determine whether the site is in a location that will provide adequate drainage for the VWIM sensors, controller cabinet, observation pad, and junction boxes, considering both open and closed drainage systems as well as maintainability. These drainage considerations extend beyond the VWIM sites as rerouting of ditches, additional culverts, or impacts/conflicts to other utilities and drainage items must be contemplated.

A roadside observation pad shall be included to provide a space for law enforcement to safely observe commercial vehicles as they pass over the VWIM sensors. This pad will include a lane display that will alert State Police personnel on the pad of likely vehicle weight violations. The DSE should take into account the following considerations when determining the location and size of the pad:

- Access – Law enforcement vehicles should be able to easily and quickly enter and exit the pad and reenter the Illinois Tollway.
- Safety and clear zone – The pad abuts the edge of the roadway pavement and should be protected by guardrail to the upstream edge of the pad to ensure the safety of the law enforcement officers.
- Size – The pad should be able to accommodate a minimum of three (3) vehicles parked side by side at a 90-degree angle to the roadway.
- Automatic activation – The pad should include vehicle sensors to automatically activate the dynamic message sign that notifies State Police of potential violations.
- Adequate drainage – The pad should be well drained.

10.4.2 CCTV Camera

CCTV camera coverage should be included either by an existing or proposed camera to monitor the VWIM site and observation area.

10.4.3 Roadside Observation Pad

The DSE may need to further coordinate with the State Police to determine the detailed requirements for the observation pad depending on the VWIM station location. If truck volumes or violations are anticipated to be high, a larger pad may be required to accommodate additional vehicles than as shown on the guide drawings.

10.4.4 Lane Display Subsystem

A lane display subsystem will be provided at the roadside observation pad to show the lane number and infraction type where an overweight vehicle was detected, measured and recorded by the VWIM System. This display is intended to be used by a State Patrol officer, who would park on the observation pad near to the in-pavement VWIM sensors.

The lane display should activate upon detection of a vehicle on the observation pad, displaying a message of “Ready”. Alternatively, the system could be activated remotely by TIMS, and/or through the use of a manual activation switch in case the observation pad sensor fails. Otherwise, the lane display shall completely blank out when a vehicle is not detected on the VWIM observation pad.

The information on an overweight vehicle will be displayed for a configurable “dwell” time period, blanking out for a minimum time between lane display messages for consecutive overweight vehicles. Lane number “L” increases from inside lane to outside lane.

10.4.5 Enforcement Area

If an existing facility cannot be used it will be necessary for the DSE to include an enforcement area as part of the VWIM station design. The DSE should work with the State Police in determining the location and requirements for the enforcement area. Factors affecting the design of the enforcement area will include the number and size of overweight vehicle enforcement details to be run out of that particular site.

11.0 COMMISSIONING AND INTEGRATION

11.1 Introduction

The construction phase of a Contract marks the commissioning and integration steps of an ITS deployment. Commissioning is necessary to ensure that equipment and systems have been installed and function properly, and are successfully turned over for operation. Commissioning may be defined as the activation and testing of the ITS asset on its own merit, independent of the Illinois Tollway network and centralized TIMS system. Commissioning may include inspection, testing, and validation of device operations in the field.

Integration ensures that the ITS asset operates in a collaborative manner as intended within the overall system design and environment. Integration may be defined as the incorporation of any deployed ITS assets to the Illinois Tollway network and centralized TIMS system. The integration may include configuring device/communication settings for the Illinois Tollway network, with testing and validation of device operations within the TIMS environment.

This section describes the commissioning and integration processes utilized during construction of ITS deployed for use by the Illinois Tollway, to ensure that systems and subsystems are properly installed, connected, integrated, tested, activated and ready to operate. The Contract Documents will govern how the commissioning and integration process are executed or required for a given Contract. This section provides a general overview and is not meant to dictate project execution in the field.

11.2 Commissioning

As noted above, the commissioning portion of the construction phase may include the inspection, testing, and validation of device operations in the field. The DSE's part in commissioning resides with the review and development of the Contract Documents, detailing the submittal requirements and test procedures to be administered by the CM. The CM is responsible for the review and acceptance of submittals and test procedures. The CM is additionally responsible for inspecting the Contractor's work to ensure all requirements and industry standard of care is met for the installation and activation of the Illinois Tollway ITS asset constructed. The CM is responsible for oversight of and coordination with the Contractor to deliver a fully commissioned ITS asset to the Illinois Tollway, for which the Illinois Tollway will then be responsible to integrate that asset into TIMS.

The DSE shall utilize the Guide Drawings and Special Provisions to provide the "tools" utilized by the CM to administer the commissioning process. This will include the material specifications, method of construction, submittal checklists, test plans, or functional requirements to which the Contractor will be held accountable. For some device types, the Contractor or Manufacturer will be required to develop a traceability matrix or test plan to be followed – which must be reviewed and approved by the CM and/or Illinois Tollway in accordance with the Contract Documents.

11.3 Integration

The integration of an ITS asset is the responsibility of the Illinois Tollway. However, certain steps must be successfully completed during the commissioning stage of construction beforehand. For example, while a DMS installation may be capable of displaying messages and logging sign status/errors, the communications must be properly connected and configured for that DMS to be integrated and operated remotely from the TOC by an operator or notification to maintenance personnel of errors. In general, the Illinois Tollway will be responsible for communications downstream of the ITS site being deployed. The contract special provisions will delineate responsibilities between the contractor and the Illinois Tollway.

For new technology or new models of devices (anything following a different communications protocol than expected) must be tested and resolved to properly communicate with the TIMS environment. This testing (and any subsequent software development within TIMS) is undertaken by the Illinois Tollway to enable integration to occur at time of construction.

Once the devices have been successfully commissioned (stand-alone tested) in the field, the network integration is performed by the Illinois Tollway, followed by system integration and testing in TIMS by the Illinois Tollway.

The device is then put through a burn-in test period, only after successful integration has occurred. The burn-in period allows the Illinois Tollway and CM to monitor the entire system while operating in place for a period of time to ensure the newly constructed devices operate normally, without issue. Only then will final acceptance be granted.

11.4 Web-Based Program Management Tools

The Illinois Tollway utilizes a Web Based Program Management (WBPM) to facilitate both design and construction projects. This software is a tool used by all parties involved; Illinois Tollway personnel, DSEs, CMs, and Contractors. WBPM is the medium for submitting product submittals, test reports, requests for information, and many other tasks required by The Contract.

Related to ITS, WBPM is capable of providing an automated means to execute processes that would otherwise require onerous outside resourcing. At the present time, several ITS processes have been documented and made available via WBPM for use during construction, such as the following:

- DMS Acceptance.
- CCTV Acceptance.
- MVDS Acceptance.
- RWIS Acceptance.
- VWIM Acceptance.
- Pre-installation Device Approval.
- Removal/Relocation.
- Burn-in.

Until such time as these processes are incorporated into the WBMPs framework, the static diagrams shall be referenced to outline the steps to be followed for the various ITS asset deployment or function execution.