

	CCTV6 I-84 (W of Exit 25/Austin Rd) EB traffic is closest to camera	
	I-84 EB PCMS Exit 23 (P-66)	EXIT 25A 3 MILES 5 MIN
	I-84 Sensor 01 (at Exit 23 E Off Ramp/Hamilton Ave)	EB WB 57 mph 50 mph



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Connecticut Department of Transportation Smart Work Zones Guide

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Executive Summary

Smart Work Zones (SWZ) are applications of Intelligent Transportation Systems (ITS) in work zones, utilized to help increase safety and mobility.

Smart work zones guide presents the basic guidelines for the consistent and uniform usage of SWZ in the State of Connecticut. Project designers remain responsible for customizing and adapting this guidance to meet specific project needs, conditions, and context. All Smart Work Zones in the State of Connecticut shall conform to standards and guidance provided in Part 6: Temporary Traffic Control of the Manual on Uniform Traffic Control Devices (MUTCD), as well as any standards and practices set by the Connecticut Department of Transportation (CTDOT).

Through appropriate use of SWZ, CTDOT aims to improve safety for roadway users and work zone personnel, increase mobility in work zones, and reduce work zone traffic incidents.

This guide provides an introduction to SWZ concepts, components, goals, and objectives to be pursued by CTDOT, as well as an overview of different SWZ applications to be used by CTDOT. These applications currently include, but are not limited to, real-time traveler information notifications, performance measurements, queue warning, intrusion detection, excessive speed warning, entering/exiting vehicle notifications, and over height vehicle notifications.

This guide also outlines the roles and responsibilities of different entities involved in the process of SWZ implementation. Such entities include CTDOT's SWZ Feasibility Determination Committee, Highway Operations, Office of Construction, Division of Traffic Engineering, District Offices, Office of Planning, the Project Designer, and the Contractor.

Guidelines for SWZ project-level feasibility determination and proper implementation are also explained in this guide.

The presented guidelines are designed to facilitate successful application of SWZ and bring about a variety of benefits including, but not limited to, increased safety to work zone personnel, emergency responders and general traffic, reduced delay, queue length, congestion and probability of secondary crashes, improved work zone travel time, travel speed and traveller information, and decreased incident clearance time.

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1 Purpose of Guide

The purpose of the smart work zones guide is to present basic guidelines for the **correct, consistent and uniform usage** of Smart Work Zones (SWZ) in the State of Connecticut.

Smart Work Zones in the State of Connecticut shall conform to the standards and guidelines contained in Part 6: Temporary Traffic Control of the Manual on Uniform Traffic Control Devices (MUTCD)¹ (see also References for this manual), as well as those standards and practices put in place by CTDOT. Project designers remain responsible for customizing and adapting this guidance to specific project needs, conditions, and context.

If there are any questions on this guide, please contact CTDOT Highway Operations ITS Engineering and Support at DOT.ITSEngineering@ct.gov for further clarification.

Acronyms used in this guide are defined in the table below:

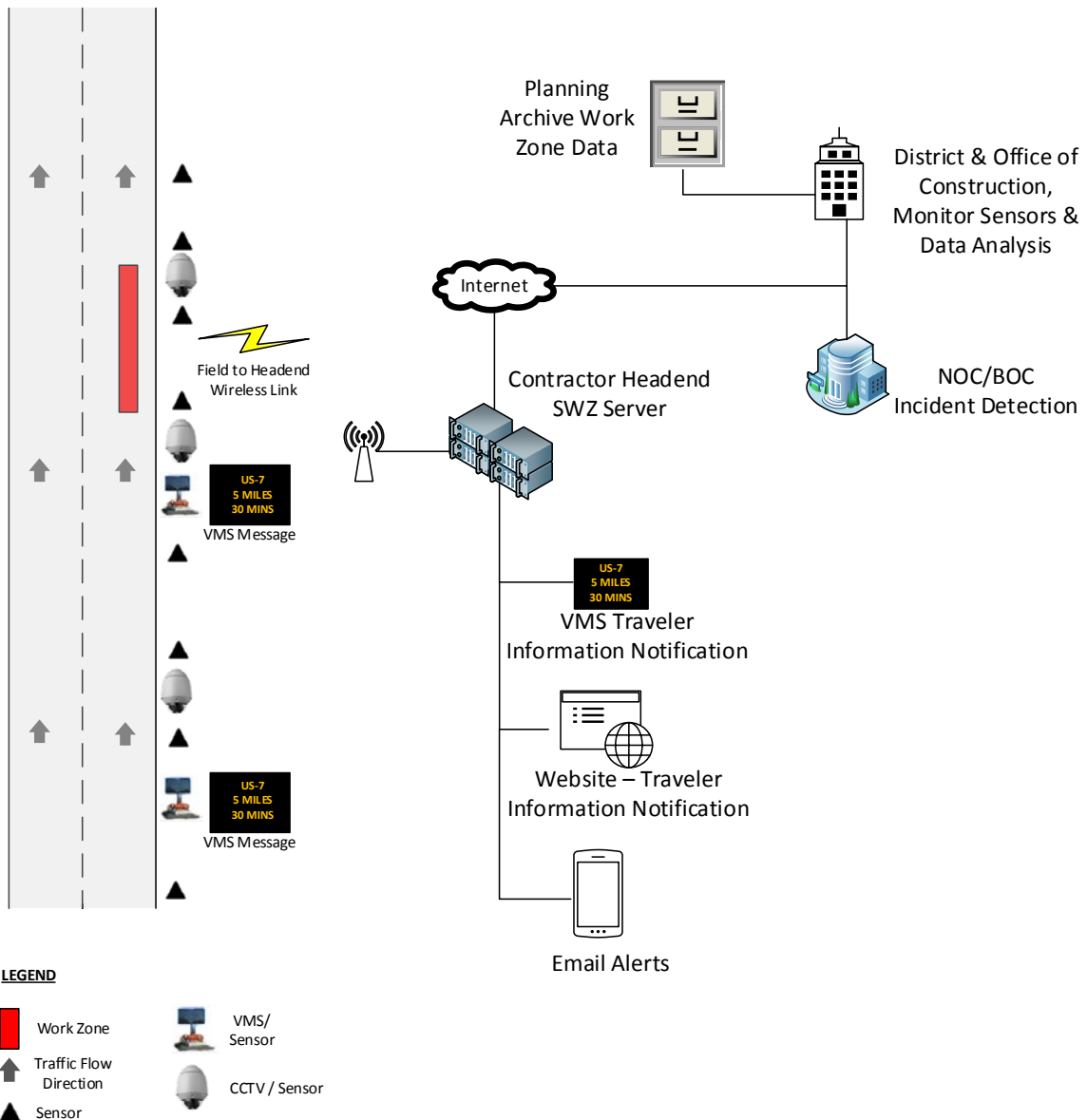
ACRONYM	DEFINITION
ADT	Average Daily Traffic
BOC	Bridgeport Operations Center
CCTV	Closed-Circuit Television
CTDOT	Connecticut Department of Transportation
DOT	Department of Transportation
FHWA	Federal Highway Administration
HOC	Highway Operations Center
ITS	Intelligent Transportation Systems
MPT	Maintenance and Protection of Traffic
MUTCD	Manual on Uniform Traffic Control Devices
NOC	Newington Operations Center
PVMS	Portable Variable Message Sign
RWIS	Road Weather Information System
SEAFORM	Systems Engineering Analysis FORM
SWZ	Smart Work Zones
TMP	Traffic Management Plan
TTC	Temporary Traffic Control
USDOT	United States Department of Transportation
VMS	Variable Message Sign

¹ Federal Highways Administration, U.S. Department of Transportation. Manual on Uniform Traffic Control Devices. 2009 Edition with Revisions 1 and 2, May 2012.

2 Introduction to SWZ Technologies

2.1 SWZ Overview

Smart Work Zones are applications of Intelligent Transportation Systems (ITS) concepts in work zones to increase safety and mobility. SWZ components are also sometimes referred to by other agencies as “Work Zone ITS” or “Portable Work Zone Technology.” SWZ typically collect real-time information at work zones, run a decision logic (standalone in the field or coordinated at a central location), and disseminate actionable information such as delay, travel time, queue warning, intrusion alert, etc. to end-users.



Example Concept of Operations Block Diagram

2.2 SWZ Components

A typical SWZ consists of field sensors or ITS equipment, communications systems, software application and electronic information distribution components.

COMPONENTS	DESCRIPTION
Sensors and ITS Field Components	<p>Sensors can be deployed along work zones to gather real time data such as traffic volume, speed, occupancy, etc. When additional monitoring of work zone conditions provides valuable information, ITS equipment such as Closed-Circuit Television (CCTV), Road Weather Information System (RWIS), etc. can be deployed. These field devices are typically portable and mounted on a trailer.</p> <p>There is also potential for future use of real-time traffic data collected and disseminated by providers such as Inrix, Here (formerly NAVTEQ Maps), WAZE, TomTom, etc.</p>
Communications Systems	<p>Communications Systems are used to transmit data collected at work zones to a central location for processing and dissemination, and/or communication between SWZ devices in the field. Due to the portable nature of SWZ devices, the typical communications systems used in SWZ deployments are wireless cellular communication.</p>
Software Application	<p>Vendor supplied or custom developed software application processes and analyzes data collected at work zones by applying decision logic based on parameters set. A typical software application allows for:</p> <ul style="list-style-type: none"> • configuration of constraints for various parameters (ex. traffic speed limits) • actions to be taken when the constraints are met (ex. display messages via Portable Variable Message Signs (PVMS)² in work zones) • provision of status and location information of field devices in a map view • dissemination of actionable information to end-users via electronic information exchange means (websites, email text alerts, PVMS, etc.) and visible or audible alarms • archiving raw and processed information and retrieval of archived data
Information Distribution Equipment	<p>The output of decision logic applied in the software application is disseminated to end-users using various information distribution methods such as PVMS, websites, email/text alerts, audible/visual alarms, or other means. Information such as travel time through work zone, delay, queue warning and speed reduction in work zone, incidents and construction vehicle entering and exiting work zone, are often communicated to end-users.</p>

2.3 SWZ Applications

Using the SWZ components described in Section 2.2, various work zone ITS applications can be developed to address specific work zone needs. The following table provides a short description of some of the applications which are of interest and applicable to CTDOT.

² CTDOT typically uses the terms Variable Message Sign (VMS) and Portable Variable Message Sign (PVMS). The terms Changeable Message Sign (CMS), Portable Changeable Message Sign (PCMS), and Dynamic Message Sign (DMS) are also used in the industry.

APPLICATION	DESCRIPTION
Real-Time Traveler Information	The Real-Time Traveler Information SWZ application provides real-time travel time information through a work zone. A typical system includes sensors in field to collect traffic data, PVMS to display travel time through work zone, communications systems, and software applications to process, analyze, disseminate, and archive data.
Performance Measurement	The Performance Measurement SWZ application is similar to Real-Time Traveler Information, except that the data collected is mainly used for the purpose of performance measurement and enables modifications to operations and support. This system is not designed to provide notifications to the general public.
Queue Warning	The Queue Warning SWZ application provides warning information on slow or stopped traffic ahead in a work zone. A typical system includes field sensors to collect traffic data, PVMS to display delay/stopped traffic in work zone, communications systems, and software applications to process, analyze, disseminate, and archive data.
Incident Management	The Incident Management SWZ application allows for increased visibility, management and quicker response and clearing of traffic incidents. A typical system includes field sensors to collect traffic data, CCTV cameras to provide live feeds, PVMS to communicate incident related delays to end-users, communications systems, and software applications to process, analyze, disseminate, and archive data.
Dynamic Lane Merge (early merge, late merge)	The Dynamic Lane Merge SWZ application provides information to drivers to enable merging earlier or later based on current conditions in the work zone. A typical system includes field sensors to collect traffic data, PVMS to display instructions to merge traffic at specific points in work zone, communications systems, and software applications to process, analyze, disseminate, and archive data.
Excessive Speed Warning	The Excessive Speed Warning SWZ application can be used to provide warning to drivers of vehicles travelling above the speed limit in or prior to approaching a work zone. A typical system includes a radar trailer with a speed display sign to measure and display vehicle speeds and alert drivers to reduce potentially excessive speed.
Entering/Exiting Vehicle Notification	Entering/Exiting Vehicle Notification SWZ application can be used to warn drivers of slow moving construction or emergency vehicles, entering or exiting the roadway. A typical system includes field sensors that activate PVMS to display notification to motorists.
Intrusion Detection	The Intrusion Detection SWZ application can be used to alert work zone personnel when a vehicle enters a work zone. A typical system includes field sensors connected to speakers and/or lights to immediately notify work zone personnel of an intrusion.
Over Height Vehicle	The Over Height Vehicle notification/warning SWZ application can be used to provide warnings to drivers of over height vehicles prior to entering areas with low clearance due to construction activity. A typical system includes field sensors along with flashing lights or signs alerting drivers about over-height restrictions, and possibly PVMS to display notification of an alternate route.

2.4 Benefits of SWZ

Work zones face issues of reduced roadway capacity; causing congestion and traveler delay and creating irregular traffic flow. Additionally, changing lane configurations, traffic incidents, and

factors such as slow or stopped traffic in work zones, can lead to safety hazards. SWZ applications provide actionable information to end users to reduce risk, delay and congestion, and improve safety. The FHWA³ SWZ implementation guide cites various studies demonstrating benefits of using SWZ. The various applications described in Section 2.3 can be used to achieve the following benefits in a work zone:

- Increased safety to work zone personnel, emergency responders and general traffic;
- Reduced delay;
- Reduced queue length;
- Reduced congestion;
- Reduced secondary crashes;
- Improved work zone travel time;
- Improved travel speed;
- Improved traveler information; and
- Decreased incident clearance time.

3 CTDOT SWZ Policies

3.1 SWZ Goals and Objectives

CTDOT's overall SWZ goal is to improve safety for roadway users and work zone personnel, increase mobility in work zones and reduce work zone traffic incidents. SWZ goals and objectives specific to offices within CTDOT are listed below.

Highway Operations goals and objectives for SWZ are to:

- Obtain video feeds from work zones, where available, to maintain situational awareness of traffic flow and incidents in work zones;
- Obtain access to real-time traffic data to maintain situational awareness of traffic flow, traffic speeds, and incident detection; and
- Coordinate SWZ with existing ITS infrastructure along state roadways.

Office of Construction goals and objectives for SWZ are to:

- Gather data for performance measurement, including queue length, speed, volume, and delay information in work zones to create a knowledge base for roadways throughout the state;
- Manage queue length and alert vehicle entry and exit into/from construction zones;
- Obtain performance measure data points during construction and analyze and modify traffic management plans accordingly (take lanes earlier to expedite construction); and
- Facilitate incident / crash reporting.

³ Work Zone Intelligent Transportation Systems Implementation Guide. FHWA-HOP-014-008. Washington D.C.: Federal Highway Administration. January 2014, Pg.21.

Office of Traffic Engineering goals and objectives for SWZ are to:

- Analyze the relationship between queue, volume, speed, and other traffic data collected in work zones with a goal of understanding how certain staging plans result in specific traffic patterns;
- Utilize volume data to develop generalized traffic diversion rates for various work zone types and patterns; and
- Obtain traffic data before and during staged construction to be used in developing limitation of operations for future projects.

Federal Highway Administration goals and objectives for SWZ are to:

- Monitor and measure performance;
- Gather crash, speed, and throughput data in work zones; and
- Reduce queue length.

3.2 Roles and Responsibilities

This sub-section discusses roles and responsibilities of various units within CTDOT.

SWZ Feasibility Determination Committee:

- A committee consisting of representatives from the Office of Traffic Engineering, Office of Construction, and Highway Operations is responsible for determining whether a project meets the criteria for the application of SWZ.
- The committee shall evaluate types of SWZ applications that should be applied to the project during the preliminary design phase and once the Maintenance and Protection of Traffic (MPT) methods have been established.
- The committee shall make recommendations to the designer on types of SWZ applications to be developed and work zone performance data to be collected for the project.
- The committee reviews SWZ design submitted as part of traffic management plans (TMP) to ensure that the initial objectives for using SWZ for the project have been addressed. The committee shall be responsible for maintaining and updating SWZ guidelines and specifications.

Project Designer

- The project designer shall provide the SWZ feasibility determination committee with information needed to determine whether the project meets the criteria for the application of SWZ. Information provided to the committee by the designer shall include, at a minimum, project description, project location, duration, anticipated construction staging, and preliminary cost information.
- For all projects determined to require SWZ, the designer shall develop a separate SEAFORM submittal specifically for the SWZ applications.
- The designer shall be responsible for adapting SWZ application guidelines to the specific project needs and project conditions.
- The designer shall follow all MUTCD and CTDOT standards, guidelines, and practices while developing project-specific customized plans.

Highway Operations:

- Owns the specifications for the SWZ bid items.
- Member of the committee that determines project-level feasibility of SWZ.

- Reviews SWZ design submitted as part of the TMP for integration with existing ITS infrastructure.
- Has access to real-time video feeds and sensor information from work zones for situational awareness and incident detection.
- Monitors operation of SWZ and reports device outages to Contractor.
- Reviews and confirms that all proposed PVMS sign locations and PVMS messages meet the MUTCD and CTDOT PVMS guidelines.

Office of Construction:

- Member of the committee that determines project-level feasibility of SWZ.
- Determines if coordination is needed for lane closures and construction signage between adjacent projects and adds necessary requirements in project contract documents.
- Reviews SWZ design submitted as part of the TMP.
- Reviews Average Daily Traffic (ADT) data and variance request from the Contractor during construction to allow lanes to be taken earlier in an effort to expedite construction.

Division of Traffic Engineering:

- Member of the team that determines project-level feasibility of SWZ.
- Reviews SWZ design submitted as part of the TMP.
- Reviews Average Daily Traffic (ADT) data and variance request from the Contractor during construction to allow lanes to be taken earlier in an effort to expedite construction.
- Participates in on-site Work Zone Safety reviews and determines work zone safety standards compliance and the potential necessary changes to be made. These inspections will also include SWZ as the systems are installed.

District Offices:

- Responsible for monitoring daily operations of construction and SWZ in work zones.
- Review SWZ design submitted as part of traffic management plans (TMP).
- Escalate the Contractor's request for changes to the limitations of operations to the Division of Traffic Engineering for review.
- Review periodic⁴ work zone traffic performance reports submitted by the Contractor.
- The Engineer is responsible for making the decision to deploy or remove the SWZ or individual devices in the field.
- The Engineer approves relocation of SWZ components in work zone. Following relocation of SWZ, Engineer confirms that SWZ components and software have been reconfigured, recalibrated, and re-tested as necessary.
- Oversee coordination of lane closures and construction signage between adjacent projects as needed.

Office of Planning:

- Responsible for archiving work zone data.
- Utilizes archived data for planning purposes.

⁴ Please refer to section 5.6 for further information on periodic work zone traffic performance reports.

Contractor:

- The Contractor's responsibilities include:
 - installation, deployment, calibration, and testing of SWZ
 - daily operations and maintenance of SWZ
 - configuration of SWZ software as directed by the Engineer and Contract requirements
 - work zone data collection, processing and archiving as directed by the Engineer and contract requirements
 - submittal of periodic work zone traffic performance reports to the District
 - responding to and fixing any failure, to provide continuous operation of SWZ as defined in the contract requirements
 - relocation, re-calibration, and re-testing of SWZ as needed (with the Engineer's approval) and as directed by the Engineer
 - removal of SWZ
- The Contractor shall request approval for the following items from the Engineer:
 - acceptance of initial SWZ testing and calibration data
 - changes to location of SWZ devices in the field
- The Contractor shall request and obtain approval for proposed PVMS sign locations and PVMS messages from the Office of Highway Operations.
- Under the direction of District Engineer, the Contractor shall coordinate lane closures and construction signage with adjacent projects as needed.

4 Project-Level Feasibility of SWZ

Project level feasibility determination and recommendation for SWZ will be provided by a committee comprised of members from Office of Traffic Engineering, Office of Construction, and Highway Operations.

4.1 Project Criteria

The Project Designer is responsible for recommending a project for evaluation by the SWZ feasibility determination committee. The committee may also recommend projects for the use of SWZ based on Department needs. Once recommended, the SWZ feasibility determination committee shall evaluate each recommended project to determine what types of SWZ applications, if any, should be applied to the project. During the evaluation process, the committee may take into consideration the criteria listed below:

- **Project cost** categories such as: (1) significant projects (>\$50 Million), (2) medium projects (\$20-\$50 Million), or (3) small projects (<\$20 Million) can be considered as a determining criterion; however, the decision on the feasibility of SWZ applications for projects is needs-based and not solely based on dollar amounts.
- **Duration of work zone** Large scale, long-term projects resulting in long term traffic issues due to complex traffic control layout.
- Projects with **staged construction** (e.g. bridge projects) resulting in frequent changes to traffic patterns and work zone traffic issues.
- **Extent of traffic impact** (traffic delay, increased travel time, queue length) due to temporary lane closure (e.g. mill and pave, deck patching on bridges)
- **Extent of queue length/delay** due to temporary signalization projects (e.g. alternate one-way traffic patterns around bridge projects, intersection improvements) or long-term MPT where lane/shoulder widths are reduced. Impact on traffic, businesses, other

destinations, or other users (e.g., extremely long delays, high risk of speed variability, access issues) for the duration of work is also a determining criterion.

- **CTDOT's internal need for traffic data** during construction on a particular roadway. In some projects, the value gained from performance data collection and evaluation may be a driving factor to implement SWZ.
- Other roadway types and traffic conditions that should be considered during the evaluation process are listed below.
 - Traffic speed variability
 - Back of queue and other sight distance issues
 - High speeds/chronic speeding
 - Work zone congestion
 - Availability of alternate routes
 - Merging conflicts and hazards at work zone tapers
 - Work zone hazards/complex traffic control layout
 - Frequently changing operating conditions for traffic
 - Variable work activities
 - Oversize vehicles (percentage of heavy vehicles >10%)
 - Construction vehicle entry/exit speed differential relative to traffic
 - Data collection for work zone performance measures
 - Unusual or unpredictable weather patterns (such as snow, ice, and fog).

4.2 Project Characteristics and SWZ Applications

Based on the project needs and characteristics, the committee may recommend use of one or more specific SWZ applications. The following table is adapted from FHWA Work Zone ITS Guidelines⁵ that shows potential situations and possible mitigation measures.

CRITICAL PROJECT CHARACTERISTICS	QUEUE WARNING	REAL-TIME TRAVELER INFORMATION	INCIDENT MANAGEMENT	DYNAMIC LANE MERGE	EXCESSIVE SPEED WARNING	CONSTRUCTION VEHICLE ENTERING AND EXITING	PERFORMANCE MEASUREMENT
Frequent planned lane closures are expected, which will create queues that cause high speed differentials between queued and approaching traffic.	x	x		o	x		
Emergency shoulders will be closed through the work zone and frequent stalls and fender-benders are expected to occur that will cause queues because they cannot be quickly moved to the shoulder.	x	x	x				
Travel times and delays through the work zone will be highly variable and real-time information can improve pre-trip and real-time route choice, departure time, and possibly mode choice decisions.		x	o				
Roadway access for emergency response vehicles will be significantly constrained by the project, increasing response and clearance times.			x				
Frequent incidents are expected to occur within the project.	o	x	x				
Having an operator able to view an incident within the project and assist responders in bringing appropriate equipment to the site will significantly reduce incident duration.			x				
The potential exists for queue spillback from the work zone into upstream interchanges or intersections (and resulting in increase in cross-street congestion and rear-end crashes) due to an unequal utilization of all lanes, such that the encouragement of the use of all lanes for queue storage would reduce that probability of spillback conditions.		o	o	x			
Work activities will frequently occur for which lower speed limits would be beneficial. Drivers will need to slow down significantly prior to entering the work zone.			o		x	o	
Access to and from the work space occurs directly from the travel lanes.						x	
A high number of construction vehicle deliveries into the work space will be required during the project.						x	
The location and design of the access points could create confusion for motorists (i.e., access to the work space looks like an exit ramp and is near an existing actual exit ramp).						x	
Little or no acceleration lane is available for construction vehicles entering the travel lanes from the work space.						x	
Capacity reductions in the work zone now create an oversaturated condition due to merging ramp vehicles.		o					
Temporary ramp geometrics have constrained acceleration lane lengths.		o					
Work zone ITS is already being deployed for other purposes.							x
Project documents include traffic mobility performance requirements (i.e., maximum allowable delays) that must be monitored to ensure and quantify compliance and subsequent incentives or penalties to be issued (performance specifications of mobility impacts [delay or queues]).							x
The agency chooses the project for assessment purposes as part of its federally-mandated bi-annual process review.							x

“x”: Characteristics could be addressed with this work zone ITS application

“o”: Characteristics could be addressed with this work zone ITS application if some modification(s) were made or real-time actions taken by an operator

⁵ Ibid, Pg. 26.

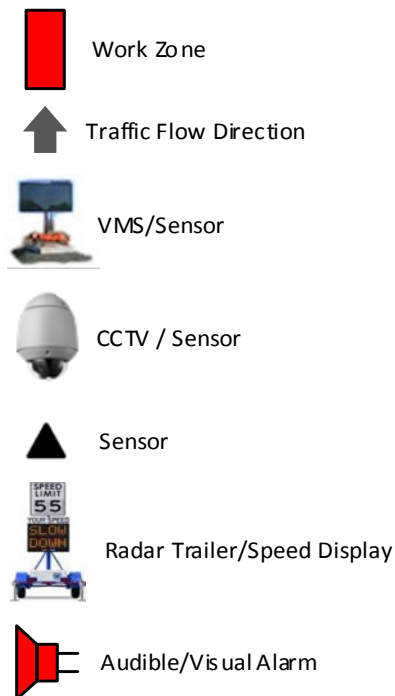
4.3 SWZ Applications

This section presents typical setups for various SWZ applications. For each application, a brief description of system overview, sample setup, and notes on considerations for design and deployment are provided.

NOTE: The sample SWZ applications shown in this section are overview representations and not detailed designs. The Designer and the Contractor are responsible to ensure all applicable CTDOT and MUTCD⁶ standards, guidelines, and practices are followed in the development of SWZ plans and during field deployment.

Illustrations of SWZ applications are adapted from MUTCD standards and NHDOT SWZ Tool Box⁷.

The legend for the icons used in the diagrams are adapted from CTDOT Specifications for SWZ⁸:



⁶ Federal Highways Administration, U.S. Department of Transportation. Manual on Uniform Traffic Control Devices. 2009 Edition with Revisions 1 and 2, May 2012.

⁷ New Hampshire Work Zone ITS Toolbox, Work Zone ITS Guideline for Smart Work Zone System Selection, 2011 Edition.

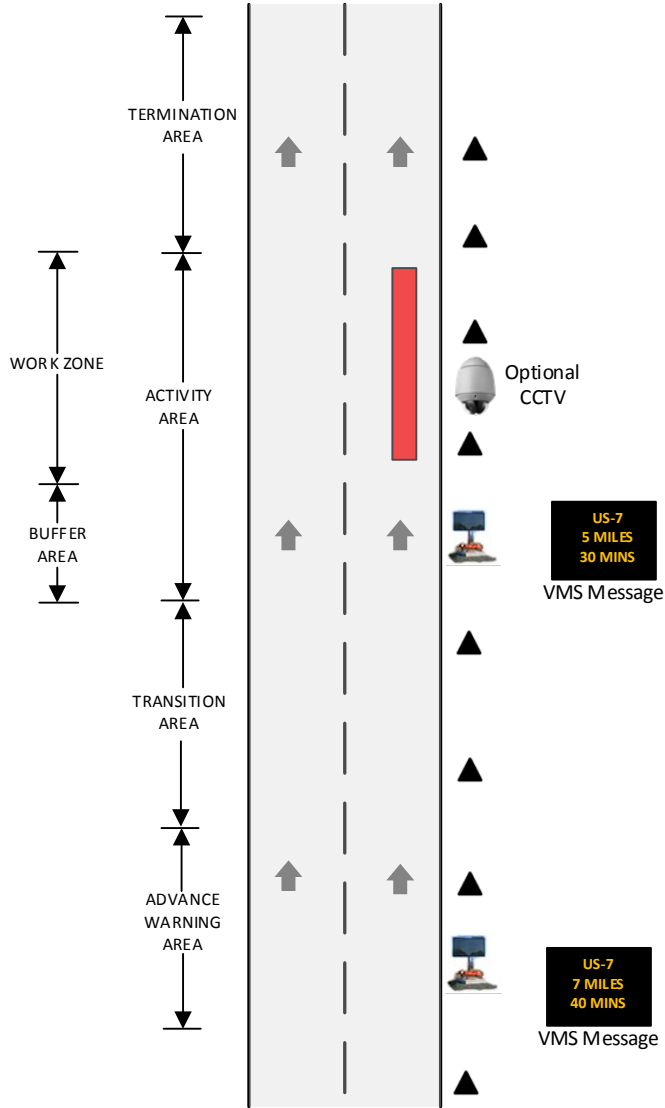
⁸ CTDOT Specification for Waterbury and Bridgeport Fairfield SWZ projects.

4.3.1 Real-Time Traveler Information

REAL-TIME TRAVELER INFORMATION

System Overview: A typical real-time traveler information system includes sensors collecting traffic data, PVMS to display travel time through work zone, communications systems and software application to process, analyze, disseminate and archive data. Typically, PVMS is used to display estimated travel time to an exit or route prior to entering work zone.

Overview Diagram:



LEGEND

- Work Zone
- Traffic Flow Direction
- Sensor
- VMS/Sensor
- CCTV/Sensor

Notes:

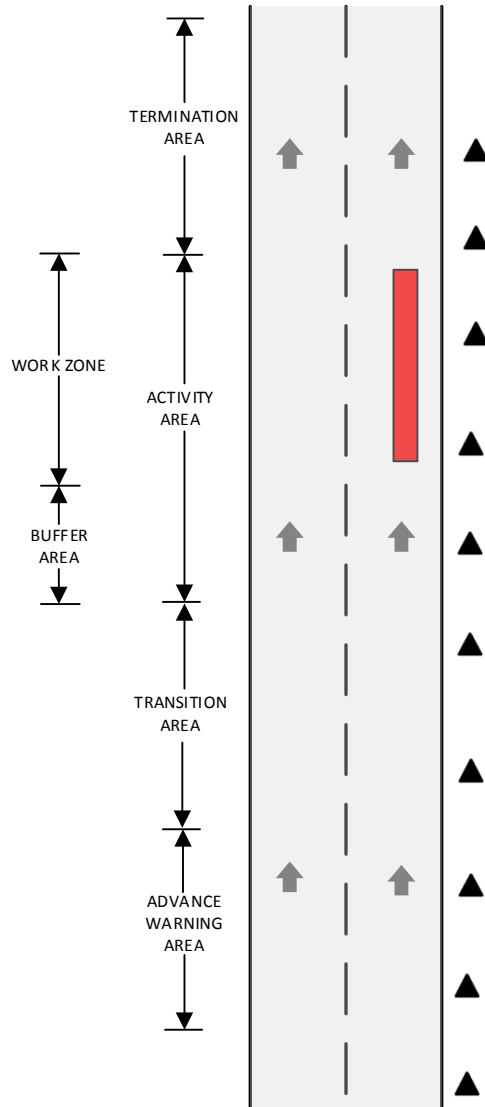
- Distance between sensors shall be as specified in the special provisions of the project.
- Actual number of sensors and location of sensors and PVMS are dependent on total project distance, road curvature and other specifics related to the project and roadway.
- CTDOT shall provide input to SWZ specification regarding what message shall be displayed on the PVMS at what threshold. During construction/deployment these initial requirements could be modified at the Engineer's discretion.
- CCTV camera is optional for this application. If visibility into work zone conditions is needed, CCTV on a trailer could be included as part of SWZ or an existing CCTV feed can be utilized.
- PVMS message size, legibility, etc. shall comply with CTDOT PVMS guidelines.
- As SWZ are considered to be part of temporary traffic control, the Contractor shall follow all applicable MUTCD standards and guidelines for placement of SWZ trailers at construction sites. Placement of field components shall take into consideration, requirements for off the road distance, position of SWZ equipment in relation to other highway signs, curvature of highway, ramps, etc. Final design should to be approved by CTDOT.
- Construction signage is not shown in this overview drawing and the Contractor shall follow all MUTCD and CTDOT standards, guidelines, and practices while developing the project specific customized plan.

4.3.2 Performance Measurement

PERFORMANCE MEASUREMENT

System Overview: A typical performance measurement system includes sensors to collect traffic data in a work zone, communications systems, and software applications for processing, analyzing, and archiving data. The data collected is mainly used for the purpose of performance measurement and to obtain insight into traffic conditions in work zones. The information is not intended for notification, but rather to allow for modifications to current project operations and future project designs.

Overview Diagram:



LEGEND

- Work Zone
- Traffic Flow Direction
- Sensor

Notes:

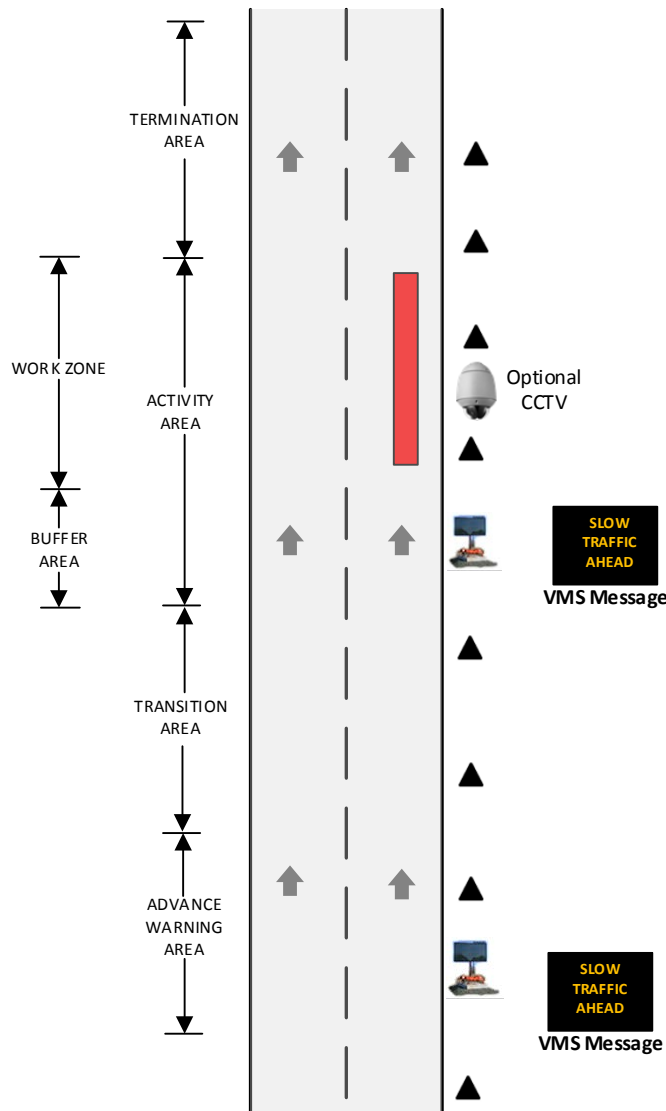
- Distance between sensors shall be as specified in the special provisions of the project.
- Actual number of sensors and location of sensors are dependent on total project distance, road curvature, and other specifics related to the project and roadway.
- CTDOT may consider the option to purchase portable sensors to implement the performance measurement SWZ application. These portable sensors could be moved to different projects and used year round to gather data from different parts of the state as needed.
- The sensors could be moved during construction/deployment at the Engineer's discretion.
- CCTV camera is optional for this application. If visibility into work zone conditions is needed, CCTV on a trailer could be included as part of SWZ or an existing CCTV feed can be utilized.
- As SWZ are considered to be part of temporary traffic control, the Contractor shall follow all applicable MUTCD standards and guidelines for placement of SWZ trailer/sensor at construction sites. Placement of field components shall take into consideration requirements for off the road distance, position of SWZ equipment in relation to other highway signs, curvature of highway, ramps, etc. Final design to be approved by CTDOT.
- Construction signage is not shown in this overview drawing and the contractor shall follow all MUTCD and CTDOT standards, guidelines, and practices while developing the project specific customized plan.

4.3.3 Queue Warning

QUEUE WARNING

System Overview: A typical queue warning system includes sensors to collect traffic data, PVMS to display delay/stopped traffic in the work zone, communications systems, and software applications to process, analyze, disseminate, and archive data.

Overview Diagram:



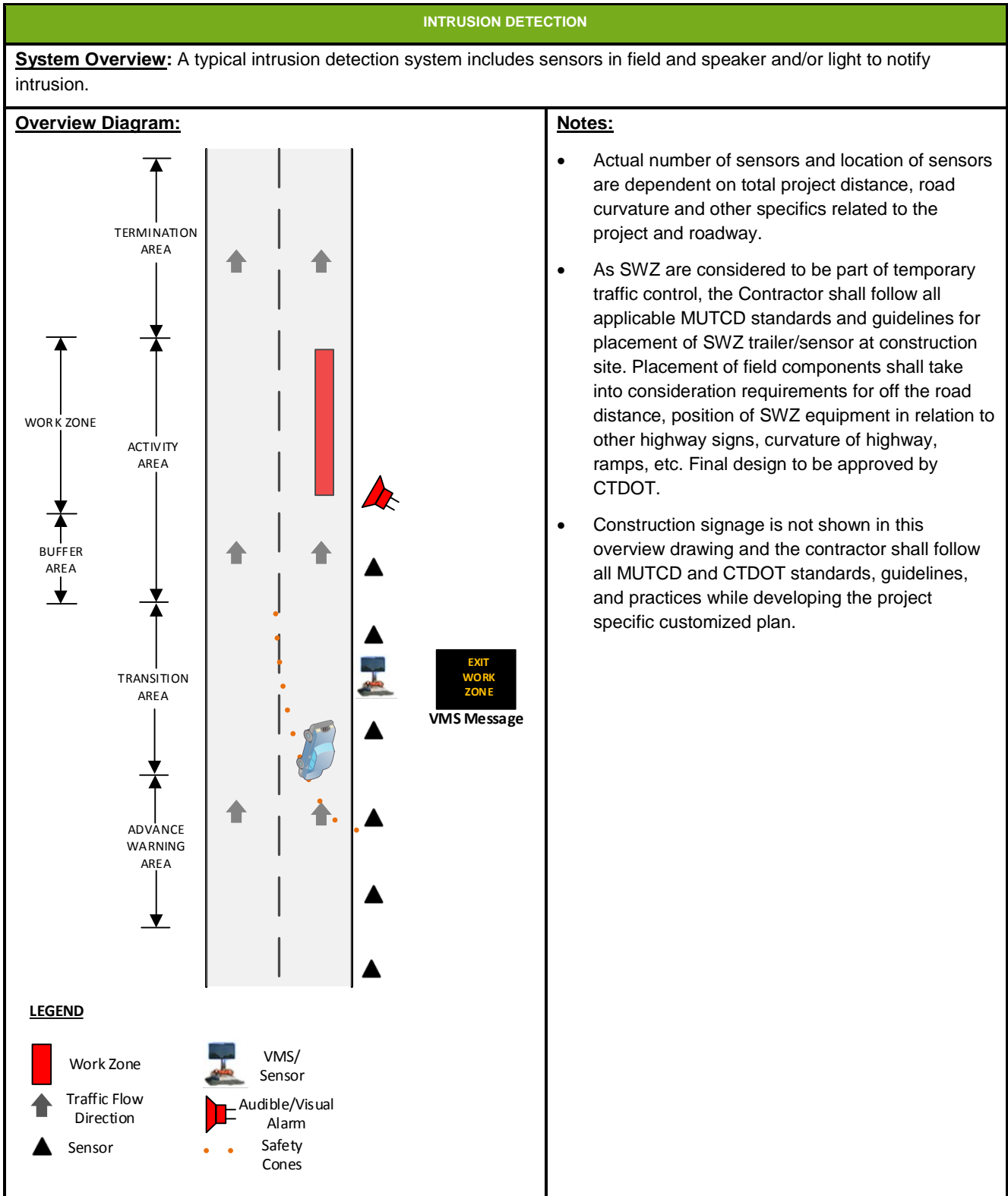
LEGEND

- Work Zone
- Traffic Flow Direction
- Sensor
- VMS/Sensor
- CCTV / Sensor

Notes:

- Distance between sensors shall be as specified in the special provisions of the project.
- Actual number of sensors and location of sensors and PVMS are dependent on total project distance, road curvature, and other specifics related to the project and roadway.
- CTDOT shall provide input to SWZ specification regarding what message shall be displayed on the PVMS and at what threshold. During construction/deployment these initial requirements could be modified at the Engineer's discretion.
- PVMS might need relocation depending on the typical queue length observed during construction.
- CCTV camera is optional for this application. If visibility into work zone conditions is needed, CCTV on a trailer could be included as part of SWZ or an existing CCTV feed can be utilized.
- PVMS message size, legibility, etc. shall comply with CTDOT PVMS guidelines.
- As SWZ are considered to be part of temporary traffic control, the Contractor shall follow all applicable MUTCD standards and guidelines for placement of SWZ trailer/sensor at construction site. Placement of field components shall take into consideration requirements for off the road distance, position of SWZ equipment in relation to other highway signs, curvature of highway, ramps, etc. Final design to be approved by CTDOT.
- Construction signage is not shown in this overview drawing and the contractor shall follow all MUTCD and CTDOT standards, guidelines, and practices while developing the project specific customized plan.

4.3.4 Intrusion Detection

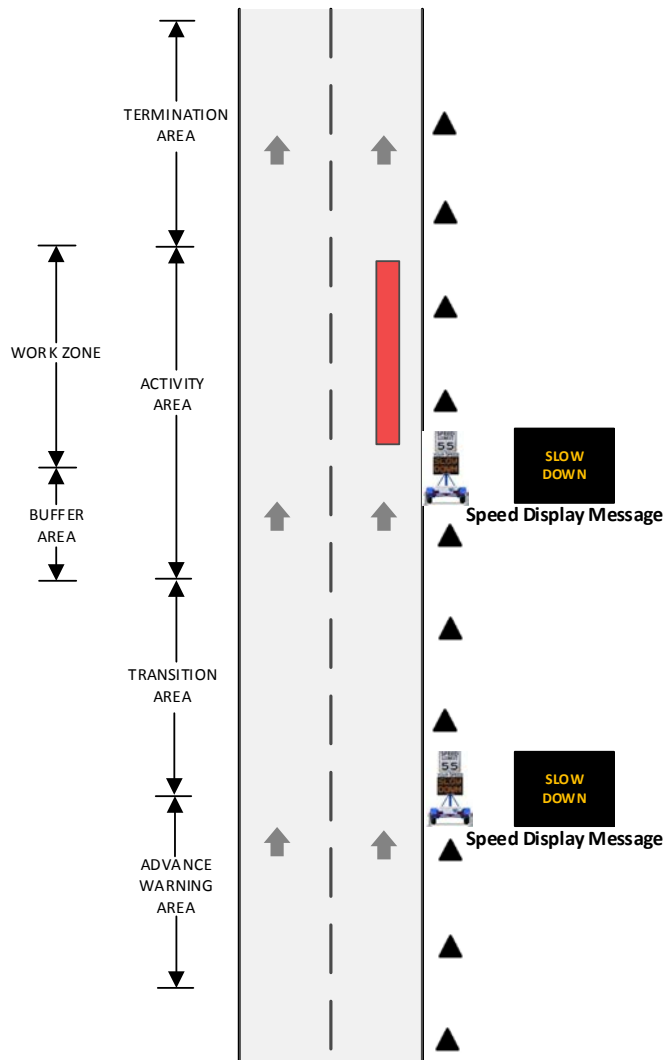


4.3.5 Excessive Speed Warning





EXCESSIVE SPEED WARNING

System Overview: A typical excessive speed warning system includes sensors to collect traffic data, a radar trailer with a speed display sign to measure and display vehicle speeds and alert drivers to reduce potentially excessive speed, communications systems, and software applications to process, analyze, disseminate, and archive data.

Overview Diagram:



LEGEND

-  Work Zone
-  Traffic Flow Direction
-  Sensor
-  Radar Trailer/Speed Display

Notes:

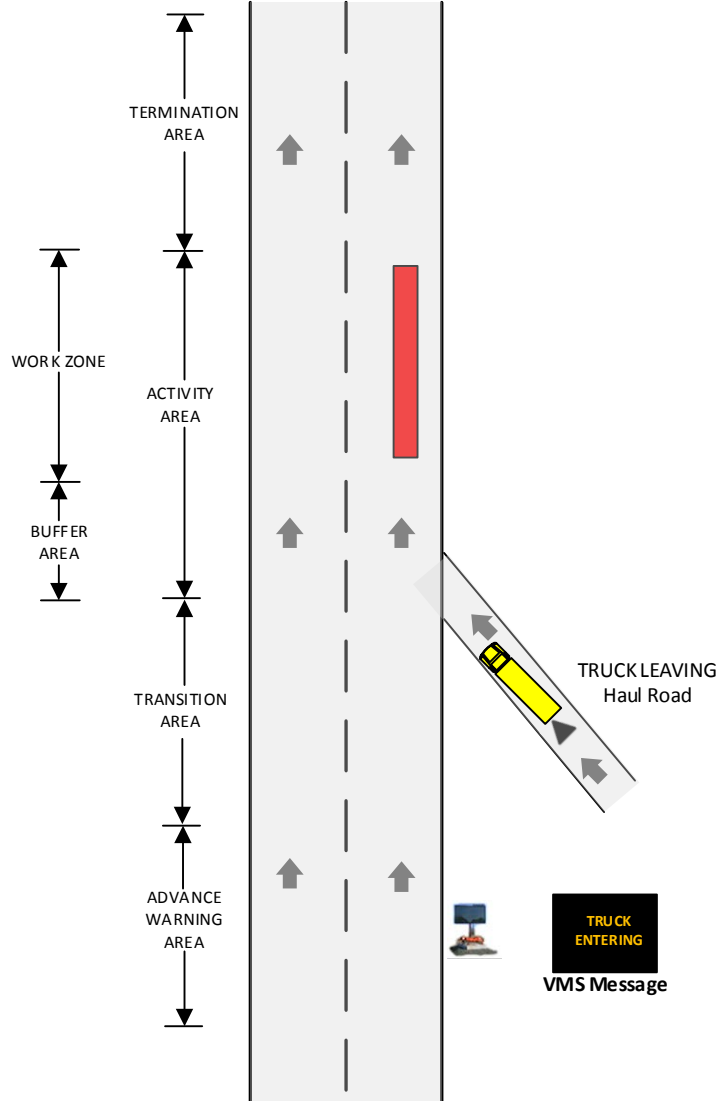
- Distance between sensors shall be as specified in the special provisions of the project.
- Actual number of sensors and location of sensors and radar trailers are dependent on total project distance, road curvature, and other specifics related to the project and roadway.
- CCTV camera is optional for this application. If visibility into work zone conditions is needed, CCTV on a trailer could be included as part of SWZ or an existing CCTV feed can be utilized.
- As SWZ are considered to be part of temporary traffic control, the Contractor shall follow all applicable MUTCD standards and guidelines for placement of SWZ trailer/sensor at construction site. Placement of field components shall take into consideration requirements for off the road distance, position of SWZ equipment in relation to other highway signs, curvature of highway, ramps, etc. Final design to be approved by CTDOT.
- Construction signage is not shown in this overview drawing and the contractor shall follow all MUTCD and CTDOT standards, guidelines, and practices while developing the project specific customized plan.

4.3.6 Entering/Exiting Vehicle Notification

ENTERING/EXITING VEHICLE NOTIFICATION

System Overview: A typical entering/exiting vehicle notification system includes sensors in field that activate PVMS to display notification of slow moving construction or emergency vehicles, entering or exiting the roadway.

Overview Diagram:



LEGEND

- Work Zone
- Traffic Flow Direction
- Sensor
- VMS/Sensor

Notes:

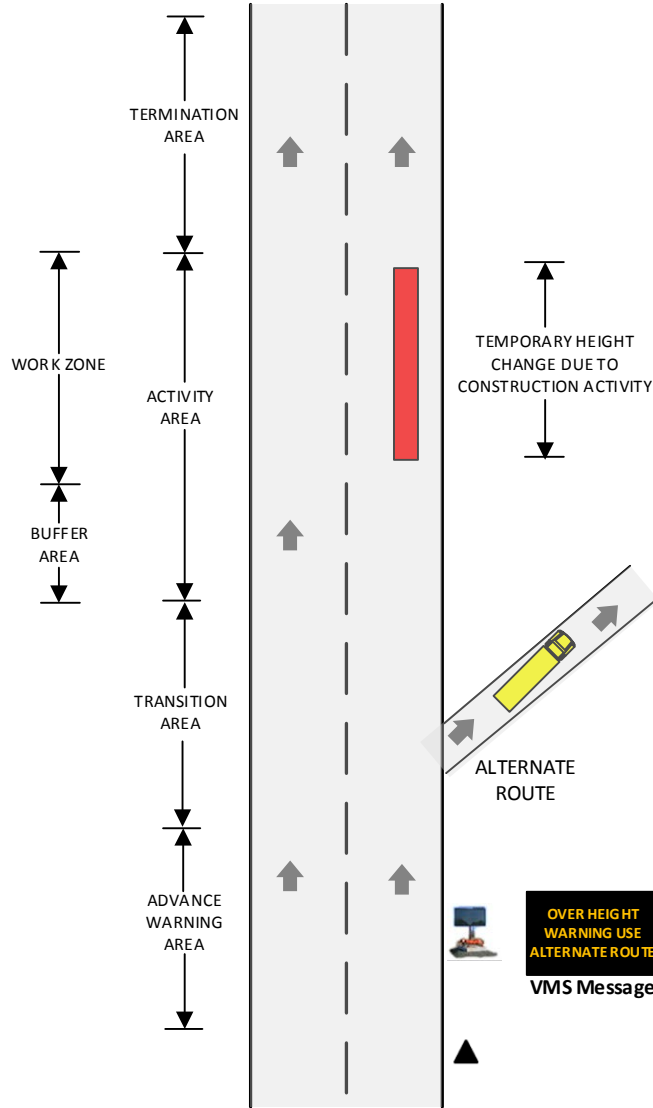
- Actual number of sensors and location of sensors are dependent on total project distance, road curvature, and other specifics related to the project and roadway.
- As SWZ are considered to be part of temporary traffic control, the Contractor shall follow all applicable MUTCD standards and guidelines for placement of SWZ trailer/sensor at construction site. Placement of field components shall take into consideration requirements for off the road distance, position of SWZ equipment in relation to other highway signs, curvature of highway, ramps, etc. Final design to be approved by CTDOT.
- Construction signage is not shown in this overview drawing and the contractor shall follow all MUTCD and CTDOT standards, guidelines, and practices while developing the project specific customized plan.

4.3.7 Over Height Vehicle Notification





OVER HEIGHT VEHICLE NOTIFICATION

System Overview: A typical over height vehicle notification system includes sensors, PVMS to display notification with an alternate route.

Overview Diagram:



LEGEND

-  Work Zone
-  Traffic Flow Direction
-  Sensor
-  VMS/Sensor

Notes:

- Actual number of sensors and location of sensors are dependent on total project distance, road curvature, access to an alternate route, and other specifics related to the project and roadway.
- As SWZ are considered to be part of temporary traffic control, the Contractor shall follow all applicable MUTCD standards and guidelines for placement of SWZ trailer/sensor at construction site. Placement of field components shall take into consideration requirements for off the road distance, position of SWZ equipment in relation to other highway signs, curvature of highway, ramps, etc. Final design should be approved by CTDOT.
- Construction signage is not shown in this overview drawing and the contractor shall follow all MUTCD and CTDOT standards, guidelines, and practices while developing the project specific customized plan.

4.3.8 Other SWZ Applications

The following is a list of other SWZ application types. Some of these applications are variations of the applications described above.

- **Alternate Route:** Real-Time Traveler Information SWZ application could be extended to provide travellers with alternate route information to encourage use of alternate routes.
- **Variable Speed Limit⁹:** The Variable Speed Limit SWZ application allows for speed limits to be changed dynamically in work zones based on current delay and traffic speeds experienced in the work zone. A typical system includes field sensors collecting traffic data, portable variable speed limit message signs to display changing speed limits set in work zone, communications systems, and software application to process, analyze, disseminate, and archive data.
- **Congestion Advisory/Stopped Traffic Advisory:** This system uses PVMS to broadcast appropriate messages in case of congestion or stopped traffic ahead of work zone. This application is a variation of Queue Warning and Real-Time Traveler Information applications. Stopped Traffic Advisory could be used for projects which result in frequent occurrence of stopped traffic.
- **Hazardous Conditions Warning:** This SWZ application alerts hazardous conditions that might arise temporarily during construction. Examples: falling debris or temporary flooding during roadway construction.
- **Dynamic Lane Merge:** Dynamic Lane Merge SWZ application provides information to drivers to enable merging earlier or later based on current conditions in the work zone.
- **Incident Management:** Incident Management SWZ application allows for increased visibility, management, and quicker response and clearing of traffic incidents.

⁹ Implementation would require legal review and counsel, as well as approval by the Office of the State Traffic Administration (OSTA) and possible modification to the Connecticut General Statutes.

4.4 Integration of Existing Permanent ITS

If existing ITS infrastructure such as CCTV and VMS (Variable Message Signs) exist within the project limits, integration with this existing infrastructure should be taken into consideration as part of SWZ design. Existing ITS may provide additional video feed and information dissemination points but they may not completely eliminate the need for CCTV or VMS as part of SWZ design, as the field equipment may not be located at the right point within the work zone. Additionally, existing VMS may have other operational uses, and may not be available for dedicated work zone use.

4.5 Typical SWZ Deployment Cost

Typical SWZ deployment cost depends on number of SWZ components (CCTV, sensors, PVMS, etc.) used in the system, duration of project, extent of changes to construction staging, etc. The cost details provided here are for planning purposes only and are not to be used to obtain exact cost of deployment.

- Typical SWZ costs often range between 3% and 5% of total project cost. This cost includes equipment purchase/lease and cost of mobilization, operation and maintenance. This cost will vary depending on project duration, complexity, and number of SWZ applications employed.

Some sample cost information from other DOTs and vendors:

- State of Illinois District 8 presentation “ITS Smart Work Zones”¹⁰ shows that based on six projects during 2014/2015 construction season, the average cost of SWZ deployment is about 3% of total project cost.
- In the case study “Massachusetts Department of Transportation Technology Applications on the Callahan Tunnel Project”, construction Dec 2013 to Mar 2014¹¹:
 - MassDOT procured equipment as a lump sum bid item and it accounted for 5% of total project cost. Project duration was about 4 months and deployment occurred during winter requiring maintenance.
 - MassDOT noted unit monthly costs to be in the range of:
 - Portable camera with trailer: \$1,000-\$1,300
 - PVMS, solar with remote operation: \$500-\$750
 - Queue Sensor Trailer with lane-by-lane data capture: System Operation with unlimited data plan: \$2,500 - \$3,500/month
- FHWA, Work Zone ITS Implementation Guide, Jan 2014¹²:
 - “As a rough estimate, purchasing a few sensors to add to an existing TMC might cost about \$5,000 plus an additional \$5,000-\$10,000 for integrating them with the existing system”.
 - “Purchasing a larger system that includes four sensors, a PVMS, and some operations support for communications and data software for a simple queue

¹⁰ State of Illinois District 8 presentation “ITS Smart Work Zones” at THE Conference 2015.

¹¹ Case study: Massachusetts Department of Transportation Technology Applications on the Callahan Tunnel Project.

¹² Work Zone Intelligent Transportation Systems Implementation Guide. FHWA-HOP-014-008. Washington D.C.: Federal Highway Administration. January 2014.

warning system might cost about \$125,000, while doubling this to a system with eight sensors and two PVMS might increase the costs to about \$200,000”

- Vendor i-cone¹³ offers products for owning or leasing. i-cone products are primarily used for traffic data collection.
 - Cost of owning: \$7500 per cone plus additional monthly charge of \$150 per cone or \$1500 per year for internet and data access.
 - Rent about \$1000 per cone per month. Cost of data access and wireless is included in rent/lease rate. The Contractor may require separate labor charge for mobilization.

5 Guidelines for Implementation of SWZ

This section defines guidelines for implementation of SWZ in the state of Connecticut. The process defined in this section allows for customization of generic SWZ applications presented in Section 4.3 to address needs and constraints specific to each project. CTDOT SWZ will closely follow federal guidelines and the Systems Engineering process for implementation of work zone ITS / SWZ. The SWZ implementation process defined in this section is presented in Appendix A in table format.

5.1 Design

As part of the preliminary engineering design phase and once the Maintenance and Protection of Traffic (MPT) methods have been established, the SWZ feasibility determination committee shall evaluate which types of SWZ applications should be applied to the project. The committee shall make a recommendation to the designer on types of SWZ applications to be developed for the project.

For all projects determined to require SWZ, the designer shall develop a SEAFORM specifically for the SWZ. Consistent with the May 2015 Stewardship and Oversight Implementation Manual¹⁴ program responsibilities, the designer shall be responsible for following the federally required Systems Engineering process and documenting its efforts using the SEAFORM. A sample SEAFORM has been provided as Appendix C. If guidance in properly filling out the SEAFORM is needed, the person filling out the form can contact the CTDOT Office of Highway Operations.

The designer shall customize the generic SWZ application to take into consideration project-specific details such as: project length/distance, roadway geometry, traffic conditions, and other project needs. Based on this project information the designer shall determine the number and placement of sensors, PVMS, and other SWZ equipment, including an assessment of the availability of integrating the SWZ with existing ITS. The designer shall follow all MUTCD and CTDOT standards, guidelines, and practices while developing a project-specific customized plan.

The SWZ design shall be included as part of the Transportation Management Plan (TMP) for the project (as part of the detailed design). As part of TMP review, various offices within CTDOT

¹³ Portable Work Zone Management Systems (ITS in Work Zones) Technology Review and Workshop Presentation: Background Material, IBI Group Memorandum dated August 22, 2016.

¹⁴ 2015 Stewardship & Oversight Implementation Manual, Federal Highway Administration and Connecticut Department of Transportation, May 2015.

shall review and ensure construction staging is taken into consideration in development of SWZ design. The designer shall follow all applicable MUTCD and CTDOT guidelines for placement of SWZ trailers and signage at the construction site. Placement of field components shall take into consideration, clear zone requirements in the Standard Specifications Form 817, position of SWZ equipment in relation to other highway signs, curvature of highway, ramps, etc. Detailed design shall be circulated to the various CTDOT offices for review and comment, including representatives from the SWZ feasibility determination committee. Final design shall be approved by CTDOT.

5.2 Procurement

SWZ shall be procured under project contract as contract bid items. CTDOT has developed the following contract bid items and specifications for procurement of SWZ.

- ITEM 1131023 – Smart Work Zone Queue Trailer/Sensor (SQT)
- ITEM 1131024 – Smart Work Zone Queue Trailer/Sensor (SQT) Service
- ITEM 1131016 – Smart Work Zone Mobile Video Camera/Queue Sensor Trailer (SVQS)
- ITEM 1131017 – Smart Work Zone Mobile Video Camera/Queue Sensor Trailer (SVQS) Service
- ITEM 1131018 – Smart Work Zone Variable Message Sign/Queue Sensor Trailer (SVMQ)
- ITEM 1131019 – Smart Work Zone Variable Message Sign/Queue Sensor Trailer (SVMQ) Service
- ITEM 1131015A – Radar Speed Display – Trailer Mount, Tow Behind

Please note that this may not be a complete list of SWZ contract bid items and specifications. CTDOT Highway Operations ITS Engineering and Support should be contacted for information on any additional SWZ components. CTDOT Highway Operations ITS Engineering and Support is responsible for maintaining these specification items.

These items shall provide a fully operational SWZ that includes vehicle trailers with sensors, variable message signs (VMS), cameras, website, communications equipment, service, and maintenance as defined in the specifications. Included in the operational responsibilities of the Contractor/Vendor is the assumption of all trailer license plates, communication costs such as FCC licensing, cellular telephone, wireless data networks, satellite and internet subscription charges, solar system support and battery charging, and maintenance. Specifications for SWZ items must be customized by the designer during design stage to meet project specific criteria and needs.

5.3 Deployment

The District and the Engineer oversee the deployment of SWZ. The Contractor shall coordinate deployment of SWZ with the District and the Engineer. CTDOT has developed the following contract bid items and specifications for initial deployment and relocation of SWZ equipment.

- ITEM 1131020 – Smart Work Zone Deployment
- ITEM 1131022 – Smart Work Zone Trailer Relocation

Please note that this may not be a complete list of SWZ contract bid items and specifications. CTDOT Highway Operations ITS Engineering and Support should be contacted for information on any additional SWZ components. CTDOT Highway Operations ITS Engineering and Support is responsible for maintaining these specification items.

The specifications for this item provides detailed guidelines for SWZ deployment, scheduling, initial placement and relocation of equipment in work zones, calibration, testing, system demonstration, and acceptance of system prior to commencement of construction activity.

The specifications require the Contractor to complete calibration and testing of SWZ prior to initial acceptance of the deployment. If the SWZ trailer is re-located, the Contractor shall re-calibrate and test the system after each re-location. The Contractor shall obtain approval from the Engineer after each re-location, on the basis of new calibration data and testing results. The Contractor shall also notify the Highway Operations ITS Engineering and Support whenever a SWZ is deployed or re-located to ensure situational awareness at the Operations Centers is maintained.

5.4 Operations and Data Collection

The Contractor is responsible for SWZ operation, maintenance and data collection during construction. CTDOT has developed the following contract bid item and specification for SWZ Operations.

- ITEM 1131021 – Smart Work Zone Operations

Please note that this may not be a complete list of SWZ contract bid items and specifications. CTDOT Highway Operations ITS Engineering and Support should be contacted for information on any additional SWZ components. CTDOT Highway Operations ITS Engineering and Support is responsible for maintaining these specification items.

The Contractor shall gather, analyze, report/disseminate and archive work zone traffic data as specified in the specifications.

- Real-time traffic data such as speed, volume, count, etc. are gathered in by the SWZ at pre-configured intervals as defined in the specifications.
- The Contractor shall continuously monitor operational status of field equipment and address any outages within the duration specified in the specifications.
- The Contractor shall periodically (at a minimum on a weekly basis), review traffic queue length and delay information to make appropriate changes to location of sensors, trailers, and/or deployment of additional PVMS with approval from CTDOT.
- Throughout the duration of construction, the Contractor may evaluate traffic operations and when feasible request from the Office of Construction and District Construction variance in the hourly limitations of operation in order to expedite construction.
- The Contractor shall coordinate with the Engineer on frequency of data reporting. Typically the reporting will be on a monthly basis.
- The Contractor shall generate and submit to the Engineer a periodic work zone traffic performance report as defined in Section 5.6 utilizing work zone traffic data collected with SWZ.
- Upon project completion as per the specifications for SWZ, the Contractor shall submit full set of work zone data collected for the project. In addition to raw data set, the Contractor shall also include electronic copy of weekly reports and raw data for the week submitted to the department for archiving (XLS).
- In addition to supplying archived data in the format as specified in contract documents, the department may request the Contractor or an external Consultant to provide reports using archived data in graphical format. Appendix B shows examples of such data analysis reports. Some reports shown in the example require development of custom data analysis tools which may not be covered under the scope of the Contractor's work.

5.5 Security

The Contractor shall meet the following security requirements.

- The Contractor shall secure physical equipment in field with a padlock and secure software access to field devices with a high-level password.
- The SWZ operator control functions shall be high-level password protected.
- The Project SWZ website shall allow password-protected project staff to manually override the automated messaging in order to display a message at any time.

5.6 Maintenance and Evaluation

The Contractor is responsible for maintenance of SWZ for the duration of construction. Maintenance activities may include snow and ice removal from solar panels, maintaining batteries charged, repositioning or calibration of field equipment as needed, etc.

Data collected in work zones during construction can be used to evaluate SWZ operational performance and work zone traffic performance. When SWZ fails to meet the operational performance limits set in the contract documents, the Contractor may incur loss of payment based on terms laid out in the specifications / contract document. Evaluation of SWZ performance could also include measurement of work zone traffic performance such as number of incidents in work zone, maximum queue length, the number of lanes to remain open, maximum traveler delay, etc.

Periodic Work Zone Traffic Performance Report:

The Contractor shall generate and submit to the Engineer a periodic work zone traffic performance report, utilizing the data collected with SWZ.

Short term traffic performance reports shall be submitted as part of periodic construction progress meetings. The report shall include the following:

- Periodic work zone traffic data in graphical format (plot as applicable, dependent on SWZ application selected). **The data should be submitted monthly for all the following fields except the speed trailers, which should be submitted weekly.**
 - Per Location – Sensor - Traffic Speed: Plot average traffic speed in 15 minute intervals with threshold of 45mph marked horizontally. Additionally this data can be compared against historical speed data for that roadway.
 - Project Segment - Travel Time: Plot average travel time in 15 minute intervals. Additionally this data can be compared against historical travel time for that roadway.
 - Project Segment - Delay: Plot average delay in 15 minute intervals.
 - Project Segment - Queue Length: Plot average queue length in 15 minute intervals, if queue warning system is deployed.
 - Project Segment – Number of Incidents: Plot number of incidents in 15 minute interval. Data for primary and secondary incidents (if any) shall be reported separately. This reporting is required for all SWZ applications.
 - Per Location (PVMS) – Message Logs: Submit a log of messages displayed on the PVMS and the time stamp at which the message was displayed. A short analysis and statement on accuracy of messages displayed shall be submitted along with the log, identifying any issues. If any issues (example: unexpected message such as “slow traffic” when there was no congestion reported at that

same time, inferred from low volume, etc.) are identified, the Contractor shall submit a plan of action to remedy the issue identified.

- Construction staging information for the reporting period. In the event of construction staging changes during the reporting period, the data for the two different staging plans shall be submitted separately.
- The report shall include a brief note describing any significant change in performance from prior period.
- Upon project completion as per the specifications for SWZ, the Contractor shall submit the full set of work zone data collected for the project. In addition to raw data set, the Contractor shall also include electronic copy of periodic reports and raw data for the period submitted to the department for archiving.

5.7 Removal

The Contractor is responsible for the removal of SWZ as part of removal of temporary traffic control. This should be coordinated with Office of Construction. Office of Construction or Office of Traffic could consider using the existing resources in field to gather useful post construction data prior to removal of SWZ. The Contractor shall also notify the Highway Operations Center when a SWZ is removed.

REFERENCES

1. *Work Zone Intelligent Transportation Systems Implementation Guide*. FHWA-HOP-014-008. Washington D.C.: Federal Highway Administration. January 2014.
2. Federal Highways Administration, U.S. Department of Transportation. *Manual on Uniform Traffic Control Devices*. 2009 Edition with Revisions 1 and 2, May 2012.
3. Federal Highways Administration, U.S. Department of Transportation. *Portable Changeable Message Sign Handbook*. FHWA-RD-03-066. 2003.
4. New Hampshire Work Zone ITS Toolbox, Work Zone ITS Guideline for Smart Work Zone System Selection, 2011 Edition
5. Iowa DOT, Traffic Critical Projects Program 2015 Final Report.
6. CTDOT Specification for Waterbury and Bridgeport Fairfield PWZMS projects.
7. State of Illinois District 8 presentation "ITS Smart Work Zones" at THE Conference 2015. <http://www.theconf.com/presentations/2015/Experiences%20with%20Smart%20Work%20Zones%20in%20Southern%20Illinois.pdf>
8. Case study: Massachusetts Department of Transportation Technology Applications on the Callahan Tunnel Project.
9. Portable Work Zone Management Systems (ITS in Work Zones) Technology Review and Workshop Presentation: Background Material, IBI Group Memorandum dated August 22, 2016.
10. 2015 Stewardship & Oversight Implementation Manual, Federal Highway Administration and Connecticut Department of Transportation, May 2015.

APPENDIX A – SWZ Implementation Plan

Mapping Between CTDOT SWZ Guidelines and FHWA WZ ITS Guidelines Six-Steps

FHWA WORK ZONE ITS GUIDELINES SIX-STEPS	CTDOT SWZ GUIDELINES	CTDOT UNIT
Step 1: Assessment of Needs	5.1 Design	Highway Operations, District, Construction, Traffic
Step 2: Concept Development and Feasibility		Highway Operations, District, Construction, Traffic
Step 3: Detailed System Planning and Design		Highway Operations, District, Construction, Traffic
Step 4: Procurement	5.2 Procurement	District, Construction, Contractor
Step 5: System Deployment	5.3 Deployment	District, Construction, Contractor
Step 6: System Operation, Maintenance and Evaluation	5.4 Operations and Data Collection	Highway Operations, District, Construction, Contractor
	5.5 Security	District, Construction, Contractor
	5.6 Maintenance and Evaluation	District, Construction, Contractor
	5.7 Removal	District, Construction, Contractor

PROCESS	ACTIONS IN EACH STAGE
Assess Needs of the Project	<ul style="list-style-type: none"> As part of the preliminary engineering and once MPT methods have been established, the SWZ feasibility determination committee shall evaluate applicability of SWZ for the project.
Feasibility Review and Concept Development	<ul style="list-style-type: none"> SWZ feasibility determination committee conducts a review and makes recommendations on use of SWZ and SWZ application types to be deployed.
Detailed Planning and Design	<ul style="list-style-type: none"> SWZ detailed plan is developed by the designer and included as part of TMP. TMP is reviewed as part of standard design review process. SWZ aspects are reviewed to ensure that SWZ objectives have been addressed.
Procurement	<ul style="list-style-type: none"> Equipment is procured as items in project contract bid process. Items for deployment, relocation, and operations are also included in the contract bid process.
System Deployment and Acceptance	<ul style="list-style-type: none"> The Contractor deploys system under District oversight. The Contractor is responsible for initial placement of equipment in work zones, calibration, testing, system demonstration and acceptance of system prior to commencement of construction activity.
System Operation	<ul style="list-style-type: none"> The Contractor is responsible for operations, including maintaining security.
Maintenance	<ul style="list-style-type: none"> The Contractor maintains equipment and websites as defined in the contract documents.
Data Collection	<ul style="list-style-type: none"> Automated system collects field data and archives. The Contractor has responsibility to collect and generate periodic work zone traffic performance reports for submittal to CTDOT.

Appendix B – Data Analysis Examples

SWZ collect data in real-time and archives for the duration of SWZ deployment. Typically the Contractor is not responsible for analysis and DOTs have required the Contractor to provide information in a specific format. As part of SWZ specifications, the Contractor is required to supply vendor software for the SWZ which includes data analysis and reporting functionality.

Many of the vendor provided software has ability to process and present the short-term/near-term and historical data in graphical format. Speed, volume, travel time information can be plotted graphically or presented in table format over a day/week/month/custom time frame. Additional reports such as number of times a particular type of message was posted on the PVMS, operational status of a sensor over a period of time can be generated from raw information. NH DOT (and other DOTs) use these plots and reports from vendor software to generate reports and analyze the data.

“NHDOT collects speed, volume and occupancy data from sensors. NHDOT does not evaluate data in real time. If a pattern is seen in the data, they work with the construction personnel to make a change in traffic control. NHDOT generates a monthly reports that provides information on work zone incidents.”¹⁵

http://www.nhtmc.com/Dashboard/TMC_Operations/

Comprehensive report using historical data with custom plots requires development of custom data analysis tools which is typically not covered under the scope of the Contactor’s work. Some states assign this as a task to an external consultant or collaborate with research groups in universities. Iowa DOT in collaboration with Center for Transportation Research and Education at Iowa State University (CTRE) has invested considerable effort and time to generate extensive analysis and reporting of work zone data. CTRE website contains plots with near real-time performance information (average and maximum - delay and queue length, speed heat map, sensor performance, volume, etc.). The university research center assists IOWA DOT in analysis and reporting that requires major effort.

“IOWA DOT works with the Center for Transportation Research and Education at Iowa State University doing extensive data collection and analysis—both near real-time and long-term. Various performance measures data can be queried and plotted at the following site.”¹⁶

<http://reactor.ctre.iastate.edu/TCP/overview.html>

¹⁵ Portable Work Zone Management Systems (ITS in Work Zones) Technology Review and Workshop Presentation: Background Material, IBI Group Memorandum dated August 22, 2016.

¹⁶ Ibid

Source: VER-MAC - 2013 TX DOT Waco Speed-Mac AQW PI Sheet (Project Info / Cut Sheet from Vendor)



Source: VER-MAC - 2013-16 MA I-95 Whittier Bridge SWZ PI Sheet (Project Info / Cut Sheet from Vendor)

The screenshot displays a software interface with a menu bar (File, Edit, View, Tools, Options, Window), a toolbar, and a 'Begins With' search field. The main area is divided into a 'Devices' table and a 'Map' window.

Type	Status	Name	Voltage	Value
	Green hexagon	I-95 Sensor 07 (S of I-95) SB/NB	13.30 V	NB SB 46 mph 68 mph
	Green hexagon	I-95 Sensor 08 (N of I-95) SB/NB	13.20 V	NB SB 75 mph 53 mph
	Green hexagon	I-95 Sensor 09 (N of Main St/S of Exit 60) SB/NB	13.20 V	NB SB 57 mph 68 mph
	Green hexagon	MAIN ST EB (Prior to I-95 Ramp) PCMS 03	11.84 V	I-95 TO RTE 110 EXIT 57 2
	Green hexagon	MAIN ST WB (Prior to Toll Rd) PCMS 04	13.82 V	5 MILES 8 MINS 11:51 PM
	Green hexagon	NB (EB) I-95 (Prior to Exit 54) PCMS 10	12.43 V	I-95 TO RTE 286 EXIT 60 2
	Green hexagon	NB I-495 PCMS 10 to Rte 286 (Exit 60) = Route 10		00:04:49
	Green hexagon	NB I-95 (0.5 mi b4 Exit 58/Rte 110) PCMS 09	12.51 V	I-95 TO RTE 286 EXIT 60 2
	Green hexagon	NB I-95 (Prior to Exit 54/Rte 133) PCMS 14	12.57 V	I-95 TO RTE 110 EXIT 58 2
	Green hexagon	NB I-95 (Prior to Exit 57/Rte 113) PCMS 13	12.66 V	I-95 TO RTE 110 EXIT 58 2
	Green hexagon	NB I-95 PCMS 11 (Rte 113/Exit 57) to (Rte 110/Exit 58) = Route 11		00:02:20
	Green hexagon	NB I-95 PCMS 13 to (Rte 110/Exit 58) = Route 13		00:03:17
	Green hexagon	NB I-95 PCMS 14 to (Rte 110/Exit 58) = Route 14		00:12:40

The 'Map' window shows a geographic view of the I-95 corridor in Massachusetts, with various locations labeled such as Kensington, Hampton Falls, Amesbury, Salisbury, and Newburyport. A green line indicates the I-95 route, and several blue icons are placed along it, corresponding to the device locations in the table.

Source: VER-MAC - 2013-14 MA Callahan Tunnel RTTM PI Sheet (Project Info / Cut Sheet from Vendor)

The screenshot displays the Ver-Mac JamLogic software interface. The main window shows a table of PCMS devices with columns for Type, Status, Name, Voltage, Value, and Image. The device PCMS 08 I-93 SB at Tunnel Entrance is highlighted in blue. To the right, a map shows the Boston area with a highlighted route. A properties window is open for the selected device, showing details like Name, Status, Last Communication, and Description.

Type	Status	Name	Voltage	Value	Image
	Green Hexagon	PCMS 05 - Rutherford Ave	11.92 V	DELAYS VIA TOBIN E 2	Ver-Mac CP0 2014-01-14 19:51:58
	Green Hexagon	PCMS 06 Nashua St	12.11 V	EXPECT MAJOR DELAYS 2	Ver-Mac CP0 2014-01-14 19:51:46
	Green Hexagon	PCMS 07 SBRR at Ramp A	12.19 V	2 MILES 5 MINS 9:51 2	Ver-Mac CP7 2014-01-14 19:53:02
	Green Hexagon	PCMS 08 I-93 SB at Tunnel Entrance	12.25 V	CALLAHAN TUNNEL CLOSED	Ver-Mac CP8 2014-01-14 19:53:22
	Green Hexagon	PCMS 09 Storrow EB at Charles	12.18 V	CONSIDER RTE 1 N TOBIN E 2	Ver-Mac CP 9 2014-01-14 16:01:17

Properties Window:
 VmsDevice: PCMS 08 I-93 SB at Tunnel Entrance
 Name: PCMS 08 I-93 SB at Tunnel Entrance
 Status: OK
 Last Communication: 1/14/2014 4:51:28 PM
 Description: NE# 451

English (United States) 0-SWZ - MA - Boston Callahan Tunnel 4:52 PM (-05:00)

Source: ASTI (Screenshot-Hosting NH DOT Data)

The screenshot displays the ASTI Transportation ITS Management System interface. The browser address bar shows the URL: `asti-traffic.com/tcm/default.aspx?id=5f0b778d-d3e6-477e-bf91-a56ceb30cf87,fd5e3978-9043-4e20-b804-993b518c3daf`. The search bar contains "NHDOT travel time".

The main map area shows a section of the Piscataqua River and the border between Maine and New Hampshire. A road labeled "4" is highlighted in orange, indicating a speed zone. Various icons are placed along the road to represent different sensor statuses.

Two data windows are overlaid on the map:

- M01 device view:**
 - M01 Message
 - Current Message: **3 MINS**, **3 MILES**, **TO US 4**
 - Loaded!
- 61334515i device view:**
 - 61334515i Data
 - Current Sensor Data
 - Refreshing Data. Please Wait...
 - Speed**
 - S Lanes Average Speed: 63
 - Lane #1 63
 - Volume**
 - S Lanes Total: 1 Hourly: 50 Daily: 640
 - Lane #1 1
 - Density**
 - S Lanes Average Density: 0
 - Lane #1 0
 - Loaded!

A **Map Legend** is located in the bottom right corner of the map area:

- Speed > 45 mph (Green tree icon)
- Speed 15 to 45 mph (Yellow house icon)
- Speed < 15 mph (Red house icon)
- Inactive (Grey house icon)
- Live Video (Camera icon)
- Roadside Alerts (Speaker icon)

At the bottom of the screen, there is a navigation bar with the text: "Click the 'Menu' button to access available map customization options". The status bar at the very bottom shows "www.nhtmc.com/Work_Zones/travel_time.html", "334515i device view", "Next update in: 32", "11:00 AM", and "10/13/2016".

Source i-Cone, screenshot from demo view

The screenshot displays the iCone web application interface. The main map shows a location in Dallas, Texas, with a red and green iCone icon. A popup window provides details for iCone 0x063C, including location and data times. A 'Reports' window is open, showing configuration options for a 24-hour report for Project 499. A 'Travel Time' graph window shows a line chart of travel time over a 24-hour period. The sidebar on the right contains navigation links and data record information.

iCone® 0x063C
 GroupID: 70
 Project 499(NTTA-IN1): DNT NB

Info Details Config

Location Time: 2016-07-20 06:09:00
 Data Time: 2016-07-20 12:01:00
 Avg Speed: 9 mph
 Battery: 13.562 V
 Switch: On

[Get Historical Report](#)

iCone® Reports - Mozilla Firefox

iconetraffic.com/tools/reports.aspx?icone=1861&offset=-4&icc

Close Window Advanced

Time Selection
 Time Range: 24 Hours
 Start Time: 07/19/2016 12:00
 Stop Time: 07/20/2016 12:00
 Smoothing Interval: 5 Minutes

iCone Selection
 iCone ID: 1861

Project Selection
 Project ID: 499
 Queuing Speed (mph): 40

Download

Location: Speed Voltage Travel Time* Queue Length*
 Reads Temperature Prevailing Spd*

[CSV](#) [Graph](#)

*Some reports may require a specific setup. Please contact iCone for more details.

projectTravelTime-1 - Windows Photo Viewer

File Print E-mail Burn Open

Travel Time for Project 499
 5 Minute Intervals

Travel Time (min)

Tue, Jul 19 12:00:00 PM Tue, Jul 19 06:00:00 PM Wed, Jul 20 12:00:00 AM Wed, Jul 20 06:00:00 AM Wed, Jul 20 12:00:00 PM

view my 119 iCones®

Get All Current iCones®

Historical Display

Display Time:

Show All iCones®:

[Get Data](#)

iCone® Data Records

Sample Timestamp Formats:
 '2013-2-18 13:20'
 '2/18/13 13:20'
 'Feb 18, 2013 1:20 PM'
 'February 18, 2013 1:20 PM'

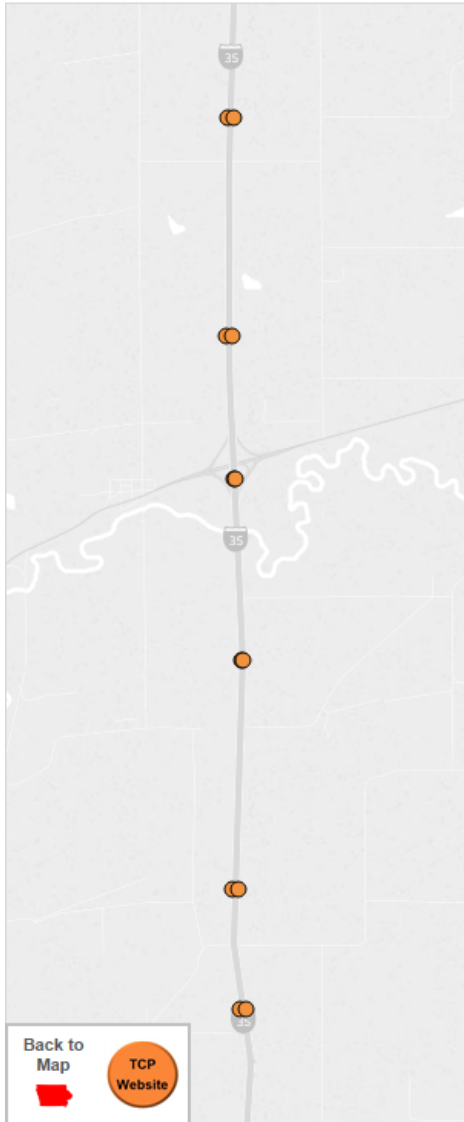
Sample iCone® ID Formats:
 '123'
 '0x0ABC'

Source: IOWA DOT/CTRE Website - Sensor Performance

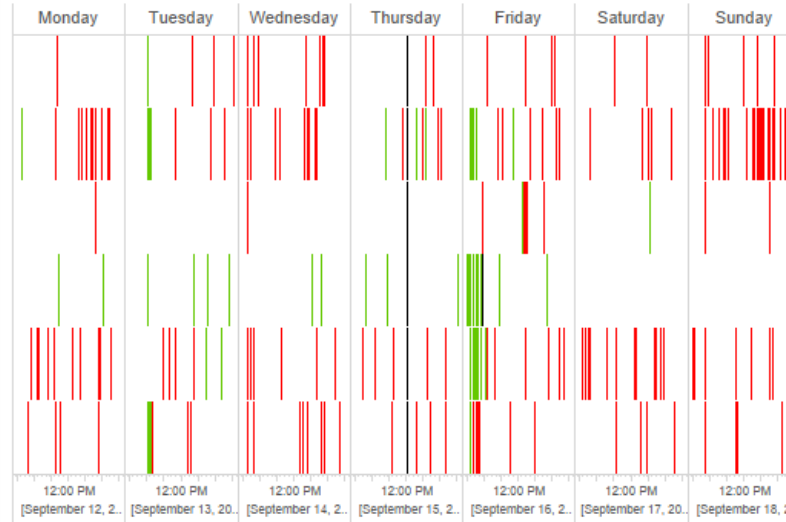
Group 5b and 5.4

Range: 9/12/2016 to 9/18/2016

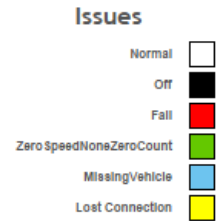
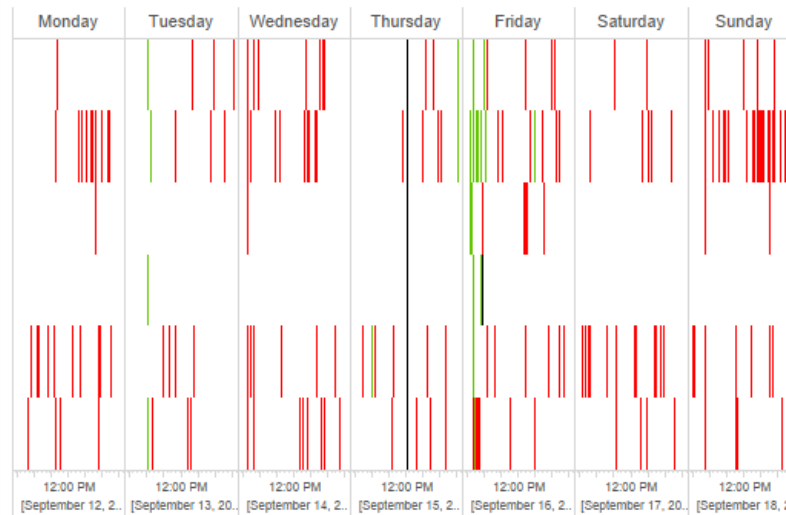
Last Updated: 9/19/2016 7:54:27 AM



Northbound



Southbound

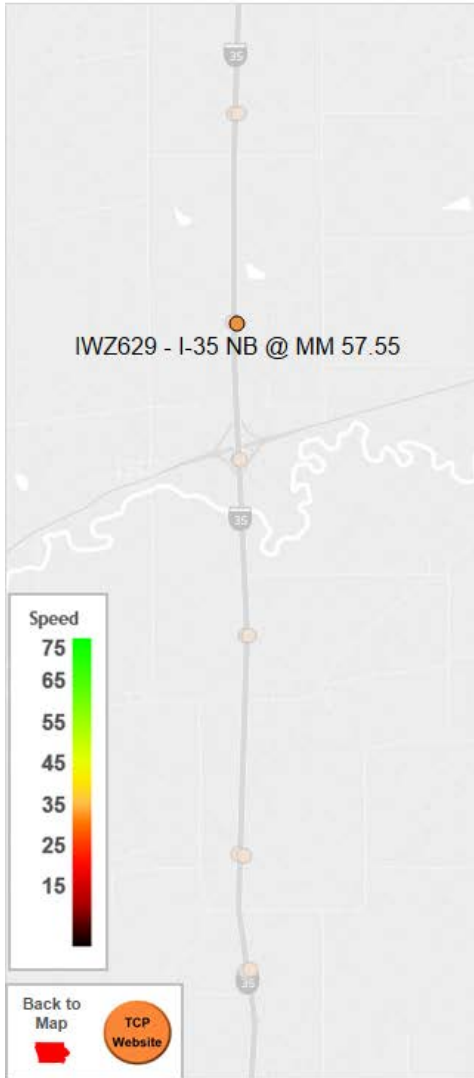


Source: IOWA DOT/CTRE Website - Heat Map

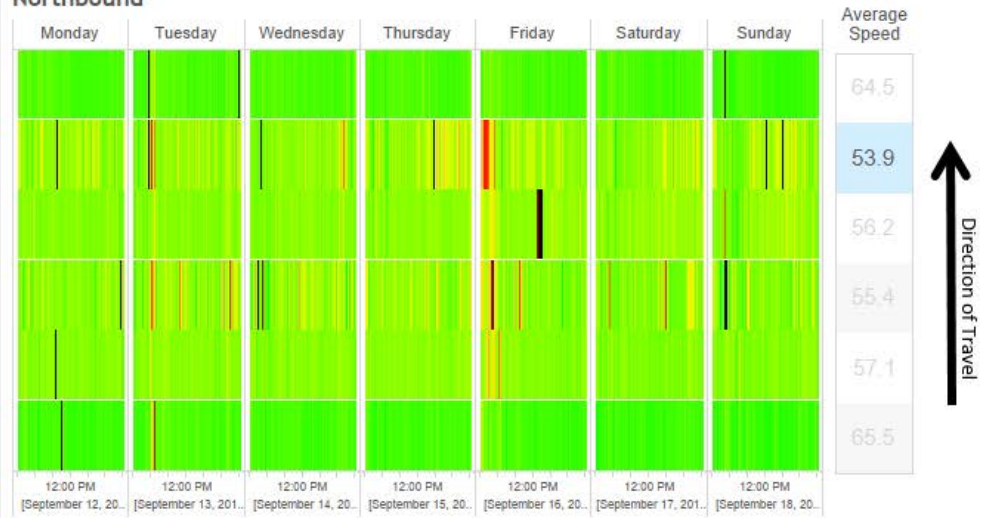
Group 5b and 5.4

Range: 9/12/2016 to 9/18/2016

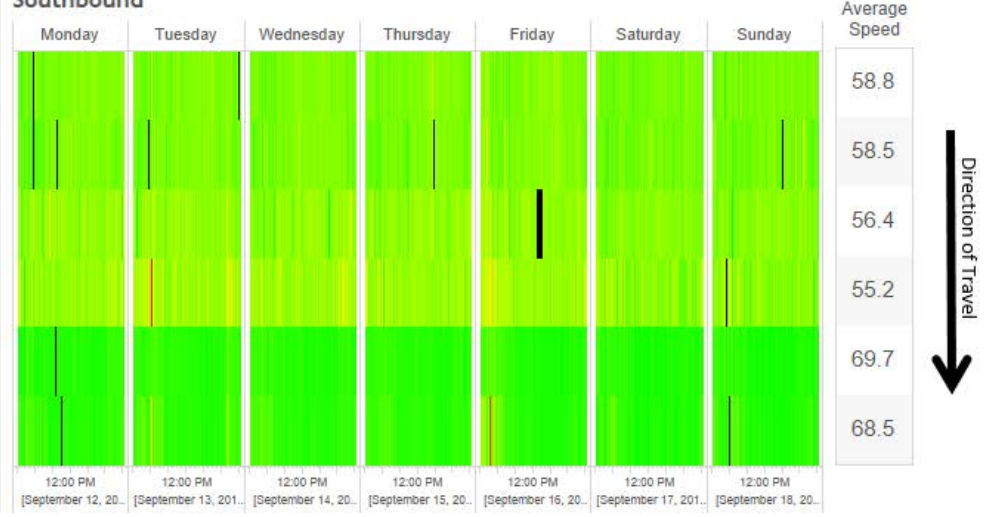
Last Updated: 9/19/2016 7:54:27 AM



Northbound



Southbound



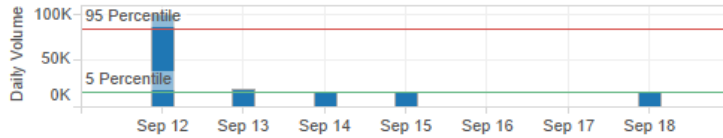
Source: IOWA DOT/CTRE Website - Daily Performance

Group 5b and 5.4

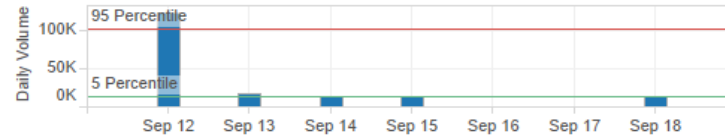
Range: 9/12/2016 to 9/18/2016

Last Updated: 9/19/2016 7:54:27 AM

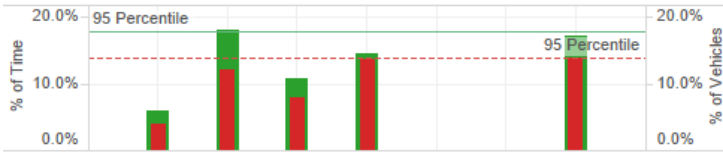
Northbound - Daily Volume



Southbound - Daily Volume



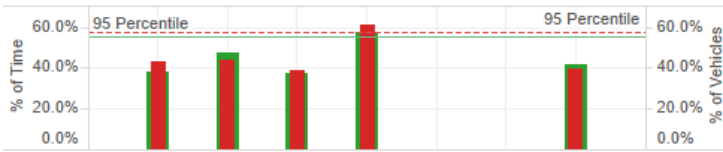
Northbound - Speed < 45 mph



Southbound - Speed < 45 mph



Northbound - Delay > 10%



Southbound - Delay > 10%



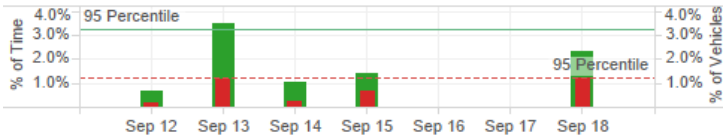
Northbound - Delay > 30%



Southbound - Delay > 30%



Northbound - Delay > 50%



Southbound - Delay > 50%



[Back to Map](#)

Measure Names
■ % of Time
■ % of Vehicles

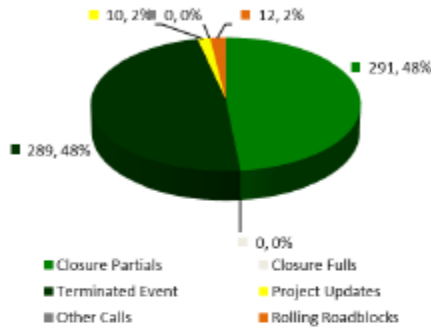
Source NHDOT report July 2016:

Work Zone Communication

July 2016

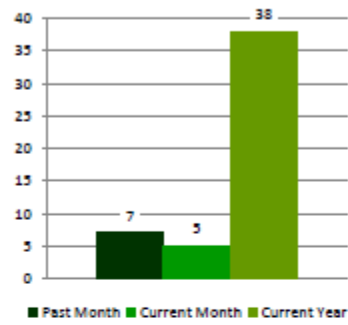
Current Month – Construction Calls

This graph shows the different types of construction related calls that dispatchers receive.

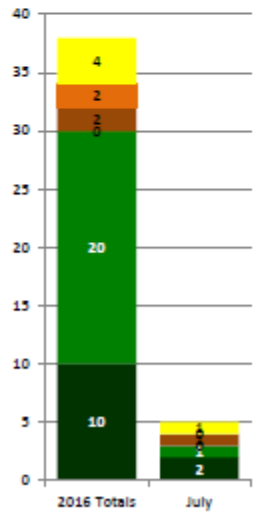


Incidents Occurring in Work Zones

This graph shows the total number of incidents reported on Work Zone Crash Reports from the Bureau of Construction..

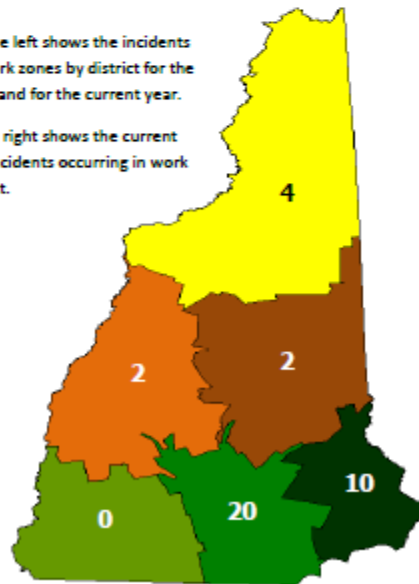


Incidents Occurring in Work Zones by Location



The graph to the left shows the incidents occurring in work zones by district for the current month and for the current year.

The map to the right shows the current year total for incidents occurring in work zones by district.



Appendix C – Sample SEAFORM



ITS Projects – Systems Engineering Analysis FORM (SEAFORM)

The Checklist needs to be filled out by the Project Manager. Please refer to the guidance document accompanying the checklist for information on the checklist items as well as a completed example.

Project Name:		
Date	Name of Person Filling/Modifying the Form	Notes

ITS Projects – Systems Engineering Analysis FORM (SEAFORM)

SECTION 1 – Project Information

1.1 PROJECT TITLE	1.2 PROJECT NUMBER <input type="checkbox"/> New Project <input type="checkbox"/> Modification to existing Project
--------------------------	--

1.3 BRIEF DESCRIPTION/PURPOSE

1.4 CONTACT PERSON/GROUP	1.5 PROJECT LOCATION	1.6 PERIOD OF PERFORMANCE	1.7 BUDGET & FUNDING SOURCE
---------------------------------	-----------------------------	----------------------------------	--

1.8 NATURE OF WORK
 Scoping Design Software/Integration Implementation Operations Evaluations Others (Please specify)
 If Other, Please Specify

1.9 RELATIONSHIP TO OTHER PROJECTS AND PHASES

1.10 EQUIPMENT TO BE PURCHASED WITH PROJECT FUNDING

1.11 STATUS <input type="checkbox"/> CMAQ <input type="checkbox"/> Environmental Compliance, If applicable <input type="checkbox"/> SLOSS/Safety Improvement	<input type="checkbox"/> TIP/STIP Approval <input type="checkbox"/> FHWA Authorization
--	---

1.12 IS THERE A WORK PLAN FOR THIS PROJECT WITH TASK BREAKDOWN?
 No
 Yes, Provide Document Reference
 To Be Developed

SECTION 2 – Needs Assessment

2.1 WHAT IS/ARE THE PROBLEM(S) WITH THE CURRENT SITUATION?

2.2 WHAT NEEDS DOES THIS PROJECT ADDRESS?

2.3 HOW WERE THESE NEEDS IDENTIFIED?
 Internal CTDOT Assessment Town / City Request From CE Technical Review or other studies Other
 Please provide details on how needs were identified – If other documentation was used as reference, please identify it here.

SECTION 3 – Regional Architecture Assessment and Concept Exploration

3.1 TOWN / CITY IN CTDOT REGIONAL ARCHITECTURE INCLUDED IN DESIGN ATMS03
 Included Yes No
 Architecture is a project specific description of both logical and physical elements arranged in a hierarchical form showing inter-connections among the elements.

3.2 INVENTORY CURRENT SYSTEMS IN CTDOT REGIONAL ARCHITECTURE INCLUDED IN PROJECT

3.3 SYSTEM IMPACTS / INTEGRATION (I.E DATA EXCHANGES) DUE TO PROJECT. PORTIONS OF ARCHITECTURE BEING IMPLEMENTED

3.4 OTHER REGIONAL ARCHITECTURES IMPACTED BY PROJECT

NYDOT Massachusetts Other CTDOT Districts CTDOT Statewide None

Changes communicated to appropriate architecture maintenance agencies Yes No

3.5 CHANGES RECOMMENDED TO CTDOT and/or REGIONAL ARCHITECTURES

Yes No

If "Yes", Please Specify and provide detail

SECTION 4 – Alternative Analysis

4.1 WERE ANY ALTERNATE CONCEPTS/IDEAS CONSIDERED? ANY OTHER SOLUTIONS TO THE PROBLEM?

Yes No

Please Specify how the best concept was selected

4.2 REFERENCE DOCUMENTS (IF ANY)

SECTION 5 – Concept of Operations

5.1 IS THERE A CONCEPT OF OPERATIONS (COO) FOR THIS PROJECT?

Yes No To Be Developed

If "No" was selected, please specify reason

The Concept of Operations is a description of how the system will be used.

5.2 IF "Yes" WAS SELECTED, PLEASE FILL OUT THE FOLLOWING

COO Contains:

Scope (Geographic, Timeframe, Region etc)

- | | |
|--|--|
| – Description of what the project/system is expected to do | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| – Roles and Responsibilities for Town / City / State | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| – Operational Scenarios | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| – Project/System Impacts | <input type="checkbox"/> Yes <input type="checkbox"/> No |

If "No" was checked in any of the boxes, please specify reason

SECTION 6 – Requirement Definitions (High-Level and Detailed)

6.1 ARE HIGH-LEVEL FUNCTIONAL REQUIREMENTS WRITTEN AND DOCUMENTED

Yes No To Be Developed

High-level design is the transitional step between WHAT the proposed requirements i.e. Design Scope and HOW system will be implemented i.e. Preliminary Engineering, Preliminary Design, SF and FD.

6.2 IF "Yes" WAS SELECTED, PROVIDE REQUIREMENTS DOCUMENT REFERENCE IF AVAILABLE

Attached Unavailable

SECTION 7 – Detailed Design

7.1 IS THERE A DESIGN DOCUMENT AVAILABLE

Yes No To Be Developed

Please provide reference to design document

Signal system elements, standard interfaces and System Integration structured into modules.

7.2 IF "YES" WAS SELECTED, PLEASE FILL OUT THE FOLLOWING

- Are the design details well documented Yes No
- Do the details of the design trace to requirements definitions Yes No
- Are boundaries and interfaces of the system clearly identified Yes No
(Limit of computer, signal, camera control)
- Is there a process for Configuration Control Yes No
(System Setup by Contractor or Highway ops.)

If No was checked in above boxes , please provide an explanation

7.3 DOES THE DESIGN INCORPORATE NATIONAL ITS STANDARDS

No Yes

IF YES, Please mention what ITS Standards are being used

Standards development statuses as of May 2, 2007 http://www.standards.its.dot.gov/Status_Published.asp

NEMA/AASHTO/ITE

[Advanced Transportation Controller \(ATC\) Standard Specification for the Type 2070 Controller](#) ITE ATC Type 2070

AASHTO/ITE

[Standard for Functional Level Traffic Management Data Dictionary \(TMDD\)](#) ITE TM 1.03

[Message Sets for External TMC Communication \(MS/ETMCC\)](#) ITE TM 2.01

AASHTO/ITE/NEMA

[Transportation Management Protocols \(TMP\)](#) NTCIP 1103

[Center-to-Center Naming Convention Specification](#) NTCIP 1104

[Object Definitions for Signal Control and Prioritization \(SCP\)](#) NTCIP 1211

[Structure and Identification of Management Information](#) NTCIP 8004

[Testing and Conformity Assessment Documentation within NTCIP Standards Publications](#) NTCIP 8007

ANSI

[Commercial Vehicle Safety Reports](#) ANSI TS284

[Commercial Vehicle Safety and Credentials Information Exchange](#) ANSI TS285

[Commercial Vehicle Credentials](#) ANSI TS286

APTA

[Standard for Transit Communications Interface Profiles](#) APTA TCIP-S-001 3.0.0

ASTM

[Standard Specification for Dedicated Short Range Communication \(DSRC\) Physical Layer using Microwave in the 902-928 MHz Band](#) ASTM

E2158-01

[Standard Specification for Telecommunications and Information Exchange Between Roadside and Vehicle Systems - 5 GHz Band Dedicated Short](#)

[Range Communications \(DSRC\) Medium Access Control \(MAC\) and Physical Layer \(PHY\) Specifications](#) ASTM E2213-03

[Standard Guide for Archiving and Retrieving ITS-Generated Data](#) ASTM E2259-03

[Standard Practice for Metadata to Support Archived Data Management Systems](#) ASTM E2468-05

EIA

[Data Radio Channel \(DARC\) System](#) EIA 794

[Subcarrier Traffic Information Channel \(STIC\) System](#) EIA 795

IEEE

[Standard for Message Sets for Vehicle/Roadside Communications](#) IEEE 1455-1999

[Standard for Common Incident Management Message Sets for use by Emergency Management Centers](#) IEEE 1512 -2006

[Standard for Traffic Incident Management Message Sets for Use by Emergency Management Centers](#) IEEE 1512.1-2006

[Standard for Public Safety Traffic Incident Management Message Sets for Use by Emergency Management Centers](#) IEEE 1512.2-2004

[Standard for Hazardous Material Incident Management Message Sets for Use by Emergency Management Centers](#) IEEE 1512.3-2006

[Standard for the Interface Between the Rail Subsystem and the Highway Subsystem at a Highway Rail Intersection](#) IEEE 1570-2002

[Standard for Wireless Access in Vehicular Environments \(WAVE\) - Resource Manager](#) IEEE 1609.1-2006

[Standard for Wireless Access in Vehicular Environments \(WAVE\) - Security Services for Applications and Management Messages](#) IEEE 1609.2-

2006

[Standard for Wireless Access in Vehicular Environments \(WAVE\) - Multi-Channel Operation](#) IEEE 1609.4-2006

[Standard for Wireless Access in Vehicular Environments \(WAVE\) - Networking Services](#) IEEE P1609.3

[The Survey and Analysis of Existing Standards and those Under Development Applicable to the Needs of the Intelligent Transportation System \(ITS\)](#)

[Short Range and Wide Area Wireless and Wireline Technologies](#) IEEE SH94633-SH94638

NEMA/AASHTO/ITE

[Advanced Transportation Controller \(ATC\)](#) ITE ATC Controller 5.2

[ITS Standard Specification for Roadside Cabinets](#) ITE ITS Cabinet

AASHTO/ITE

[TMDD & MS/ETMCC Guide Standard for Functional Level Traffic Management Data Dictionary \(TMDD\) and Message Sets for External Traffic](#)

[Management Center Communications](#) ITE TMDD Guide

AASHTO/ITE/NEMA

[Simple Transportation Management Framework \(STMF\)](#) NTCIP 1101

[Octet Encoding Rules \(OER\) Base Protocol](#) NTCIP 1102

[Global Object Definitions](#) NTCIP 1201

[Object Definitions for Actuated Traffic Signal Controller \(ASC\) Units](#) NTCIP 1202

[Object Definitions for Dynamic Message Signs \(DMS\)](#) NTCIP 1203

[Object Definitions for Environmental Sensor Stations \(ESS\) NTCIP 1204](#)
[Object Definitions for Closed Circuit Television \(CCTV\) Camera Control NTCIP 1205](#)
[Object Definitions for Data Collection and Monitoring \(DCM\) Devices NTCIP 1206](#)
[Object Definitions for Ramp Meter Control \(RMC\) Units NTCIP 1207](#)
[Object Definitions for Closed Circuit Television \(CCTV\) Switching NTCIP 1208](#)
[Data Element Definitions for Transportation Sensor Systems \(TSS\) NTCIP 1209](#)
APTA
[TCIP Framework Standard NTCIP 1400](#)
[TCIP Common Public Transportation \(CPT\) Objects NTCIP 1401](#)
[TCIP Incident Management \(IM\) Objects NTCIP 1402](#)
[TCIP Passenger Information \(PI\) Objects NTCIP 1403](#)
[TCIP Scheduling/Runcutting \(SCH\) Objects NTCIP 1404](#)
[TCIP Spatial Representation \(SP\) Objects NTCIP 1405](#)
[TCIP On-Board \(OB\) Objects NTCIP 1406](#)
[TCIP Control Center \(CC\) Objects NTCIP 1407](#)
[TCIP Fare Collection \(FC\) Business Area Objects NTCIP 1408](#)
AASHTO/ITE/NEMA
[Class B Profile NTCIP 2001](#)
[Point to Multi-Point Protocol Using RS-232 Subnetwork Profile NTCIP 2101](#)
[Point to Multi-Point Protocol Using FSK Modem Subnetwork Profile NTCIP 2102](#)
[Point-to-Point Protocol Over RS-232 Subnetwork Profile NTCIP 2103](#)
[Ethernet Subnetwork Profile NTCIP 2104](#)
[Transportation Transport Profile NTCIP 2201](#)
[Internet \(TCP/IP and UDP/IP\) Transport Profile NTCIP 2202](#)
[Simple Transportation Management Framework \(STMF\) Application Profile NTCIP 2301](#)
[Trivial File Transfer Protocol \(TFTP\) Application Profile NTCIP 2302](#)
[File Transfer Protocol \(FTP\) Application Profile NTCIP 2303](#)
[Application Profile for DATEX-ASN \(AP-DATEX\) NTCIP 2304](#)
[Profile Framework NTCIP 8003](#)
[NTCIP Guide NTCIP 9001](#)
[XML in ITS Center-to-Center Communications NTCIP 9010](#)
SAE
[Truth-in-Labeling Standard for Navigation Map Databases SAE J1663](#)
[Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicle Applications SAE J1708](#)
[ISP-Vehicle Location Referencing Standard SAE J1746](#)
[Standard Metrology for Vehicular Displays SAE J1757](#)
[ITS Data Bus Data Security Services SAE J1760](#)
[Location Referencing Message Specification \(LRMS\) SAE J2266](#)
[On-Board Land Vehicle Mayday Reporting Interface SAE J2313](#)
[Mayday Industry Survey Information Report SAE J2352](#)
[Message Set for Advanced Traveler Information System \(ATIS\) SAE J2354](#)
[ITS Data Bus Architecture Reference Model Information Report SAE J2355](#)
[Calculation of the Time to Complete In-Vehicle Navigation and Route Guidance Tasks SAE J2365](#)
[ITS Data Bus - IDB-C Physical Layer SAE J2366/1](#)
[ITS Data Bus - Low Impedance Stereo Audio SAE J2366/1L](#)
[ITS Data Bus - Link Layer SAE J2366/2](#)
[ITS Data Bus - Thin Transport Layer SAE J2366/4](#)
[ITS Data Bus - Application Message Layer SAE J2366/7](#)
[Standard for ATIS Message Sets Delivered Over Reduced Bandwidth Media SAE J2369](#)
[Field Test Analysis Information Report SAE J2372](#)
[Stakeholders Workshop Information Report SAE J2373](#)
[ITS In-Vehicle Message Priority SAE J2395](#)
[Definitions and Experimental Measures Related to the Specification of Driver Visual Behavior Using Video Based Techniques SAE J2396](#)
[Adaptive Cruise Control \(ACC\) Operating Characteristics and User Interface SAE J2399](#)
[Human Factors in Forward Collision Warning Systems: Operating Characteristics and User Interface Requirements SAE J2400](#)
[Comparison of GATS Messages to SAE ATIS Standards Information Report SAE J2539](#)
[Messages for Handling Strings and Look-Up Tables in ATIS Standards SAE J2540](#)
[RDS \(Radio Data System\) Phrase Lists SAE J2540/1](#)
[ITIS \(International Traveler Information Systems\) Phrase Lists SAE J2540/2](#)
[National Names Phrase List SAE J2540/3](#)
[Converting ATIS Message Standards from ASN.1 to XML SAE J2630](#)
[Dedicated Short Range Communications \(DSRC\) Message Set Dictionary SAE J2735](#)

Turbo Architecture – “Standards Report” Attached Unavailable

7.4 DOES THE DESIGN INCORPORATE ANY CTDOT STANDARDS

No Yes,

If Yes, Please mention what CTDOT Standards are being used

SECTION 8 – Implementation

8.1 PROCURMENT DETAILS

(i.e. Competitive Low Bid)

8.2 REFERENCE DOCUMENTS (IF ANY)

Turbo Architecture – “List of Agreements” Attached Unavailable

SECTION 9 – Integration and Test

9.1 IS THERE AN INTEGRATION PLAN

No Yes To Be Developed

If “Yes” Please provide reference

An Integration Plan as a separate written document is not always needed. The complexity of the system, the complexity of the eventual deployment of the system and the complexity of the development effort, influence the decision to prepare an Integration Plan.

Integration Plan includes and covers integration of all of the components and sub-systems either developed or purchased of the project.

Account for all external systems to be integrated with the system (i.e. communications networks, field equipment and other systems owned by controlling agency.)

An Integration Plan should identify all participants, define what their roles and responsibilities are, establish the sequence - schedule for every integration step and document how integration problems are recorded and resolved.

9.2 IS THERE A TEST PLAN

No Yes To Be Developed

If “Yes” Please provide reference

SECTION 10 – System Verification and Acceptance

10.1 IS THERE A SYSTEM VERIFICATION AND ACCEPTANCE PLAN (verification of the entire system and acceptance criteria)

No Yes To Be Developed

If “Yes” Please provide reference

(i.e. Signal, Construction checklist)

10.2 IF YES, PLEASE FILL OUT THE FOLLOWING

- Is there a clear criteria for completion Yes No
- Are there clear performance metrics for system acceptance Yes No
- Will there be adequate system documentation for all users and maintainers Yes No

If No was checked in above boxes , please provide an explanation

SECTION 11 – Operations and Maintenance

11.1 WHO WILL MAINTAIN THE SYSTEM

11.2 IS THERE A SCHEDULE FOR UPGRADES/ENHANCEMENTS TO THE SYSTEM

11.3 WILL THERE BE AN EVALUATION OF THE SYSTEM



Prepared for Connecticut Department of Transportation
by IBI Group