
Work Zone Intrusion Warning System

System Requirements

December 2015

Acknowledgements

This document was prepared for the Minnesota Department of Transportation (MnDOT) Systems Engineering for Work Zone Challenges project.

Project Champion

Rashmi Brewer, is the MnDOT project champion for this effort. MnDOT stakeholders and a project management team were heavily involved in identifying the key challenges with using Intelligent Transportation Systems to address and enhance safety, operations, mobility and efficiency in work zones. This document covers the system requirements to address some of these challenges.

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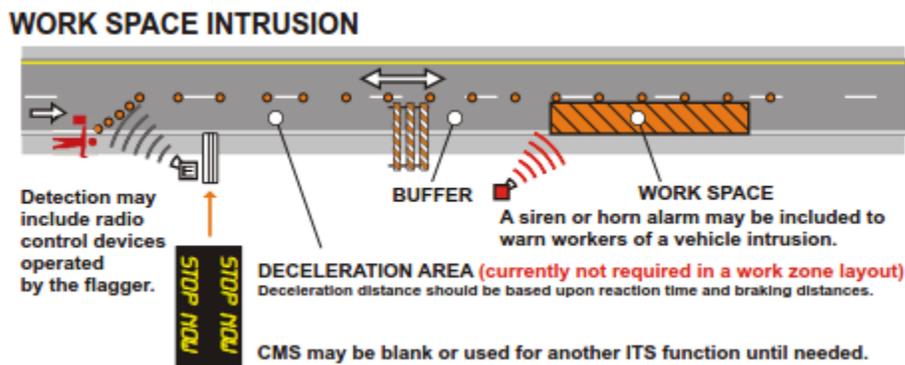
Introduction

This document provides high-level system requirements for a Work Zone Intrusion Warning System (WIWS) to support enhanced work zone safety. The requirements in this document are derived from the companion Concept of Operations for WIWS, which is one of three Work Zone Challenges identified that may be addressed using Intelligent Transportation System (ITS) technologies. The other two ITS Systems identified to potentially address Work Zone Challenges are: End of Queue Warning System; and Distracted Driver Alert System.

This set of requirements should be considered as a starting point for system requirements development for a project. In addition, a set of requirements that fuses all three ITS Work Zone systems should be considered, as there will be instances when all three systems may be deployed together and several elements of the systems overlap or interoperate.

Work Intrusion Warning Systems are installed upstream of a work zone to address drivers not complying with the work zone and roadway messaging and entering an active work area where workers are located. These systems improve upon existing work zone signage which intends to provide safety to workers, allow sufficient space for roadway work, and provide signs and/or messaging systems that improve roadway safety and inform motorists. WIWS offers an alert to roadway workers when a non-authorized vehicle enters the work zone. WIWS typically consists of static signing, detection devices, Dynamic Message Signs (DMS or CMS), and an alarm or other notification device, as seen in Figure 1. The WIWS configuration in Figure 1 is found in the Minnesota Department of Transportation Intelligent Work Zone (IWZ) Toolbox guidance document.

Figure 1 Typical Work Space Intrusion Warning System Configuration



Both the system requirements and concept of operations are intended to illustrate the basic needs and requirements surrounding WIWS, as well as, serve as model documents that may be adapted to meet individual deployments. The materials do not mandate the deployment of such systems, nor do they limit the engineering judgment or policy discretion of the transportation agencies who may consider deploying WIWS. The materials reflect stakeholder needs and they should be adapted as necessary to reflect any unique or additional needs and requirements driven by individual deployments. The remainder of this document presents high-level system functional requirements for WIWS as derived from the previously developed concept of operations.

System Requirements

High-level system functional requirements are verifiable statements that define what a work zone intrusion warning system will do, but not how it is accomplished (i.e. from a technical/technology standpoint). An important starting point for developing system requirements is to understand where the system is reflected within the National ITS architecture. This section shows how WIWS fit within the National ITS Architecture version 7.1, and then presents a series of high-level system functional requirements associated with the detection, alert, and system operation functions.

WIWS and the National ITS Architecture

WIWS are considered part of the [Maintenance and Construction Operations User Service](#) in the National ITS Architecture, version 7.1. Systems within in this user service provide Work Zone Management Safety function, which provides support for the effectiveness, safety, and efficiency of roadway operations during all work zone activities. The service will provide information concerning work zone activities.

Within the physical architecture of the National ITS Architecture, WIWS are primarily addressed under the following:

- Roadway (Subsystem)
 - Roadway Work Zone Safety (Equipment Package)
 - MC09 Work Zone Safety Monitoring (Service Package)
- Maintenance and Construction Vehicle (Subsystem)
 - Maintenance and Construction Vehicle (Equipment Package)
 - ATIS09 In Vehicle Signing (Service Package)
 - MC09 Work Zone Safety Monitoring (Service Package)
- Maintenance and Construction Management. (Subsystem)
 - MCM Work Zone Safety Management (Equipment Package)
 - MC09 Work Zone Safety Monitoring (Service Package)

Table 1 presents a series of high-level requirements as they are presented within the Roadway Work Zone Safety Equipment Package, Maintenance and Construction Vehicle Equipment Package, and MCM Work Zone Safety Management Equipment Package of the National ITS Architecture. Currently, the applicable requirements have been incorporated into the document.

Table 1 WIWS Functional Requirements from “Roadway Work Traffic Control” and “MCM Work Zone Management” Equipment Packages from National ITS Architecture

Roadway Work Zone Safety Equipment Package	Functional Requirements
	1. The field element shall include work zone intrusion detection devices that detect when a vehicle has intruded upon the boundary of a work zone, under center control.
	2. The field element shall include work zone intrusion detection devices that detect when crew workers have crossed the boundary between the work zone and vehicle traffic, under center control.
	3. The field element shall include work zone intrusion alerting devices that alert crew workers of a work zone emergency or safety issue such as the intrusion of a vehicle into the work zone area or movement of field crew into the travel lanes.
	4. The field element shall include work zone intrusion alerting devices that notify crew via maintenance vehicles of a work zone emergency or safety issue such as the intrusion of a vehicle into the work zone area or movement of field crew into the travel lanes.
	5. The field element shall include work zone intrusion alerting devices that alert drivers that they have intruded upon the perimeter of the work zone, or are about to do so; may provide alerts to drivers directly or via in-vehicle signing.
	6. The field element shall provide operational status for the work zone intrusion detection devices to the maintenance center.
	7. The field element shall provide fault data for the work zone intrusion detection devices to the maintenance center for repair.
	8. The field element shall provide operational status for the work zone intrusion alerting devices to the maintenance center.
9. The field element shall provide fault data for the work zone intrusion alerting devices to the maintenance center for repair.	

****“Equipment Package” from National ITS Architecture**

Table 1 WIWS Functional Requirements from “Roadway Work Traffic Control” and “MCM Work Zone Management” Equipment Packages from National ITS Architecture (cont.)

MCV Vehicle Safety Monitoring Equipment Package	Functional Requirements
	1. The maintenance and construction vehicle shall detect that a vehicle has intruded upon the boundary of a work zone. The boundary of the work zone represents an area around the maintenance and construction vehicle, which may be stationary or moving.
	2. The maintenance and construction vehicle shall receive work zone warnings from the field equipment at the roadside, other maintenance and construction vehicles.
	3. The maintenance and construction vehicle shall present work zone warnings to the field personnel using direct warning signals or in-vehicle signage functions.
	4. The maintenance and construction vehicle shall monitor the crew movements to identify when a crew member is crossing the boundary between a work zone and vehicle traffic and issue an alert to the crew member.
	5. The maintenance and construction vehicle shall provide status of the work zone warning systems to the center.

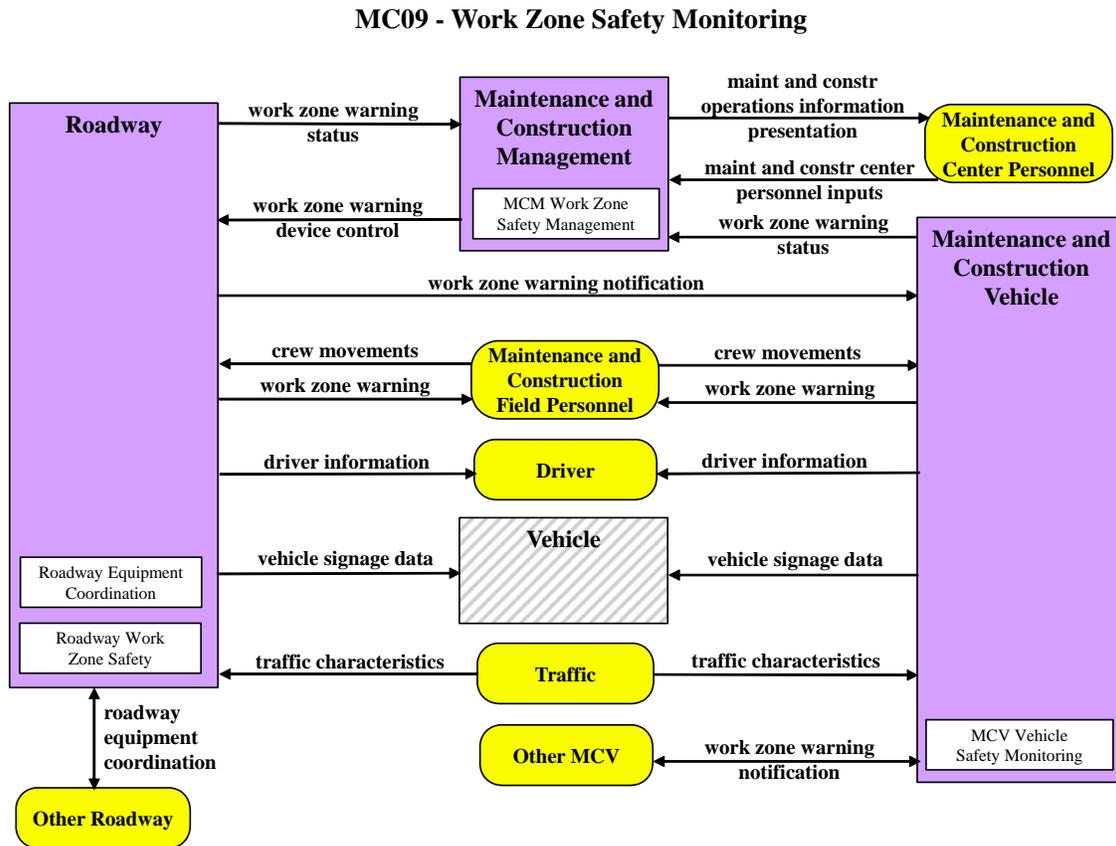
**“Equipment Package” from National ITS Architecture

MCM Work Zone Safety Management Equipment Package	Functional Requirements
	1. The center shall provide remote monitoring and control of work zone safety devices - including intrusion detection devices that have been installed in work zones or maintenance areas.
	2. The center shall provide remote monitoring and control of intrusion alert devices that have been installed in work zones or maintenance areas.
	3. The center shall collect status information of work zone safety device status from field equipment or the maintenance and construction vehicles.
	4. The center shall collect and store work zone data collected from work zone monitoring devices (such as intrusion detection or alert devices and speed monitoring devices) on-board the vehicle and at the roadside.

**“Equipment Package” from National ITS Architecture

Further illustrating how WIWS fit within the National ITS Architecture, Figure 2 shows the potential system components and interconnects within the MC09 – Work Zone Safety Monitoring Service Package.

Figure 2 MC09 – Work Zone Safety Monitoring Service Package Graphic



The information presented in this section should be reviewed, confirmed or modified within the context of any state or regional ITS architecture that may impact individual WIWS deployments.

High-Level System Functional Requirements

These system requirements are derived from the needs identified in the concept of operations. They address functional aspects of the system. Table 2 presents the requirements. The number references allow for traceability back to the needs identified in the concept of operations. The first identification number references the stakeholder need as presented in the concept of operations. The second number identifies the associated high-level functional requirement. If further derivation is needed, a third reference number is provided.

For many of these requirements, special considerations are noted to explain what details were considered as the requirement was developed or what additional details may need to be considered as the requirement is further refined for individual deployments. In some cases, the consideration may also note if a requirement is relevant to a specific type of WIWS deployment. These considerations are intended to offer context and provide insight that might help support further derivation and tailoring of the requirements to the individual deployment as needed.

Table 2 WIWS System Requirements

ID #	Needs	ID #	High Level Requirements	ID #	Detailed System Requirements
1	Workers in a work zone need an alert when a vehicle enters a restricted area.	1.1	WIWS shall detect all unauthorized vehicles entering a work zone.	1.1.1	WIWS shall detect unauthorized vehicles entering a work zone with at least XX% accuracy.
Considerations: This should cover all components needed for the system to function at a rate which is acceptable by the agency.					
				1.1.2	WIWS shall send notification within XX seconds of vehicle entering restricted area.
Considerations: The specified time should include all latency between devices and include data processing needed to generate the notification to the alert system.					
				1.1.3	WIWS shall provide a means to disable detection in the field manually to allow authorized vehicles to enter work zone.
		1.2	WIWS shall alert workers when a vehicle enters a work zone.	1.2.1	WIWS alert may be audible, visual, sensory (e.g. vibration) or a combination of any or all of these alerts.
				1.2.2	WIWS alert shall be activated within XX seconds of vehicle entering a restricted area.
Considerations: The specified time should include all latency between devices and include data processing needed to receive the notification and generate the alert.					
				1.2.3	WIWS shall only alert workers in danger, in the vehicle's path.
Considerations: In an attempt to reduce de-sensitization of the alerts only those works in immediate danger should be notified with alert (proximity of intrusion and downstream workers).					

Table 2 WIWS System Requirements (Continued)

ID #	Needs	ID #	High Level Requirements	ID #	Detailed System Requirements
2	Drivers in a work zone need an alert when their vehicle enters a restricted area.	2.1	WIWS shall provide an alert to the driver of an unauthorized vehicle when the driver crosses into a restricted area.	2.1.1	WIWS shall provide an audible and / or visual alert.
Considerations: The advancement of the connected vehicles in the coming years will provide more opportunities for the visual notifications to drivers via En-Route Driver Information. However a work zone protection system with flashing lights when a vehicle enters the restricted area may help reduce unintentional intrusions.					
				2.1.2	WIWS shall provide a physical notification when driver crosses into a restrictive area.
Considerations: Temporary rumble strips or current vehicles lane detection system, may help reduce unintentional intrusions.					
		2.2	WIWS deployment shall follow MN IWZT guidance on spacing before work space.	2.2.1	WIWS shall provide adequate buffer area to allow for braking and exit before entering work space.
Considerations: Ideal placement of signs and detectors will vary per roadway speed, braking distances, and the acceptable driver reaction time.					
		2.3	Warnings and alerts provided shall follow the existing standards to help aid in compliance and understanding.	2.3.1	WIWS messages in and approaching the work zone shall provide information that is compliant and consistent with applicable national standards.
Considerations: The MUTCD should be the starting point for how messages are displayed.					
				2.3.2	WIWS messages integrated with connected vehicles shall provide information that is compliant and consistent with national standards.
Considerations: The National ITS Architecture should be the starting point for user requirements for how En-Route driver information messages are displayed in a vehicle .					
3	Agency and Law Enforcement Officials responsible for the work zone need the system to aid enforcement by generating reports identifying locations where violations are occurring.	3.1	Field devices shall receive alerts from system of a violation.	3.1.1	WIWS shall provide an alert to the central system.
Considerations: Agency will need to determine how enforcement will be handled before requirements are established for how fast an alert to the Central System must be generated.					
				3.1.2	Central System shall provide an alert to the Law enforcement of violation.
Considerations: System should have a reporting structure which allows for notifications of incidents and also the ability to record video after an intrusion is detected for review.					

Table 2 WIWS System Requirements (Continued)

ID #	Needs	ID #	High Level Requirements	ID #	Detailed System Requirements
4	Drivers, Agencies, and Law Enforcement monitoring work zones need work zone alerts to be consistent and easily understood by all users.	4.1	Warnings and alerts provided shall follow the existing standards to help aid in compliance and understanding.	4.1.1	WIWS messages shall provide information that is compliant and consistent with national and state specific standards.
Considerations: The MUTCD should be the starting point for how messages are displayed and further requirements should meet requirements included in the MN MUTCD.					
				4.1.2	WIWS messages integrated with connected vehicles shall provide information that is compliant and consistent with national standards.
Considerations: The National ITS Architecture should be the starting point for user requirements for how En-Route driver information messages are displayed in a vehicle.					
5	Agencies with WIWS need ability to communicate with devices at all times.	5.1	Agencies shall be able to communicate remotely with device and check equipment status.	5.1.1	The communication media used for the system and field devices shall have 99.9% uptime (excluding maintenance periods).
Considerations: Agency should determine if one medium is preferred over another.					
				5.1.2	The Central System shall record when system power or communication is lost.
				5.1.3	The Central System shall be able to send alerts via email, text, or phone when communication losses occur.
				5.1.4	WIWS field components shall be capable of being powered via wither AC or DC power sources, with solar power as an option.
Considerations: Agency need this type of information to aid in payment, as these systems provide no benefit to workers if there is a breakdown in detection, communication, or power.					
6	Agencies monitoring work zones need access to reports and logs when requested.	6.1	WIWS shall include a data and system archive and reporting function.	6.1.1	The system data archive and reporting function shall be remotely accessible.
Considerations: Agency need this type of information to aid in payment, as these systems provide no benefit to workers if there is a breakdown in detection, communication, or power.					
				6.1.2	The data archive shall include system faults.
Considerations: Agency need this type of information to evaluate the effectiveness of the system, as these systems provide no benefit to workers if there is a breakdown in detection, communication, or power.					
				6.1.3	The system shall allow for configuration and automated generation of system reports.
				6.1.4	The system shall be capable of generating reports in a variety of file formats for ease of use.
Considerations: The system needs to be able to summarize data in an applicable format for end use needs.					
				6.1.5	The system shall be capable of distributing reports generated automatically.