



**Systems Engineering Analysis for Standard Traffic Signal
Test Plan**

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Introduction

This document presents a model test plan to support testing and validation activities during the integration and deployment stages of standard traffic signals to confirm that the system is developed, installed, and operating as specified by the system requirements.

Each standard traffic signal deployment will be different, and the testing and validation performed will likely vary depending upon the complexity of the system and the familiarity with the vendor products.

A concept of operations has been developed to present an overview of the current environment, identify the relevant stakeholders, translate current challenges into specific needs, outline the envisioned operational concept, suggest likely roles and responsibilities, describe scenarios for operation of the new standard traffic signal system, and present potential risks and recommended mitigation strategies associated with this effort. Systems requirements have also been developed to address the needs identified in the concept of operations. The requirements describe what the standard traffic signal system must do as the basis for further design, procurement, installation, testing and operation. It also presents an assessment of how the standard traffic signal fits within the Minnesota Statewide Regional ITS Architecture.

The table below provides a series of testing instructions related to the requirements presented above. The intent is that agencies using this model systems engineering document will incorporate these tests into their overall testing and validation plans, adapting them as needed.

Column 3 in the table below describes ‘testing instructions’ for each requirement. The standard traffic signal requirements include a range of requirement types and therefore the testing instructions vary.

The following bullet list explains the approach to different testing instructions:

- *Advisory requirement – no testing required:* This is noted for requirements that are primarily operational advice (e.g. the locating and use of standard traffic signal) and therefore no formal testing is required;
- *Design:* these test instructions are used to describe testing in the form of design reviews or documentation reviews describing standard traffic signal and data outputs that will be produced by standard traffic signal. These are typically not physical tests, but rather reviews of processes or documents;
- *Factory Acceptance Test (FAT):* These represent recommendations for FATs to allow the agency deploying the standard traffic signal to verify the quality assurance/quality control and standard traffic signal operational parameters at the site of manufacturing and assembly. This can involve the procuring agency on-site at the vendor factory testing the actual equipment to be delivered or the reports of previous tests of components, software, or features;
- *Field:* These represent recommendations for tests to be conducted in MnDOT offices or the field to test the actual deployment and functionality of the standard traffic signal.

Table 1. Model Test Plan

ID	System Requirement	Testing Instructions	Type of Result	Comments / Notes
TS-BTS	Basic Traffic Signal Requirements			
TS-BTS-1	The field element shall control traffic using actuated timing as specified in the plans, and under central control where specified. The signal shall use standard red-yellow-green indications with design and operation in conformance with the latest version of the Minnesota Manual on Traffic Control Devices (MN MUTCD) to optimize efficiency and safety.	<p>Design: Confirm the signal uses standard red-yellow-green indications with design and operation in conformance with the latest version of the MN MUTCD to optimize efficiency and safety.</p> <p>Field: Confirm the signal uses standard red-yellow-green indications with design and operation in conformance with the latest version of the MN MUTCD to optimize efficiency and safety.</p> <p>Field: Confirm the field element controls traffic using actuated timing as specified in the plans, and under central control where specified.</p>	Pass/Fail	
TS-BTS-2	The field element shall include wiring for emergency vehicle preemption (EVP).	<p>Design: Confirm the field element includes wiring for emergency vehicle preemption (EVP).</p> <p>Field: Confirm the field element includes wiring for emergency vehicle preemption (EVP).</p>	Pass/Fail	
TS-BTS-3	The field element shall include a local interface that provides operational status and fault data for connected field equipment to field personnel.	<p>Design: Confirm the field element design includes a local interface that provides operational status and fault data for connected field equipment to field personnel.</p> <p>Field: Confirm the local interface provides operational status and fault data for connected field equipment to field personnel.</p>	Pass/Fail	

ID	System Requirement	Testing Instructions	Type of Result	Comments / Notes
TS-BTS-4	The field element shall include a local interface that allows field personnel to conduct diagnostic tests on connected field equipment.	Design: Confirm the field element design includes a local interface that allows field personnel to conduct diagnostic tests on connected field equipment. Field: Confirm the local interface allows field personnel to conduct diagnostic tests on connected field equipment.	Pass/Fail	
TS-BTS-5	The field element design shall address Americans with Disability Act Accessibility Guidelines (ADAAG) as required in Sec 4D.33 of the latest version of the MN MUTCD and Public Rights-of-Way Accessibility Guidelines (PROWAG) as adopted by MnDOT.	Design: Confirm the field element design addresses Americans with Disability Act Accessibility Guidelines (ADAAG) as required in Sec 4D.33 of the latest version of the MN MUTCD and Public Rights-of-Way Accessibility Guidelines (PROWAG) as adopted by MnDOT.	Content Review	
TS-BTS-6	The field element shall include detection.	Design: Confirm the field element design includes detection. Field: Confirm as specified in the plans the field element design includes detection.	Pass/Fail	
TS-BTS-7	The field element in Metro Area shall include interconnect and communications back to central control.	Design: Confirm the field element design includes interconnect and communications back to central control. Field: Confirm as specified in the plans the field element design includes interconnect and communications back to central control.	Pass/Fail	

ID	System Requirement	Testing Instructions	Type of Result	Comments / Notes
<i>Pedestrian Aspects</i>				
TS-BTS: PED-1	When specified in the plans, the field element shall include pedestrian signal indications, push buttons, and timing.	<p>Design: Confirm, when specified in the plans, that the field element design includes pedestrian signal indications, push buttons, and timing.</p> <p>Field: Confirm, when specified in the plans, that the pedestrian signal indications, push buttons, and timing operate to provide pedestrians with means of crossing roadways.</p>	Pass/Fail	
TS-BTS: PED-2	Except when other requirements supersede it, the field element shall include Accessible Pedestrian Signals (APs) that provide both audio and vibrotactile indication of "WALK/DON'T WALK" intervals wherever pedestrian signal indications are provided.	<p>Design: Confirm, except when other requirements supersede it, that the field element design includes Accessible Pedestrian Signals (APs) that provide both audio and vibrotactile indication of "WALK/DON'T WALK" intervals wherever pedestrian signal indications are provided.</p> <p>Field: Confirm, except when other requirements supersede it, that the Accessible Pedestrian Signals (APs) provide both audio and vibrotactile indication of "WALK/DON'T WALK" intervals wherever pedestrian signal indications are provided.</p>	Pass/Fail	

ID	System Requirement	Testing Instructions	Type of Result	Comments / Notes
TS-BTS: PED-3	When specified in the plans, the field element shall include APS pushbutton detectors that are active or passive. Active detectors shall include a pushbutton locator tone.	<p>Design: Confirm, when specified in the plans, that the field element design includes APS pushbutton detectors that are active or passive. Active detectors shall include a pushbutton locator tone.</p> <p>Field: Confirm, when specified in the plans, that the APS pushbutton detectors are active or passive. Active detectors shall include a pushbutton locator tone.</p>	Pass/Fail	
TS-BTS: PED-4	The field element shall include Countdown Pedestrian Signal (CPS) indications that provide display of seconds remaining in the pedestrian change ("Flashing DON'T WALK") interval.	<p>Design: Confirm the field element design includes Countdown Pedestrian Signal (CPS) indications that provide display of seconds remaining in the pedestrian change ("Flashing DON'T WALK") interval.</p> <p>Field: Confirm the Countdown Pedestrian Signal (CPS) indications provide display of seconds remaining in the pedestrian change ("Flashing DON'T WALK") interval.</p>	Pass/Fail	
TS-BTS: PED-5	CPS indications shall be blank except when counting down in integer numbers to and through "0" during the pedestrian clearance interval.	<p>Design: Confirm the field element design includes CPS indications that are blank except when counting down in integer numbers to and through "0" during the pedestrian clearance interval.</p> <p>Field: Confirm the CPS indications are blank except when counting down in integer numbers to and through "0" during the pedestrian clearance interval.</p>	Pass/Fail	

ID	System Requirement	Testing Instructions	Type of Result	Comments / Notes
TS-BTS: PED-6	When specified in the plans, the field element shall collect pedestrian images and pedestrian sensor data, and respond to pedestrian crossing requests via display, audio signal, or other manner.	<p>Design: Confirm, when specified in the plans, that the field element design collects pedestrian images and pedestrian sensor data, and responds to pedestrian crossing requests via display, audio signal, or other manner.</p> <p>Field: Confirm, when specified in the plans, that the field element collects pedestrian images and pedestrian sensor data, and responds to pedestrian crossing requests via display, audio signal, or other manner.</p>	Pass/Fail	
<i>Detection Aspects</i>				
TS-BTS: DET-1	When specified in the plans, the field element shall include loop, video or other detection on identified approaches.	<p>Design: Confirm, when specified in the plans, that the field element includes loop, video or other detection on identified approaches.</p> <p>Field: Confirm, when specified in the plans, that the loop, videos or other detection on identified approaches operate to detect passing vehicles and provide communication to traffic signals.</p>	Pass/Fail	
TS-BTS: DET-2	When specified in the plans, collected field data from the site shall be archived at a central location for use in traffic analysis, planning, studies, and performance measurement. Archived data at a minimum shall consist of volume, occupancy, and speed.	Field: Confirm that archived data at a minimum consists of volume, occupancy, and speed archived at a central location, when specified in the plans.	Pass/Fail	

ID	System Requirement	Testing Instructions	Type of Result	Comments / Notes
<i>Monitoring Aspects</i>				
TS-BTS: MON-1	When specified in the plans, the field element shall monitor operation of the traffic signal controller(s) and report to the center any instances in which the indicator response does not match that expected from the indicator control information.	Field: Confirm, when specified in the plans, that the field element monitors operation of the traffic signal controller(s) and reports to the center any instances in which the indicator response does not match that expected from the indicator control information.	Pass/Fail	
TS-BTS: MON-2	When specified in the plans, the field element shall monitor operation of traffic signal controllers and report to the center any instances in which the indicator response does not match that expected from known indicator preemptions.	Field: Confirm, when specified in the plans, that the field element monitors operation of traffic signal controllers and reports to the center any instances in which the indicator response does not match that expected from known indicator preemptions.	Pass/Fail	
TS-BTS: MON-3	When specified in the plans, the field element shall return traffic signal controller operational status to the control center.	Field: Confirm, when specified in the plans, that the field element returns traffic signal controller operational status to the control center.	Pass/Fail	
TS-BTS: MON-4	When specified in the plans, the field element shall return traffic signal controller fault data to the maintenance center for repair.	Field: Confirm, when specified in the plans, that the field element returns traffic signal controller fault data to the maintenance center for repair.	Pass/Fail	

ID	System Requirement	Testing Instructions	Type of Result	Comments / Notes
<i>Interface Aspects</i>				
TS-BTS: IFC-1	When specified in the plans, the field element shall include detection that provides data and status information to other field element devices (such as other traffic signals, dynamic message signs, ramp meters, work zone intrusion alert systems), without center control.	<p>Design: Confirm, when specified in the plans, that the field element design includes detection that provides data and status information to other field element devices (such as other traffic signals, dynamic message signs, ramp meters, work zone intrusion alert systems), without center control.</p> <p>Field: Confirm, when specified in the plans, that the detection provides data and status information to other field element devices (such as other traffic signals, dynamic message signs, ramp meters, work zone intrusion alert systems), without center control.</p>	Pass/Fail	
TS-BTS: IFC-2	When specified in the plans, the field element shall include detection that receives control information from other field element devices, without center control.	<p>Design: Confirm, when specified in the plans, that the field element design includes detection that receives control information from other field element devices, without center control.</p> <p>Field: Confirm, when specified in the plans, that the detection receives control information from other field element devices, without center control.</p>	Pass/Fail	

ID	System Requirement	Testing Instructions	Type of Result	Comments / Notes
TS-BTS: IFC-3	When specified in the plans, the field element shall include arterial signal controllers that provide data and status information to other field element devices (such as traffic controllers at adjacent intersections and dynamic message signs), without center control.	<p>Design: Field: Confirm, when specified in the plans, that the field element design includes arterial signal controllers that provide data and status information to other field element devices (such as traffic controllers at adjacent intersections and dynamic message signs), without center control.</p> <p>Field: Confirm, when specified in the plans, that the arterial signal controllers provide data and status information to other field element devices (such as traffic controllers at adjacent intersections and dynamic message signs), without center control.</p>	Pass/Fail	
TS-BTS: IFC-4	When specified in the plans, the field element shall include arterial signal controllers that receive control information from other field element devices, without center control.	<p>Design: Confirm, when specified in the plans, that the field element design includes arterial signal controllers that receive control information from other field element devices, without center control.</p> <p>Field: Confirm, when specified in the plans, that the arterial signal controllers receive control information from other field element devices, without center control.</p>	Pass/Fail	

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TS-FYA	Flashing Yellow Arrow Requirements			
TS-FYA-1	When specified in the plans, the field element shall include Flashing Yellow Arrows (FYA) on the identified approaches that indicate permissive vehicle movement when activated.	<p>Design: Confirm, when specified in the plans, that the field element design includes Flashing Yellow Arrows (FYA) on the identified approaches that indicate permissive vehicle movement when activated.</p> <p>Field: Confirm, when specified in the plans, that Flashing Yellow Arrows (FYA) are installed on the identified approaches that indicate permissive vehicle movement when activated.</p>	Pass/Fail	
TS-AWF	Advanced Warning Flasher Requirements			
TS-AWF-1	When specified in the plans, the field element shall include Advanced Warning Flashers (AWF) on the identified approaches tied to signal phasing and timing for activation.	<p>Design: Confirm, when specified in the plans, that the field element design includes Advanced Warning Flashers (AWF) on the identified approaches tied to signal phasing and timing for activation.</p> <p>Field: Confirm, when specified in the plans, that Advanced Warning Flashers (AWF) are installed on the identified approaches tied to signal phasing and timing for activation.</p>	Pass/Fail	
TS-AWF-2	AWF shall be set up and timed to flash a warning to approaching drivers that the signal has turned or is about to turn to red.	Field: Confirm that AWF are set up and timed to flash a warning to approaching drivers that the signal has turned or is about to turn to red.	Pass/Fail	

ID	System Requirement	Testing Instructions	Type of Result	Comments / Notes
TS-RRP	Railroad Preemption			
TS-RRP-1	When specified in the plans, the field element shall include Railroad Preemption (RRP) in which the adjacent railroad track circuit is interfaced with the traffic signal to provide grade crossing clearance and protection.	<p>Design: Confirm, when specified in the plans, that the field element design includes Railroad Preemption (RRP) in which the adjacent railroad track circuit is interfaced with the traffic signal to provide grade crossing clearance and protection.</p> <p>Field: Confirm, when specified in the plans, that the field element includes Railroad Preemption (RRP) in which the adjacent railroad track circuit is interfaced with the traffic signal to provide grade crossing clearance and protection.</p>	Pass/Fail	
TS-RRP-2	RRP shall provide fail-safe operation in coordination with other protection devices, such as flashers and gates, to clear the tracks of conflicting objects and persons and hold the protection throughout the train crossing time.	<p>Design: Confirm the RRP provides fail-safe operation in coordination with other protection devices, such as flashers and gates, to clear the tracks of conflicting objects and persons and hold the protection throughout the train crossing time.</p> <p>Field: Confirm the RRP provides fail-safe operation in coordination with other protection devices, such as flashers and gates, to clear the tracks of conflicting objects and persons and hold the protection throughout the train crossing time.</p>	Pass/Fail	
TS-RRP-3	RRP shall revert to normal traffic signal operation through pre-determined signal phase sequencing and timing.	Field: Confirm the RRP reverts to normal traffic signal operation through pre-determined signal phase sequencing and timing.	Pass/Fail	

ID	System Requirement	Testing Instructions	Type of Result	Comments / Notes
TS-EVP	Emergency Vehicle Preemption			
TS-EVP-1	When specified in the plans, the field element shall include Emergency Vehicle Preemption (EVP) in which green time is extended or red time is truncated to improve safety and expedite the movement of authorized emergency vehicles on the identified approach(es).	<p>Design: Confirm, when specified in the plans, that the field element design includes Emergency Vehicle Preemption (EVP) in which green time is extended or red time is truncated to improve safety and expedite the movement of authorized emergency vehicles on the identified approach(es).</p> <p>Field: Confirm that Emergency Vehicle Preemption (EVP) is installed, in which green time is extended or red time is truncated to improve safety and expedite the movement of authorized emergency vehicles on the identified approach(es), when specified in the plans.</p>	Pass/Fail	
TS-EVP-2	EVP shall include confirmatory lights that indicate to emergency vehicle drivers whether or not preemption has been granted.	<p>Design: Confirm that EVP design includes confirmatory lights that indicate to emergency vehicle drivers whether or not preemption has been granted.</p> <p>Field: Confirm that EVP contains confirmatory lights that indicate to emergency vehicle drivers whether or not preemption has been granted.</p>	Pass/Fail	
TS-EVP-3	EVP shall revert to normal traffic signal operation through pre-determined signal phase sequencing and timing.	Field: Confirm the EVP reverts to normal traffic signal operation through pre-determined signal phase sequencing and timing.	Pass/Fail	

ID	System Requirement	Testing Instructions	Type of Result	Comments / Notes
TS-TSP	Transit Signal Priority			
TS-TSP-1	When specified in the plans, the field element shall include Transit Signal Priority (TSP) in which green time is extended or red time is truncated to expedite the movement of transit vehicles on the identified approach(es). Preemption control for RRP or EVP shall take precedence over TSP.	<p>Design: Confirm, when specified in the plans, that the field element design includes Transit Signal Priority (TSP) in which green time is extended or red time is truncated to expedite the movement of transit vehicles on the identified approach(es). Preemption control for RRP or EVP shall take precedence over TSP.</p> <p>Field: Confirm, when specified in the plans, that installation contains Transit Signal Priority (TSP), in which green time is extended or red time is truncated to expedite the movement of transit vehicles on the identified approach(es). Preemption control for RRP or EVP shall take precedence over TSP.</p>	Pass/Fail	
TS-TSP-2	TSP shall include rules to negotiate competing calls for priority and allowed frequency of TSP operation.	<p>Design: Confirm the TSP design includes rules to negotiate competing calls for priority and allowed frequency of TSP operation.</p> <p>Field: Confirm the TSP design includes rules to negotiate competing calls for priority and allowed frequency of TSP operation.</p>	Content Review Pass/Fail	
TS-TSP-3	TSP shall revert to normal traffic signal operation through pre-determined signal phase sequencing and timing.	Field: Confirm that the TSP reverts to normal traffic signal operation through pre-determined signal phase sequencing and timing.	Pass/Fail	

ID	System Requirement	Testing Instructions	Type of Result	Comments / Notes
TS-EnL	Enforcement Lights			
TS-EnL-1	When specified in the plans, the field element shall include Enforcement Lights (EnL) that provide confirming display of red signal indications to support red light running enforcement.	<p>Design: Confirm, when specified in the plans, that the field element design includes Enforcement Lights (EnL) that provide confirming display of red signal indications to support red light running enforcement.</p> <p>Field: Confirm, when specified in the plans, that the Enforcement Lights (EnL) provide confirming display of red signal indications to support red light running enforcement.</p>	Pass/Fail	
TS-EnL-2	EnL shall be placed in a location so that enforcement personnel can observe the EnL and the associated approach to allow the personnel to pull out and pursue a red-light running driver from a safe location.	<p>Design: Confirm that EnL are placed in a location so that enforcement personnel can observe the EnL and the associated approach to allow the personnel to pull out and pursue a red-light running driver from a safe location.</p> <p>Field: Confirm that EnL are placed in a location so that enforcement personnel can observe the EnL and the associated approach to allow the personnel to pull out and pursue a red-light running driver from a safe location.</p>	<p>Content Review</p> <p>Pass/Fail</p>	

ID	System Requirement	Testing Instructions	Type of Result	Comments / Notes
TS-TSC	Traffic Signal Coordination			
TS-TSC-1	When specified in the plans, the field element shall include Traffic Signal Coordination (TSC) that allows the signal to be sequenced and timed with adjacent signals to provide progressive traffic movement.	<p>Design: Confirm, when specified in the plans, that the field element design includes Traffic Signal Coordination (TSC) that allows the signal to be sequenced and timed with adjacent signals to provide progressive traffic movement.</p> <p>Field: Confirm, when specified in the plans, that the TSC allows the signal to be sequenced and timed with adjacent signals to provide progressive traffic movement.</p>	Pass/Fail	
TS-CAV	CAV Infrastructure Systems			
TS-CAV-1	In locations where CAV infrastructure systems broadcast messages to vehicle systems, the traffic signal controller shall communicate the signal status (e.g. SPaT data) to the CAV infrastructure system.	<p>Design: Confirm that the traffic signal controller design communicates the signal status to the CAV infrastructure system.</p> <p>Field: Confirm, in locations where CAV infrastructure systems broadcast messages to vehicle systems, that the traffic signal controller communicates the signal status (e.g. SPaT data) to the CAV infrastructure system.</p>	Pass/Fail	
TS-CAV-2	In locations where CAV infrastructure systems acquire data from traffic signals and vehicle systems, CAV infrastructure systems shall warn drivers of potential violations of traffic signals.	<p>Design: Confirm that the CAV infrastructure system design warns drivers of potential violations of traffic signals.</p> <p>Field: Confirm, in locations where CAV infrastructure systems acquire data from traffic signals and vehicle systems, that the CAV infrastructure systems warn drivers of potential violations of traffic signals.</p>	Pass/Fail	

ID	System Requirement	Testing Instructions	Type of Result	Comments / Notes
TS-CAV-3	In situations where direct traffic signal to CAVs is operational, traffic signal shall generate a message conveying the status of the signal (e.g. SPaT data), in a format compatible with the two-way vehicle to roadside or cloud-based communication medium.	<p>Design: Confirm that the traffic signal design generates a message conveying the status of the signal in a format compatible with the two-way vehicle to roadside or cloud-based communication medium.</p> <p>Field: Confirm, in situations where direct traffic signal to CAVs is operational, that the traffic signal generates a message conveying the status of the signal (e.g. SPaT data), in a format compatible with the two-way vehicle to roadside or cloud-based communication medium.</p>	Pass/Fail	
TS-Oth	Other			
TS-Oth-1	[Develop as appropriate]			