ITS SERVICE BOOK

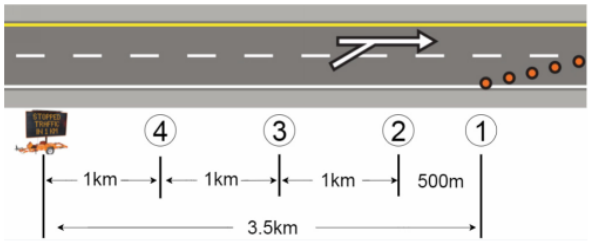
ITS914 WORK ZONE or TEMPORARY QUEUE WARNING

Purpose

Queue Warning Systems (QWS) are used to monitor and inform drivers of the presence of a vehicle queue downstream. Work zone environments are well-suited for QWS as conditions such as lane closures, reduced lane widths, reduced speed limits, moving construction equipment, and driver distractions provide scenarios where queues may occur at various times throughout the day and night.

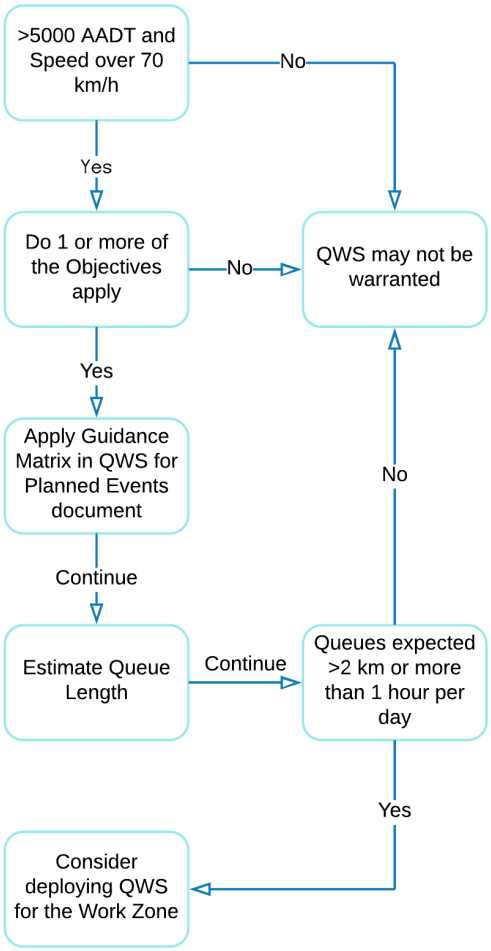
The objectives of a QWS in a work zone application includes any of the following items:

- **Improved Safety - Reduce sudden/dangerous lane changes:** Discrepancies between vehicle speeds in adjacent lanes is the major source of sudden/dangerous lane changes. When faced with a traffic queue, some drivers appear to purposely postpone their deceleration in order to prevent other drivers from moving ahead of them. Other drivers maintain a higher speed until the last possible moment to make quick lane changes if another lane appears to be moving faster.
- **Improved Safety - Minimize queue-end incidents:** Research has shown that drivers do a poor job of reacting and maintaining a safe distance when approaching a traffic queue and that an unexpected queue will increase the risk of a collision. QWS can reduce the likelihood of rear-end collisions in work zones by providing advanced notification to drivers of conditions ahead.
- **Improved congestion management - Infer a detour:** When congestion is likely to occur due to the influence of a work zone, it is sometimes beneficial to promote the use of alternate roads. While specific detour information is not required, inference to drivers of other routes can be made by providing them with real-time information about long delays or travel times.



Considerations for Use

The following process flowchart helps determine the need for a Queue Warning System. The flowchart reflects the procedures documented in "Queue Warning Systems - Guidelines for Work Zones" dated February 2017.



ITS Service Applicability and Limitations of this Service Book

This Service Book may be used in conjunction with other related MTO ITS Services that may have Service Books associated with them.

- ITS202 – Performance Monitoring
- ITS304 – Work Zone Management
- ITS305 – Work Zone Personnel Safety Warnings
- ITS913 – Permanent Queue Warning

Limitations

While this Service Book will aid in determining the need, components, purpose and general location of a QWS in Work Zones, it should be used in conjunction with MTO's Guidelines for Queue Warning Systems for Planned Events. It is also recommended that a proper analysis is undertaken to estimate the queue lengths for a work zone for each stage of construction to ensure system components are placed in correct locations. Finally, it should be understood that the deployment of QWS for Work Zones does not replace any requirements outlined in OTM Book 7.

System Components

The application of a queue warning system to a work zone typically consists of the following components to form one (1) set of a QWS dissemination.

- Detection
- Communications
- Message Dissemination

Depending on the anticipated length of the queue, multiple sets may need to be deployed in succession. Estimated Costs can be seen in detail on the following pages, as well as cost estimates for typical deployments.

Detection

Vehicle detectors collect traffic data along the queue zone. The following detection options are available for temporary installations:

Technology	Advantages	Disadvantages	Comments
Pole-Mounted Sensors • Radar	• Configurable to changing lane patterns • High sample size • Ideal for multi-season deployments	• Requires mounting on existing poles or deploying temporary poles (e.g. wood) • Limited portability once installed	• Consider for longer-term construction applications (> 1 year)
Trolley/Trailer-Mounted Sensors • Radar	• Portability • Configurable to changing lane patterns • High sample size	• Require flat roadside terrain	• Ideal for rental applications
Traffic Barrels • Radar	• Best Portability	• Require battery maintenance every 10 days • Reduced sample size due to low sensor height	• Ideal for shifting work zones with short-term closures
Bluetooth	• Portability	• Sample size variations	• Not suited for standalone queue

Technology	Advantages	Disadvantages	Comments
	• Low cost	• Requires vehicle to span queue for determination of travel times	detection, but as a travel time enhancement
Crowd-Sourced Data • Inrix • Tom-Tom • Waze • Cellint	• Requires no infrastructure • Scalable • Portable	• Still in development and early stages • Requires software programming to integrate to VMS controller	• An untested solution at this time

Communications Options (Field to System Gateway)

Technology	Advantages	Disadvantages	Comments
Third-Party Cellular	• High reliability • Easy to deploy and configure	• Reliant on third-party • Continuous costs • Lack of signal coverage in rural areas	• Suited for most applications including cloud-based processing systems
Wireless Radio	• Independent system	• Requires line of sight • Subject to interference	• Ideal for a clear line of sight applications
Hardwired	• Most reliable, independent	• Aerial cable prone to elements • Can be costly to deploy and maintain	• Best suited where existing backhaul can be leveraged • Not suited for standalone systems

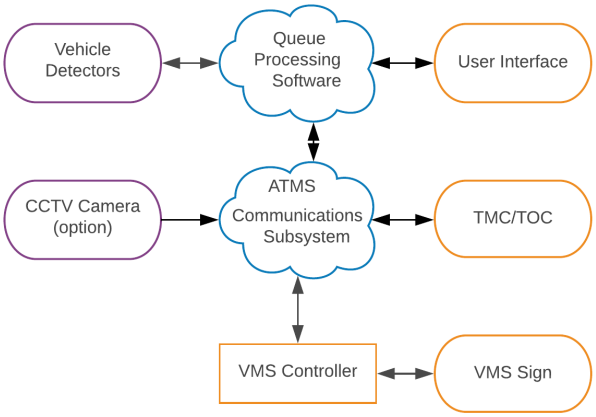
Message Dissemination

Technology	Advantages	Disadvantages	Comments
Portable Variable Message Sign	• Good Readability	• Require ideal terrain, clear zone characteristics	• Typically best-suited option
Portable-Mounted Variable Message Sign	• Best readability • Median-mounted • Terrain independent	• Limited applications for median-mount	• Ideal for long-term deployments (>1-year)

Technology	Advantages	Disadvantages	Comments
LED Blank Out Sign	• Simple to deploy • Contact closure input	• Limited messages	• Ideal for generic queue ahead messages
Flasher Beacons	• Low cost • Contact closure input	• Limited visibility and applications	• Should only be considered for enhancement to an existing dissemination medium (e.g. flashing when queue is present)

Architecture

The architecture shown below gives a general overview of the typical system components that are used in a Queue Warning System. These components can either be assembled together or purchased/rented as an "Off-the-Shelf" system.



Traffic Management

While queue warning systems for work zones are capable of working autonomously and should normally be operated as a standalone system without the need for oversight by the TMC/TOC, the capability should exist to be able to remotely override the PVMS and monitor the QWS if required.

Concept

An example of a system concept is shown on the first page with four (4) detectors (numbered 1 to 4). The spacing of the first two detectors near the work zone is 500 meters to provide more accurate and quicker queue detection. A PVMS sign is placed 1 km upstream of the last detector. In-field installations may vary based on site conditions.

Deployment Considerations

The following are some considerations for system deployment:

- Consider deploying temporary poles for fixed work zones deployments longer than 12 months
- Consider trailer/trolley or traffic barrels for work zones that may continually shift along the corridor
- Consider local terrain and clear zone requirements to assess the placement of trailers/trolleys for detectors and/or PVMS
- Consider mounting sensors on existing poles if pole infrastructure is currently in place
- Consider CCTV camera coverage of the system as a remote monitoring option
- Consider geometric constraints and limited sightlines of potential queue ends when placing message dissemination signage
- Consider battery spares, maintenance roles and processes when deploying traffic barrel sensors
- There are existing non-standard special provisions (NSSPs) for battery replacement and for QWS deployment

- Consider adequate cellular coverage for deployments in Northern / rural locations

Costs and Procurement Strategy

There are significant benefits to renting systems of queue warning systems in that the deployment, maintenance, management, and responsibility for the system are that of the contractor. However, for long-term work zones, the purchase of equipment may be more economical, with the understanding that the responsibility for the system and its operation will need to be defined.

Budgetary costs are provided for system components. A combination of the components can help to provide an estimate based on the application.

There may be additional costs to integrate the system into MTO's TMC/TOC Operations and associated systems.

Refer to HiCo for additional details and regional estimates.

Element	Cost (2019)
Purchase: Supply and Install	
Pole-Mounted Sensor on Trailer	$10,000
Pole-Mounted Sensor on Trolley	$8,500
Traffic Barrel Sensor	$5,000
Portable Variable Message Sign	$30,000
Portable-Mounted VMS	$75,000
LED Blank Out Sign	$4,000 - $15,000
Flasher Beacons	$1,500
Temporary Rumble Strips:	$45,000 per lane
9.0 m Wooden Pole	$1.800
Solar Power Kit	$3,000
Cellular Modem	$1,000
Traffic Control (per lane closure)	$4,000
Operations and Maintenance	
Cellular Fees (if applicable)	$75 per month
Data Processing (cloud)	$25 per device per month
Maintenance of signs, cabinets, solar power systems, etc.	~10% of capital/year
Rental	
Traffic Detection Kit (4 detectors, PVMS)	$8,500 per month
Probe Data	$500 per km/year

Sample Cost Deployment

An example of QWS system may consist of:

- Four (4) traffic barrel sensors
  4 x $5,000 = $20,000
- One (1) PVMS
  1 x $30,000 = $30,000
- Four (4) devices' data processing
  4 x $25 per month = $100 per month
- Five (5) devices' cellular fees
  5 x $50 per month = $250 per month
- Total Deployment: $50,000
- Total Operations: $350 per month plus maintenance

System Life Cycle

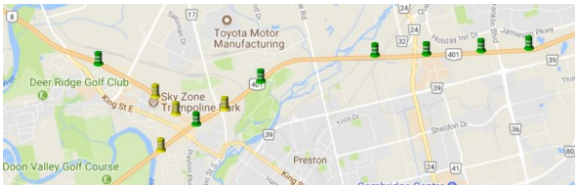
The expected life cycle is about 5 years for a temporary QWS system.

The mean time between failures (MTBF) of relevant equipment for planning, and rehabilitation purposes:

- Cellular Modem – 5 years
- Network Switch – 15 years+
- Non-intrusive Traffic Sensor – 5 years
- Portable Mounted VMS – 5 years
- Portable VMS – 5 years

Case Studies/Previous Deployments

Description	Components
Currently used in West Region on the Highway 401/Highway 8 Work Zone **(Long term deployment)** Ministry of Transportation Ontario	• 12 iCones • Three (3) PVMS • Cellular communications • Queue Software • $25,500 per month



Description	Components
2015 Pan Am / Para-Pan Am Games for the Games Route Network (2-month deployment) Ministry of Transportation Ontario	• 16 iCones • Four (4) PVMS • Cellular communications • Queue Software • $34,000 per month Deployments: • 401EB from Salem to Stephenson • 403WB from 407/QEW to Main • 401WB from 427 to Hurontario
Highway 400 / Line 5 Bridge Replacement (Weekend Closure) Ministry of Transportation Ontario	• 8 iCones • 2 PVMS • Cellular comm • Queue Software • $17,000 per month

Performance Measures

- Number of rear-end collisions
- Severity of rear-end collisions

Emerging/Alternative Technologies

This section details emerging technologies and/or alternative technologies not currently supported by the MTO.

Probe Data

- Portable, scalable, infrastructure-free, granularity
- Untested solution