ITS SERVICE BOOK

ITS913 PERMANENT QUEUE WARNING

Purpose

Queue Warning Systems (QWS) are used to monitor and inform drivers of the presence of a vehicle queue downstream. Permanent applications for queues include areas prone to abrupt speed drops due to a queue. This may include border crossings, highway terminations, lane drops, high traffic demands at interchanges and other areas which have a higher than an average tendency for queue related collisions. Queue related collisions may tend to increase when queue ends are in areas with sightlines and/or geometric constraint issues on the roadway.

The objectives of a permanent QWS application may include any of the following items:

- **Improve 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.
- **Improve 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 by providing advanced notification to drivers of conditions ahead.
- **Improve congestion management - Infer a detour:** During periods of heavy recurring congestion, 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.

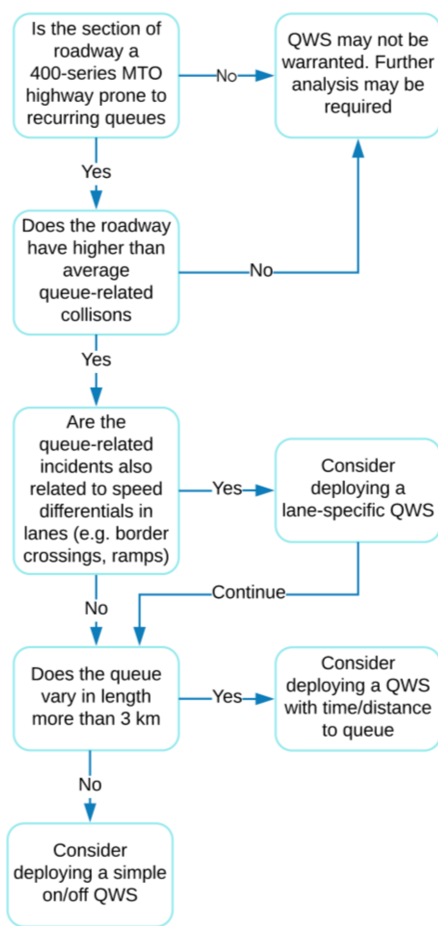
Considerations for Use

Permanent Queue Warning Systems should be considered for select sections of roadway types and situations. The types of queue warning messages provided to drivers may include:

- Queue ahead notification (on/off)
- Queue ahead notification with distance to queue end
- Queue ahead with time to queue end
- Lane-specific notifications with time/distance to queue end

During periods in which there is no queue, the sign may be used for other applications.

The following decision trees provide a reference for considering permanent QWS on Ontario roads.



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.

- ITS201 – Planning Data
- ITS501 – Routing Support for First Responders
- ITS903 – Freeway Ramp Metering
- ITS906 – Roadside Travel Time Information
- ITS909 – Traffic Incident Management
- ITS914 – Work Zone or Temporary Queue Warning
- ITS922 – Variable Speed Limits for Congestion
- ITS924 – Border Approach Lane Management System
- ITS925 – Border Crossing Delay Information
- ITS1005 – En Route Traveller Information
- ITS1106 – CVAV Queue Warning

Limitations

This Service Book may be used in conjunction with other Service Books that have been developed.

While this Service Book will aid in determining the need, components, purpose and general location of a QWS, it is still recommended that a formal analysis and design take place.

System Components

The application of QWS typically consists of the following components:

- Detection
- Processing
- Traveller Information

Detection

Vehicle detectors collect traffic data throughout the area in which queues recur. While in-pavement detectors (e.g. inductive loops, magnetometers, magnetic detectors) are proven as a reliable source of detection, they do create maintenance issues. As such, this Service Book focuses on the more preferred non-intrusive detection technologies.

The following detection options are available:

Radar/Microwave Traffic Sensors

Pole-based sensors utilizing microwave/radar technology to detect vehicle speeds, classification and volume data and they represent a reliable, tested, and non-intrusive approach for permanent deployments.

Advantages

- Configurable to changing lane patterns
- High sample size
- Can be leveraged for traffic count data

Disadvantages

- Requires mounting on existing infrastructure or installing new poles

Bluetooth Detectors

Roadside sensors scan for passing Bluetooth devices as a surrogate to the presence of a vehicle. A second Bluetooth device placed downstream provides comparative data to determine average vehicle speeds.

Not well suited for standalone queue detection .

Advantages

- Low cost
- Can be leveraged for travel time

Disadvantages

- Sample size constrained to availability of passing Bluetooth devices
- Requires the same vehicles to span two or more detection points.

Probe Data

Privately sourced vehicle location data through a combination of car manufacturers, commercial fleet trackers and/or cell phones (e.g. INRIX, TomTom, Cellint).

An untested solution at this time.

Advantages

- Requires no infrastructure
- Scalable
- Portable

Disadvantages

- Still in development and early stages
- Unproven for this application
- Requires new software to integrate to VMS controller

Processing

The data collected by the detectors need to be processed by a queue detection algorithm. Upon determination of a queue, the appropriate information can be issued to message signs and/or traveller information systems.

This system offers the ability to monitor and override the messages as needed.

MTO's current system is an Advanced Traffic Controller (ATC) based system near the end of its design life. MTO is currently exploring alternative options which may include Software-as-a-Service (SaaS) or server-based systems.

Message Dissemination

Queue warning messages are conveyed to upstream drivers through dynamic message signs. A variety of dedicated and multi-purpose sign types are available.

Static Queue Warning Signs

A static sign advising to "Watch for Slow Traffic" accompanied by flasher beacons. Flasher beacons are actuated when a downstream queue is detected.

Advantages

- Low cost
- Contact closure input allowing for simplified integration

Disadvantages

- Limited visibility and applications
- No time or distance information is provided

Hybrid Queue Warning Signs

Like the static queue warning sign with the addition of a single-line VMS providing the distance to the queue

Advantages

- Low cost and lower power compared to other variable message sign options

Disadvantages

- Combination of static and variable text may hinder readability

Variable Message Signs

Permanent Portable Variable Message Sign

Portable variable message signs (PVMS) deployed on a concrete pad to provide a "permanent" application

Advantages

- VMS provides additional messaging options
- Medium cost
- Large sign face for detailed messaging and high readability across all lanes

Disadvantages

- Low, roadside deployment may limit visibility to drivers across all lanes
- Does not provide clean, permanent aesthetics

Overhead Variable Message Sign

Typically used for multi-purpose applications such as congestion, safety, and traveller information

Advantages

- Large sign face for detailed messaging and high readability across all lanes
- Can be utilized for alternate applications when a queue is not present

Disadvantages

- High cost

Pole-mounted Variable Message Sign

Permanent, roadside pole-mounted option

Advantages

- Great readability across all lanes with a higher mounting height
- Can be utilized for alternate applications when the queue is not present
- Finished design and look

Disadvantages

- Moderate to high cost

Portable Mounted Variable Message Sign (PMVMS)

Can be deployed on the median, separator or roadside using a temporary concrete barrier system

Advantages

- Great readability across all lanes with a higher mounting height
- Flexibility in deployment locations
- Can be utilized for alternate applications when a queue is not present

Disadvantages

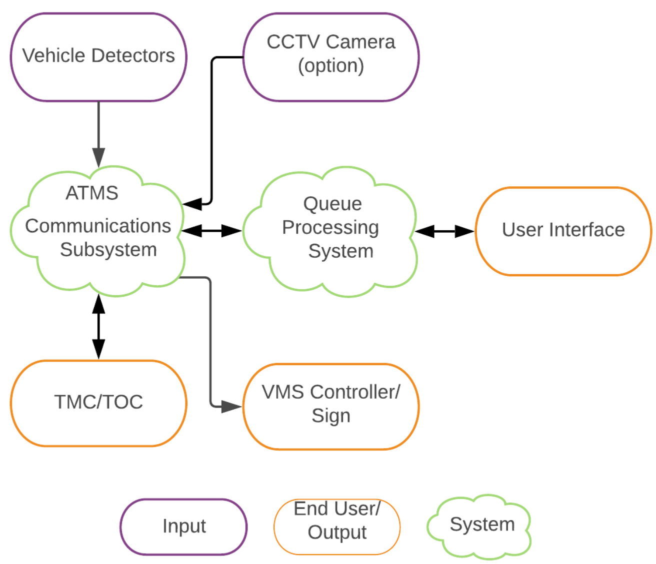
- Originally designed for temporary applications
- Typically used for construction or special event applications, not providing dedicated queue warning function

Traveller Information Systems

In addition to operating autonomously for field messaging, QWS may also interface with traveller information systems to provide queue information to other sources such as Ontario511.

Architecture

The architecture diagram provides an overview of the typical system components that are used in a Queue Warning System. These components can either be assembled together as a group of independent systems or configured as an "Off-the-Shelf" system.



Traffic Management

QWS typically operate autonomously with minimal operational support. Nonetheless, MTO Operations shall be able to remotely control sign as needed. Furthermore, if the QWS sign is used for multi-purpose applications, message prioritization shall be considered.

Concept

An example of a typical concept:

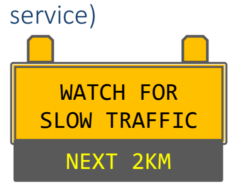
Deployment Considerations

The following are some deployment considerations:

- Consider local terrain and clear zone requirements to assess the placement of detectors and information signs. Existing poles may be used for detectors if they are in appropriate locations.
- Permanent power options should be used for permanent applications (i.e. if used, solar should sustain system operations throughout the year)
- Signs should be bagged in burlap or similar, durable, opaque material when they will be offline for an extended period
- Deployments in Northern / rural locations should consider and ensure adequate cellular coverage
- Detector spacing can vary from 300 m to 600 m depending on the granularity, local geometry and need to provide time/distance to queue end
- If queue lengths may exceed 3 km, consider deploying multiple queue warning signs
- Distance to the queue can be defined as follows:
  - "Ahead" = sign to 500 m
  - "Next 1 KM" = 500 m to 1 km
  - "Next 2 KM" = 1 km to 2 km
  - "Next 3 KM" = 2 km or more
  - Blank sign = No queue present
- Signs located within the queue should be active.
- Cameras can be included to monitor, troubleshoot and/or verify QWS operations. Considerations for deploying cameras will be determined by the designer but may include:
  - Cost, available power/comm, local recording, remoteness, time to travel to the QWS location for maintenance, road geometrics

Messaging Examples

Hybrid Queue Warning Sign (Dedicated, single service)



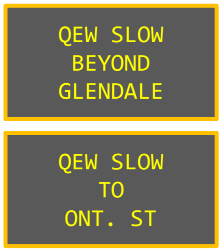
Traffic Flow Condition (Multi-purpose)

EXPRESS MOVING WELL
COLLECTOR MOVING SLOWLY
BEYOND NEXT TRANSFER

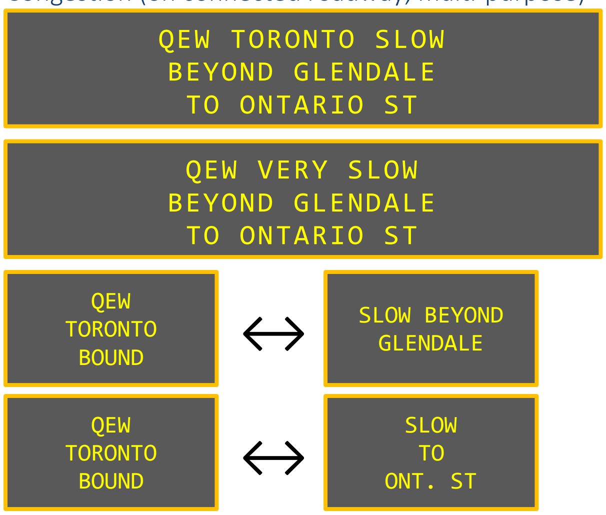
Congestion (on mainline, multi-purpose)

QEW VERY SLOW
TO HWY 427

QEW VERY SLOW
BEYOND GLENDALE
TO ONTARIO ST



Congestion (on connected roadway, multi-purpose)



Lane-Specific Queue Warning

Costs and Procurement Strategy

Budgetary costs are provided below for system components. A sum of the costs for required components can help to provide an estimate for a specific application.

However, there may be additional costs to integrate the QWS to MTO's TMC/TOC Operations and associated systems.

Refer to HiCo for additional details and regional estimates.

Element	Cost (2019)
Purchase: Supply and Install	
Non-Intrusive Traffic Sensor	$10,000
Bluetooth Detector	$7,000
ATMS Controller Cabinet Site	$30,000
Civil Provisions (Ducts, F/O, Power)	$150,000 per km
Pole-Mounted Cabinet	$12,000
Probe Data	$500 per km/year
Hybrid QWS Sign	$7,000
Pole-Mounted VMS	$100,000
Portable Mounted VMS	$75,000
Flasher Beacons	$1,500
Solar Power Kit	$3,000
Cellular Modem	$1,000
9.0 m Concrete Pole	$2,800
Traffic Control (per lane closure)	$4,000
Operations and Maintenance	
Cellular Fees (if applicable)	$75 per month
Hosted Data Processing and Maintenance of Bluetooth Detectors and Modems	$125 - $175 per month per detector
Maintenance of signs, cabinets, solar power systems, etc.	~10% of capital/year

Sample Cost Deployment

An example of QWS system may consist of:

- Eight (8) non-intrusive traffic detectors on concrete poles

  8 x $10,000 = $80,000

  8 x $2,800 = $22,400
- Two (2) Hybrid VMS

  2 x $7,000 = $14,000
- ATMS Controller Cabinet at Signs

2 x $30,000 = $60,000

- Miscellaneous Civil Provisions (power and fibre plant already deployed)

  $50,000
- Total Deployment: $226,400

System Life Cycle

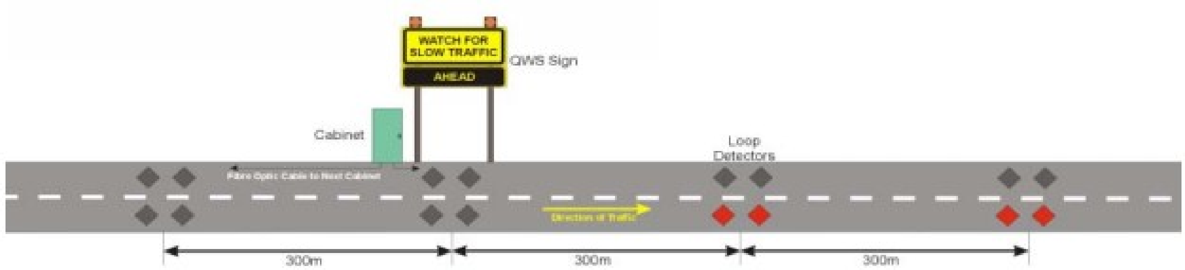
The expected life cycle may range from 5 to 10 years depending on the configuration.

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

- ATMS Controller – 15 years+
- Bluetooth Detectors – 5 years
- CCTV Camera – 5 years
- Cellular Modem – 5 years
- Civil Provisions – 25+ years
- Controller Cabinet – 25+ years
- F/O Cable – 25+ years
- Hybrid Queue Warning Sign – 15 years
- Network Switch – 15 years+
- Non-intrusive Traffic Sensor – 5 years
- Overhead VMS – 15 years
- Pole-Mounted VMS – 15 years
- Poles – 25 years+
- Portable-Mounted VMS – 5 years
- Portable VMS – 5 years

Case Studies/Previous Deployments

Description	Components
Border Queue Warning System Ministry of Transportation Ontario – Central Region	• Deployed at various border crossings • Loop detector-based • Successive sets of detectors and signs operating autonomously



Description	Components
A77 Belfield Interchange Scotland TransServ	• Loop detector-based • Queues on an off-ramp were common • Utilized "Queue Ahead" LED Blank Out Sign with built-in flashing lights

Performance Measures

- Number of queue-related collisions
- The severity of queue-related collisions

Emerging/Alternative Technologies

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

- Video-based Queue Detection – video analytics for queue detection is an emerging technology for freeway queue detection.