Purpose

Work Zone Management, also known as Smart Work Zones (SWZ), helps to improve safety and mobility by using data and technologies to increase driver awareness within and in advance of construction work zones.

The objectives of SWZ are to:
- Increase driver awareness of upstream conditions
- Increase traveller and worker safety
- Improve incident management
- Improve mobility
- Monitor Contractor construction/traffic management

Considerations for Use

Smart Work Zones can be applied to:
- Construction-related events impacting motorists such as lane closures
- Special conditions impacting motorists such as reduced speed limits

Applications may include:
- Traveller Information
- Incident Management
- Queue Detection
- Dynamic Merge
- Construction Access/Notification
- Performance Measurement
- Live Traffic Data (Traffic Studies)

The following decision tree provides a reference for when Smart Work Zone systems may be considered.
**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
- ITS908 – Regional Traffic Management
- ITS914 – Work Zone or Temporary Queue Warning

**Limitations**

This Service Book will aid in determining the need, components, purpose and general placement of an SWZ. Further analysis to identify the specific needs for SWZ is encouraged.

While technologies and data sources continue to evolve, this service book references technologies already approved by MTO.

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**Smart Work Zone Applications**

<table>
<thead>
<tr>
<th>SWZ Application</th>
<th>Issues Addressed</th>
<th>ITS Components</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Traveller Information</strong></td>
<td>Safety</td>
<td>Traffic Data</td>
</tr>
<tr>
<td>Provide information about downstream travel conditions, roadside travel time information, alternate routes, etc.</td>
<td>Congestion</td>
<td>Software</td>
</tr>
<tr>
<td>Warrants</td>
<td>Driver awareness</td>
<td>VMS</td>
</tr>
<tr>
<td>• Informing drivers of downstream conditions offers recognized safety benefits</td>
<td></td>
<td>Communications</td>
</tr>
<tr>
<td>• Travel delay resulting from the work zone is excepted to be more than fifteen (15) minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Conditions due to construction activities are expected to change more than once every 60 days</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Incident Management**          | Safety                            | Traffic Data                    |
| Automated detection of incidents allowing for shorter response and clearance time | Incident Response                  | Software |
| Warrants                         | Congestion/Delay                   | Cameras                         |
| • Incidents and events may typically cause a delay of at least 15 minutes while the incident is active |                                 | Communications                   |

| **Queue Warning**                | Safety                            | Traffic Data                    |
| Warning of slow or stopped traffic downstream | Speed Harmonization                | Software |
| Warrants                         |                                 | VMS                             |
| • Consider queue warning where the traffic flow speed is expected to reduce to 30% or more of the posted speed limit and may potentially result in rear-end collisions |                                 | Communications                   |

| **Queue Length Detection**       | Safety                            | Traffic Data                    |
| Provide alerts to the Contractor when the queue reaches a certain point away from the work zone | Traffic Management                 | Software |
| Warrants                         |                                 | VMS                             |
| • Queue lengths are constrained contractually and/or have significant impacts on upstream traffic, ramps, or affect other corridors, interchanges, etc. |                                 | Communications                   |
### SWZ Application

#### Dynamic Lane Merge
Advise drivers to merge at select points due to downstream lane closures/reductions.

- This is not currently implemented by the MTO.

**Warrants**
- The resulting queue may encroach upstream corridors or cause a delay in excess of 15 minutes
- Continuous lane closure expected for more than twenty (20) days

<table>
<thead>
<tr>
<th>Issues Addressed</th>
<th>ITS Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Safety</td>
<td>• VMS</td>
</tr>
<tr>
<td>• Congestion/Delay</td>
<td>• Communications</td>
</tr>
<tr>
<td>• Queue Length</td>
<td></td>
</tr>
</tbody>
</table>

#### Construction Notification
Advise of local construction activities (e.g. construction vehicle, slow-moving vehicle entering/exiting roadway)

**Warrants**
- One or more construction vehicles accelerate and decelerate along the travelled lane to enter/exit a construction area which may disrupt traffic and/or safety

<table>
<thead>
<tr>
<th>Issues Addressed</th>
<th>ITS Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Safety</td>
<td>• VMS</td>
</tr>
<tr>
<td></td>
<td>• Vehicle Detector</td>
</tr>
<tr>
<td></td>
<td>• Communications</td>
</tr>
</tbody>
</table>

#### Performance Measurement
Use work zone data to monitor and assess impacts of construction and outcomes to Contractor and/or justification for additional SWZ systems

**Warrants**
- Need for contractual performance measures
- Need for construction zone data

<table>
<thead>
<tr>
<th>Issues Addressed</th>
<th>ITS Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Safety</td>
<td>• Traffic Data</td>
</tr>
<tr>
<td>• Congestion/Delay</td>
<td>• Data Storage</td>
</tr>
<tr>
<td>• Contractor Management</td>
<td>• Communications</td>
</tr>
</tbody>
</table>

#### Live Traffic Data
Use live-work zone data including traffic counts, video and other field data to manage and monitor mobility and traffic management

**Warrants**
- Existing ITS subsystems within a work zone are not available and there is a need to maintain TMC/TOC operations
- Need for live traffic data to support TMC/TOC operations

<table>
<thead>
<tr>
<th>Issues Addressed</th>
<th>ITS Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Safety</td>
<td>• Any ITS Component(s)</td>
</tr>
<tr>
<td>• Congestion/Delay</td>
<td>• Traffic Data</td>
</tr>
<tr>
<td>• Traffic Management</td>
<td>• Software</td>
</tr>
<tr>
<td>• Contractor Management</td>
<td>• Communications</td>
</tr>
</tbody>
</table>

### System Components

#### Traffic Data
Traffic data may be sourced from a variety of sensors depending on the applications. Sensors include:

- **Bluetooth/Wi-Fi Detectors**
  - Portable, low-cost
  - Suited for Traveller Information applications
Radar Sensors
- Portable with both low cost (traffic barrels), and higher cost (pole-mounted sensors) options
- Suited for Incident Management, Queue Warning, and Performance Measurement applications

Existing Infrastructure
- Existing traffic data collection infrastructure can also be utilized as a data source. This may include inductive loops

Message Dissemination
Motorists can be made aware of conditions through a variety of signs including:

Portable Variable Message Sign
- 30 pixels high x 56 pixels wide (typically)
- Best suited for temporary roadside applications (short-term)
- Limited visibility due to low height
- Lowest cost

Portable-Mounted Variable Message Sign
- 30 pixels high x 56 pixels wide
- Suited for median, separator or roadside long-term temporary applications
- The best visibility due to a higher height
- Higher cost than PVMS

Architecture
The following architecture provides an overview of how the various SWZ applications may interact. Although there may be variations between the various applications, the information and data flows are expected to be similar for each subsystem.

Traffic Management
While Smart Work Zones are capable of working autonomously, select data and field devices can be accessed and modified to suit the needs of MTO and TMC/TOC operations. This may include replacing SWZ messages with those of higher priority such as Amber Alerts.

Concept
Example concepts are provided for the various SWZ systems. Actual deployments may vary based on specific requirements relevant to the work zone. Concepts are not to scale.

Traveller Information
Incident Management

Queue Warning

Queue Length Detection

Dynamic Lane Merge

RIGHT LANE CLOSED AHEAD

MERGE AHEAD
USE BOTH LANES

STOPPED TRAFFIC AHEAD
USE BOTH LANES

STOPPED TRAFFIC IN 2 KM
Construction Notification

Deployment Considerations
The following are some deployment considerations:

General Considerations
- Multiple SWZ applications can be deployed simultaneously to leverage components, communications backhaul, and central systems
- Consider local terrain and clear zone requirements to assess the placement of PVMS or PMVMS
- Consider mounting detectors on existing poles as appropriate
- Consider geometric constraints, sightlines, and decision points when placing PVMS or PMVMS
- Consider maintenance roles, responsibilities, and processes for each SWZ device, application
- Monitor and adapt equipment placement for longer and/or shifting work zones
- SWZ operation, remote monitoring, and management of data need to be defined and made clear between Contractor and MTO

Traveller Information
- Consider providing time delay rather than travel time to differentiate work zones from other systems
- Consider deploying Roadside Travel Time Information Systems for alternative routes to encourage diversions or support detours
- Place the sign upstream of a decision point to allow motorists an opportunity to consider alternative routes
- For additional information on Roadside Travel Time Information, refer to the respective Service Book

Incident Management
- Incident detection can be based on a combination of CCTV monitoring/video analytics or traffic data from sensors/probes

Queue Warning
- For additional information on Queue Warning Systems for Work Zones, refer to the respective Service Book

Queue Length Detection
- The Contractor should have means to be notified of queue length (e.g. SMS alert) and adapt accordingly (e.g. open up a lane, postpone works)

Dynamic Lane Merge ("Zipper Merge")
- Place one (1) VMS at the point of the merge
- Place at least one (1) additional VMS upstream beyond the estimated queue length
- Utilize traffic detectors to detect speeds/queues to actuate the system
- Promote early merge during lighter traffic conditions

Performance Management
- Performance management could be a combination of any of the above applications and configurations. The work zone system provides a means to generate reports, access logs, and/or hosted data showing historical conditions to assess the Contractor and their management of traffic for contractual and/or informational purposes.
Costs and Procurement Strategy
Budgetary costs are provided below for system components. A combination of the components can help to provide an estimate for a specific application.

However, there may be additional costs to integrate the Smart Work Zone subsystems to MTO’s TMC/TOC Operations and systems.

Refer to HiCo for additional details and regional estimates.

<table>
<thead>
<tr>
<th>Element</th>
<th>Cost (2019)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purchase: Supply and Install</strong></td>
<td></td>
</tr>
<tr>
<td>Bluetooth Detector</td>
<td>$7,000</td>
</tr>
<tr>
<td>Pole-Mounted Sensor on Trailer</td>
<td>$10,000</td>
</tr>
<tr>
<td>Pole-Mounted Sensor on Trolley</td>
<td>$8,500</td>
</tr>
<tr>
<td>Traffic Barrel Sensor</td>
<td>$5,000</td>
</tr>
<tr>
<td>Portable Variable Message Sign</td>
<td>$30,000</td>
</tr>
<tr>
<td>Pole-Mounted VMS</td>
<td>$100,000</td>
</tr>
<tr>
<td>Portable-Mounted VMS</td>
<td>$75,000</td>
</tr>
<tr>
<td>Overhead VMS Sign</td>
<td>$400,000 - $500,000</td>
</tr>
<tr>
<td>LED Blank Out Sign</td>
<td>$4,000 - $15,000</td>
</tr>
<tr>
<td>Flasher Beacons</td>
<td>$1,500</td>
</tr>
<tr>
<td>Pole-Mount Camera on Trailer</td>
<td>$30,000</td>
</tr>
<tr>
<td>Dome Camera</td>
<td>$5,000</td>
</tr>
<tr>
<td>Digital Video Recorder</td>
<td>$1,500</td>
</tr>
<tr>
<td>Solar Power Kit</td>
<td>$3,000</td>
</tr>
<tr>
<td>Cellular Modem</td>
<td>$1,000</td>
</tr>
<tr>
<td>9.0 m Concrete Pole</td>
<td>$2,800</td>
</tr>
<tr>
<td>9.0 m Wooden Pole</td>
<td>$1,800</td>
</tr>
</tbody>
</table>

**Sample Cost Deployment**
An example of a Smart Work Zone application consisting of a camera-based incident detection system may consist of:

- Four (4) trailer-mount cameras with a cellular modem
  
  \[4 \times \$30,000 = \$120,000\]
  
  \[4 \times \$1,000 = \$4,000\]

- One (1) PVMS
  
  \[\text{1} \times \$30,000\]

- Five (5) devices’ cellular fees
  
  \[5 \times \$75 \text{ per month} = \$375 \text{ per month}\]

- Total Deployment: \$154,000
- Total Operations: \$375 per month plus maintenance

**System Life Cycle**
The expected life cycle of a smart work zone system is about 5 years.

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

- Bluetooth Detectors – 5 years
- CCTV Camera – 5 years
- Cellular Modem – 5 years
- Civil Provisions – 25+ 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

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

Case Studies/Previous Deployments

<table>
<thead>
<tr>
<th>Description</th>
<th>Components</th>
</tr>
</thead>
</table>
| iCone Sensor Pilot Test along Highway 427 Northbound Ministry of Transportation Ontario | • 5 iCone Traffic Barrel Sensors  
• 2 PVMS  
• The focus of the pilot was to monitor traffic conditions to improve incident response |
| Highway 7 VIVA BRT Construction Travel Time York Region | • 8 Bluetooth Readers  
• 6 PVMS signs  
• Updated every 15 minutes  
• Showed NOW vs. NORM travel time for an additional reference point for the driver |
| 2015 Pan/Parapan Am Games Ministry of Transportation Ontario | • Semi-permanent cameras  
• Portable trailer cameras  
• Video analytics  
• Combination of devices used to support incident detection along key corridors related to the Games |

Performance Measures
• Number and types of crashes/injuries in smart work zones
• Travel Delay – observed travel time to free-flow travel time
• Queue length, duration
• Number and duration of intervals when queue length is exceeded