Ministry of Transportation, Ontario

ATMS ON HIGHWAY 402, FRONT STREET TO INDIAN ROAD, SARNIA
CONCEPT OF OPERATIONS

FINAL REPORT

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1. INTRODUCTION

The purpose of this technical memorandum is to describe the proposed concept of operations for Variable Message Signs (VMSs) along Highway 402 westbound, within the approximately 4-km-long approach corridor to the border toll plaza and Blue Water Bridge to the U.S.A. The concept of operations described would apply only after reconstruction of this section of highway is complete. The configuration of the corridor and need to separate traffic streams by vehicle type present special challenges that result in a unique approach to VMS operations.

The memorandum describes the overall context for operations, and then deals with specific concepts of operations for lane designation, queue warning and incident management functions. For each of the functions, a description is provided, along with "day in the life" anecdotal scenarios from the perspective of the driver and traffic management system, and general ground rules that will be developed into functional requirements in a subsequent technical memorandum.

2. CONTEXT FOR OPERATIONS

2.1 Layout of Cross-Section

The traffic operations design for the approximately 4 km long approach to the Blue Water Bridge is to separate the various traffic movements within the Highway 402 westbound corridor, including US-bound automobiles, NEXUS automobiles, US-bound heavy vehicles, F.A.S.T. trucks and local traffic. NEXUS is a program designed to expedite the border clearance process for low risk, pre-approved travellers into Canada and the United States. The F.A.S.T. (Free and Secure Trade) program is a bilateral initiative between the United States, Canada and Mexico designed to improve the efficiency of screening and clearing commercial traffic at shared borders, while ensuring security and safety.

Accordingly, the westbound lanes of Highway 402 will be widened from the current two-lane cross-section to four lanes with buffer zones indicated by pavement markings on either side of the two middle lanes, as shown in Appendix B on the drawing titled Proposed Improvements Option 2 (March 29, 2007). The four westbound lanes would typically be designated such that cars bound for the US would occupy the left lane (Lane 1), trucks bound for the US would occupy the two middle lanes (Lanes 2 and 3) with Lane 2 dedicated to F.A.S.T. trucks, and local traffic (cars and trucks) would occupy the right lane (Lane 4).

To form this downstream cross-section, locally destined traffic is first separated from Lane 1 and channelled into Lane 4 to the far left, at about 14+080, just upstream of Murphy Road, forming an express-collector system separated by the painted buffers. At about 13+815 and just downstream of Murphy Road, Lane 2 is added to the express roadway, along with signing to designate vehicles into Lanes 1 and 2 (typically cars and trucks, respectively). Lane 3 is then added to the express stream, at about 10+800, just upstream of Indian Road. At this point, additional lane designation signing is introduced to channel F.A.S.T. trucks into Lane 2 and trucks in general into Lane 3.

2.2 Regulatory Status

The buffer zones indicated by pavement markings currently contain no regulatory status, and are not enforceable. Supplementary signing with messages such as "do not cross buffer" will not be installed. Experience has shown that truck lane designations are self-enforced by truck drivers, especially in queue situations, and that there is generally a high level of compliance. The expectation is that vehicles in other lanes will also comply with the buffer zone markings. The non-regulatory status, however, allows for some flexibility in switching lanes, e.g., to by-pass a lane blockage incident that has just occurred.

The posted speed limit for the corridor is 70 km/h, which is reduced to 50 km/h at the toll plaza. Actual corridor operating speeds observed under free-flow conditions are about 90 km/h. Speed is a factor in determining font size on VMSs (see Section 0).

2.3 COMPASS ATMS Framework

The VMS subsystem for the approach to the Blue Water Bridge will operate as part of a full COMPASS installation, including the following components:

- Full vehicle detection and surveillance subsystems, including installation of additional loop detectors, existing CCTV cameras, and use of algorithms to interpret traffic information transmitted from the loops;
- Next Generation COMPASS Software (NGCS) development, capable of incorporating various algorithms for interpreting traffic conditions input from loop data. Custom NGCS modules for the Highway 402 border approach would also be developed, for providing VMS responses for changing traffic conditions and integrating them;
- Queue Warning Signs (QWSs). The existing QWS subsystem upstream of the project limits will continue to operate; however, all current QWSs within the proposed system limit will be removed. Their queue warning functions will be replaced by the new VMSs;
- Traffic Operations Centre (TOC) involvement, including verification/approval by TOC operators of system-generated VMS messages for incident management and lane designations, and other VMS-related functions currently performed by COMPASS operators. Queue warning messages will be posted automatically (as is currently the case), not requiring TOC operator verification/approval.

2.4 Static/Dynamic Signing Approach

Signing in the corridor will consist of a combination of static and dynamic signing. The overhead static guide signing will generally apply to the collector or local traffic stream (Lane 4), whereas the overhead hybrid static/dynamic signing will apply to the express or US-bound traffic stream (Lanes 1, 2 and 3). The colouring of the static components supports the convention for express/collector streams (i.e., green for express, blue for collector).

In addition, static signage located on ramps approaching the corridor will be revised to support the use of the US-bound lanes, as follows:

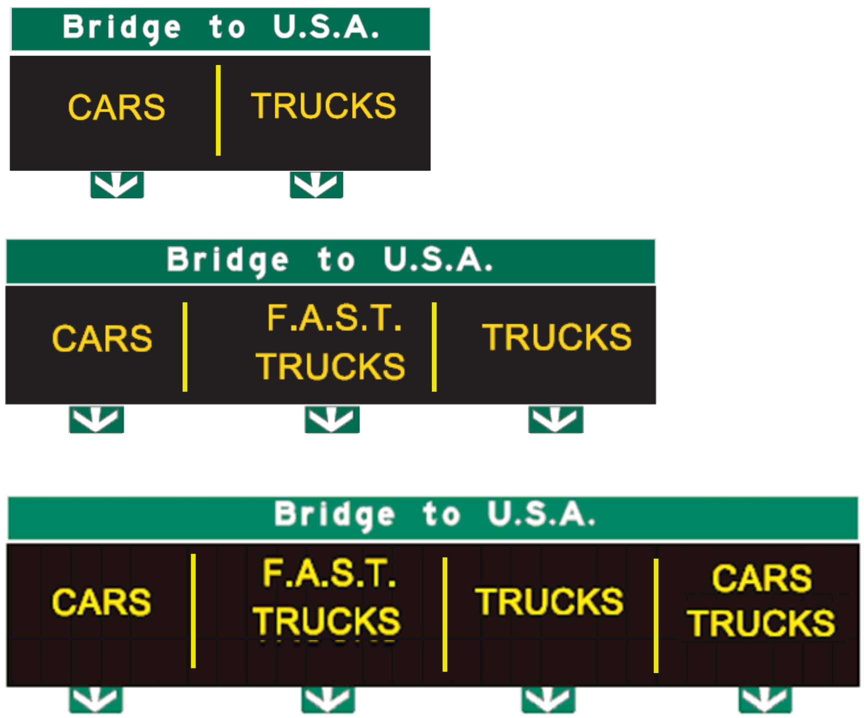
- Signage indicating to on-ramp traffic that local lanes will have access to the US further downstream;
- Signage prohibiting trucks from entering the corridor at on-ramps very close to the toll plaza.

2.5 VMS Format

The VMS format incorporates the following components (see Figure 2-1):

- Static header ("Bridge to U.S.A.");
- Dynamic main panel;
- Static lane designation arrows.

Figure 2-1: VMS Formats



The dynamic sign component can be divided horizontally to address lane designations, for two, three or four lanes, in accordance with the express stream cross-section.

2.6 VMS Locations

VMSs in the corridor will be spaced at about 600 m apart on average, with spacing ranging from about 400 m to 1 km. VMSs will be placed so that they are in view by drivers travelling in the area of the taper formation for lane additions. VMSs will also be co-located with advance and pre-advance static guide signing, including that addressing traffic entering the corridor from on-ramps. VMS locations are shown in Figure 2-2, along with zones corresponding to the roadway downstream to either the next VMS or the toll plaza in the case of Zone 1.

Figure 2-2: VMS Locations

West ↑ East

ID	Location	Lanes
Zone 1	VMS 1 to Toll Plaza	4
VMS 1	E of Front 10+945	4
Zone 2	VMS 2 to VMS 1	3
VMS 2	E of Christina 11+600	3
Zone 3	VMS 3 to VMS 2	3
VMS 3	At Colborne 12+100	3
Zone 4	VMS 4 to VMS 3	3
VMS 4	At Indian 13+115	3
Zone 5	VMS 5 to VMS 4	3
VMS 5	W of Murphy 13+500	2
Zone 6	VMS 6 to VMS 5	2
VMS 6	E of Murphy 14+075	2

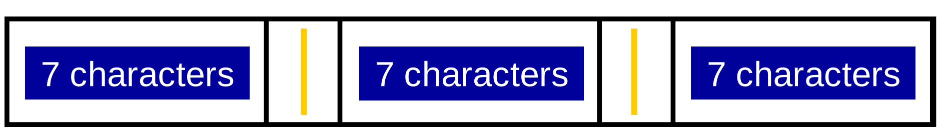
2.7 VMS Attributes

Recommended VMS attributes based on human factors principles include the following:

Width:

- VMS width for a three-lane cross-section should be equivalent to the width of the standard Highway 401 COMPASS VMS. This width enables approximately 25 characters to be displayed in MTO VMS font (i.e., 1 to 8 pixel wide characters). This width enables lane-specific messages of an average of 7 characters wide to be displayed, together with a one-pixel wide dividing line with one-character- wide spaces on either side, to visually differentiate the messages (see Figure 2-3);

Figure 2-3: VMS Horizontal Divisions



- The VMS width for a three-lane cross-section should be a minimum of 12,970 mm, including 11,906 mm for the dynamic portion of the sign and 1,064 mm for the sign border and frame (see Figure 2-1);

- VMS widths for two-lane and four-lane cross-sections should be pro-rated from the three-lane cross-section VMS width. The VMS width for the two-lane sign should be a minimum of 8,684 mm, including 7,620 mm for the dynamic portion of the sign and 1,064 mm for the sign border and frame. The VMS width for the four-lane sign should be a minimum of 17,256 mm, including 16,192 mm for the dynamic portion of the sign and 1,064 mm for the sign border and frame;

- In all cases, the width for the static portion of the sign should be the same as that of the dynamic portion below it;
- All VMS widths incorporate buffer zones. Fine-tuning of VMS legend placement will be covered under the Functional Requirements;

Height:

- VMS height should enable three lines of text to be displayed (7-pixel-high characters) with inter-line spacing of 5 pixels (approximately two-thirds of the character height) and border space above and below the text. VMS height should be a minimum of minimum of 2,784 mm, including 2,024 mm for the dynamic portion of the sign and 760 mm for the sign border and frame (see Figure 2-1);
- The height of the static portion of the sign, placed above the dynamic portion, should be 762 mm;

Font:

- If longer messages are required, the speed limit of 70 km/h for this section (as opposed to the 100 km/h speed limit typically in place where large VMS are used) may support narrower font typically used for PVMS messages (e.g., 5-pixel-wide characters with 1 pixel of inter-letter spacing). MTO font, however, should be used if messages fit;

Configuration:

- Full matrix configuration is recommended to enable flexibility with rows of text, pictogram elements (e.g., vertical dividing lines between lane-specific messages), and use of logos such as those for F.A.S.T. or NEXUS). The capability of combining text and graphics components within one VMS legend will be covered under the Functional Requirements;

Colour:

- Colour capability is recommended for message distinction, e.g.: default messages, such as lane designation messages, in green; non-default messages, such as incident or queue warning message, in amber. Colour could also be used to display logos as they typically appear.

3. VMS MESSAGE STRATEGY

The Highway 402 approach to the Blue Water Bridge is unique among COMPASS installations in several ways that affect VMS message strategy. The buffer zone dividers create lane-specific conditions, such as:

- Queue length differentials between lanes, that will not smooth out to a common queue end location among lanes because the buffers have the effect of discouraging vehicles from changing lanes;

- Issues associated with driving around blockages, again because of the effect of the buffers.

With the buffers in place, special planning will be required to implement alternate lane use patterns, e.g., implementing late at night when traffic levels are low and there are no queues; implementing using a time lag from upstream to downstream when required due to lane closure.

The corridor is also unique in that it is a wide overall cross-section, with a relatively narrow separation between the express and collector streams, containing closely spaced interchanges. This cross-section does not support side-mounted QWSs, which are difficult to see from the inner lanes, and may be associated with the collector stream only. The closely spaced interchanges require frequent interchange guide signing, and traffic entering the corridor needs to be informed and reminded of the lane designations.

The requirements for dynamic lane designation signing, combined with lane-specific queue warning and incident management messages as needed, together with frequent static interchange signing, are most efficiently addressed by:

- Static interchange signing for the collector stream; and

- Dynamic variable message signing for the express stream, capable of displaying lane-specific messages as well as general messages for the entire stream (e.g., Amber alert).

The VMS messages would therefore include lane designation messages (default), queue warning messages and incident management messages. The three types of messages are discussed in the following sub-sections. In each case, a description of the VMS approach is provided, followed by a “day in the life” scenario of how the VMS would function on the road and at the TOC, and high level ground rules for generating the messages. The ground rules will form the basis of software functional requirements, covered in a separate document.

3.1 Lane Designation

3.1.1 DESCRIPTION

When all lanes are open throughout the corridor, and no queues are in effect, VMSs would display default lane designations. Typically the default designations for the express stream would be cars in Lane 1, F.A.S.T. trucks in Lane 2 and all trucks in Lane 3. The VMS message would be clearly lane-specific, corresponding to the static lane designation arrows, and the lane specific messages would be separated by a dynamic vertical divider spaced for legibility.

Figure 3-1 shows some potential lane designation scenarios. Each scenario supplies different lane capacities available to specific vehicle types, and the selection of a particular scenario would be driven by the relative demand of each vehicle type, in accordance with MTO and BWBA policy. Other lane designation scenarios include the high car demand scenarios (e.g., on holiday weekends), and high F.A.S.T. and non-F.A.S.T. truck demand scenarios.

Figure 3-1: Potential Lane Designation Scenarios

Scenario	Description	Lane 1	Lane 2	Lane 3
1	Default	C	F	T
2	High Car Demand	C	CF	T
3	High Car Demand, Low Truck Demand	C	C	FT
4	High Non-F.A.S.T. Truck Demand	CF	T	T
5	High F.A.S.T. Truck Demand	CF	F	T

C = Cars
F = F.A.S.T. Trucks
T = Trucks

In addition, NEXUS vehicles may be indicated on the VMSs as a distinct vehicle type. NEXUS vehicles would most likely share lanes with either cars or F.A.S.T. trucks. If two lanes are at least partially allocated to the type of vehicle sharing the lane with NEXUS vehicles, either or both may be designated as partial NEXUS lanes. Figure 3-2 shows some potential combinations with NEXUS. The actual application of specific combinations will be dependent on MTO and BWBA policy.

Figure 3-2: Potential NEXUS Combinations

Scenario	Description	Lane 1	Lane 2	Lane 3
1	Default	CN	F	T
		C	FN	T
2	High Car Demand	C	CFN	T
		CN	CF	T
		CN	CFN	T
3	High Car Demand, Low Truck Demand	CN	C	FT
4	High Non-F.A.S.T. Truck Demand	CFN	T	T
5	High F.A.S.T. Truck Demand	CFN	F	T
		CF	FN	T
		CFN	FN	T

C = Cars
F = F.A.S.T. Trucks
T = Trucks
N = NEXUS

For a given number of lanes, the displays on the express stream would be uniform along the corridor (see Section 2.1 for a description of cross-section layout). In the two-lane cross-section, the Lane 2 display would include the cumulative vehicle types for Lanes 2 and 3, which will become separated by a buffer further downstream. For example, under the high car demand scenario, the Lane 2 display would indicate cars and trucks. In the four-lane cross-section, the display would repeat the information for Lanes 1, 2 and 3 from the three-lane cross-section VMSs (located upstream), and add the vehicle types for Lane 4, which represents the collector stream traffic that is now joining the express stream.

The VMS lane designation messages are intended to be relatively stable. The messages would primarily changed on a time-of-day schedule basis to accommodate anticipated major shifts in demand by vehicle type. Historic experience would likely be the main indicator of when to change lane designations. The capability to change lane designation dynamically is discussed under the queue warning function (see Section 3.2.1), but frequent changes are not recommended due to safety implications.

In the event of a power failure or VMS failure, the VMS would be blank. The fail-safe mode of operations is the default lane designation scenario. This scenario is supported by the good lane use discipline currently exercised by trucks approaching the border crossing, and static sign elements (i.e., “Bridge to USA” static element above the dynamic portion of the VMSs, static guide signing for local traffic lane).

3.1.2 DAY IN THE LIFE

In the following illustrative narrative, text pertaining to the driver perspective is shown in regular font, and text pertaining to the system perspective is shown in italics.

11:32 p.m.: Spencer is driving his transport truck on another transborder run into Lansing, Michigan. On a Thursday night, the traffic is fairly light, but tomorrow will be another story, with the holiday weekend coming on. As he gets close to the Blue Water Bridge border crossing, the familiar variable message signs come into view. He notes the green colour of the letters - that means things are okay, no major tie-ups. The signs help him navigate the new widened roadway as he approaches the bridge.

At the first lane addition, he keeps right, into the truck lane. This is what he has come to expect. About a kilometre down the road, the next lane is added. Here he gets his own lane for F.A.S.T. trucks, and through to the toll plaza, it is smooth sailing. Since joining the F.A.S.T program a year ago, he has noticed huge improvements on his border crossing time, especially with the electronic signing system to keep things in order. Unless there is some major accident on the border approach, the F.A.S.T. trucks never have to share with other trucks, and usually get a lane all to themselves. This is progress!

2:45 a.m.: *Jacqueline, the COMPASS London TOC night operator responsible for Highway 402 Sarnia is enjoying a relatively quiet shift - the calm before the storm of the upcoming holiday weekend traffic. At the beginning of her shift, she had checked the list of scheduled events and was reminded of the holiday weekend lane designation plan for high car demand. Now, the NGSC software sends her an alert that the plan is scheduled to kick-in in fifteen minutes. She scans the CCTV camera coverage and the colour graphics speeds map on her monitor. Traffic is barely there, breezing along at free flow. There is no reason not to implement the plan. At 3:00 a.m., the traffic status unchanged, she reviews the VMS plan one last time and activates the changeover using the appropriate GUI (Graphical User Interface) screen.*

She watches on her screen as the VMS messages change in real-time. First VMS 6, just before Murphy, and shortly after that VMS 5 (the exact time calculated automatically by the system based on the higher percentiles of vehicle speed registered by the loop detectors at this time). With the time-lag activation, drivers of vehicles already in the buffer sections are less likely to get confused by changing lane designations, and wondering if they are supposed to cross a double solid line based on the new VMS information. There is not a huge incentive to change lanes anyway at this dark hour of night, because traffic is flowing freely unimpeded. Soon all the lanes have changed over, and COMPASS is ready for the onslaught of the holiday weekend car traffic.

9:17 a.m.: Emma and Alex are heading to Michigan’s Lake Huron coast for a relaxing beach holiday on the long weekend. Unfortunately, they got off to a slow start and were not able to beat the other holiday traffic. As they get close to the Blue Water Bridge, however, they notice that the electronic signs are different today. The first sign indicates that cars can use the lane normally assigned to trucks, in addition to the usual car lane. Emma pulls into the right lane. While traffic is still pretty heavy, it keeps moving at a reasonable speed. It certainly helps to have two lanes available for cars at times when you really need it.

3.1.3 GROUND RULES

The following ground rules are proposed for the VMS lane designation functionality:

- Default names and logos for vehicle types to be configurable;
- Lane-specific message segments for each combination of vehicle types to be configurable (default 49 pixels wide);
- Lane 2 message segment at two-lane cross-section is configurable for each Lane 2/ 3 combination of vehicle types;
- Allocation of lane-specific segments to each of the four lanes in the four-lane cross-section to be configurable (i.e., VMS lane designation message);
- Based on above configurations, together with VMS configuration and lane cross-section configuration, the system is to be capable of automatically generating and proposing a default (modifiable) VMS lane designation plan (see Appendix A for illustrative examples);
- Two-part (system-generated) transition plan may be required for safely transitioning between radically different lane designations (radically different transitions are not recommended);
- System to have capability for scheduling VMS lane designation plans by time-of-day;
- System to be capable of generating time lags for implementation of subsequent VMSs. VMSs to change from upstream to downstream under conditions where all lanes move at relatively the same speed, and from downstream to upstream when there is a more extreme difference in speeds among lanes. Variable time lags to be calculated based on detected speed and known distances between VMSs;
- System to have capability for user implementation of unscheduled VMS lane designation plans.

3.2 Queue Warning

3.2.1 DESCRIPTION

As mentioned in Section 3.0 above, given the unique configuration and traffic flow patterns associated with the Highway 402 approach to the Blue Water Bridge, stable lane-specific queues are the rule rather than the exception. VMS messages must respond to these conditions, and therefore lane-specific messages have been proposed.

Since the lane designation function must be sustained at all times, the queue warning function of VMSs has been layered onto the lane designation function. VMS 6 is the first VMS relating to the addition of Lane 2 that drivers approach, and it must identify lane designations. Similarly, VMS 4 must also identify lane designations, since it is the first VMS relating to the addition of Lane 3 that drivers approach. The other VMSs can be used for other functions such as queue warning. With regard to the concept of operations, VMS 6 and VMS 4 are termed “lead lane designation VMSs” to identify this distinction.

Queue warning messages follow the general concepts currently used on QWSs. The standard QWS message is “Watch for slow traffic next X km”, where the “X” refers to the distance from the QWS to the detector location at which the queue end was detected. The distance would be rounded to the nearest 0.5 km, if VMS message space permits, and to the nearest km otherwise. A similar approach is proposed for the VMS queue-warning messages. Due to the size of the VMS segment, the message would have to be simplified, e.g., “Slow traffic next X km”, or possibly “Slow next X km”, or “Queue begins next X km”, depending on font, rules for message segment distribution and preferred wording. If the queue ends for two or more adjacent lanes are at the same location, the messages can be combined to extend across two VMS segments or across the whole sign.

With the exception of lead lane designation VMSs, additional VMSs in the corridor can be used for advance queue warning, displaying the appropriate distance in km to the detected queue end location. The number of advance VMSs (i.e., upstream of the primary VMS upstream of the queue end zone) is configurable, either by number of VMSs involved in the message stream, or maximum distance to be displayed within the message.

When a VMS is downstream of a queue end, the default lane designation message would be displayed, because it is no longer a requirement to warn drivers of the queue end. If VMS 5 is downstream of the queue end, no queue warning messages would appear on any of the VMSs in the corridor. Upstream warnings, however, would be shown as applicable on the QWSs upstream of the corridor.

The capability for changing lane designations to mitigate queues may be a consideration for the system software. The system could propose a modified lane designation scheme that favours additional capacity for high demand vehicle types, based on actual queues or demands by vehicle type, as conveyed by upstream detectors. If pollution detection were integrated into the NGCS, input from the pollution detection mechanism could also be incorporated into this logic.

There are safety implications associated with changing lane designations while traffic is heavy and one or more queues are in place. In addition, drivers may be confused by apparently conflicting information on the VMSs and buffers. If lane designations are changed in this way, it is recommended that they be implemented starting at the downstream-most VMS (i.e., VMS 1) and moving upstream as the speed differentials among lanes are reduced. It is also recommended that thresholds for implementing queue-mitigation changes be high, so that these types of changes occur occasionally, only under extreme circumstances.

3.2.2 DAY IN THE LIFE

In the following illustrative narrative, text pertaining to the driver perspective is shown in regular font, and text pertaining to the system perspective is shown in italics.

3:17 p.m.: *The day shift operator, Max, is scanning through the outputs from the CCTV cameras along the Highway 402 approach to Blue Water Bridge. The p.m. peak is approaching, and he can* *see the traffic getting thicker by the minutes. He knows the queues will start forming soon. He does not need to actively track the existence and shifting end of each queue, or implement the VMS responses to warn of the queue ends. All of this is automatically done for him by the detection equipment, the detection algorithms and the VMS message response software module in the Next Generation COMPASS Software (NGCS). He needs to check now and then to see that the equipment is working as it should, and no major glitches are occurring, but that is so much easier than keeping track of every single queue end in every lane. Now he can turn his attention to incident detection, monitoring, communications and all of his other duties.*

While doing a routine check of system status a few minutes later, Max notices that a queue warning message is being displayed on some of the downstream VMSs in the corridor, for Lane 3, the truck lane. A glance at the CCTV monitor downstream of VMS 1 shows him the queue. This is par for the course at this time of day. The queue will grow and the VMSs automatically adjust to the changes. Then finally shrink down to nothing once the traffic flows abate.

4:32 p.m.: Antonio is driving his transport truck on the way to a delivery in Flint. As he approaches the border, he reminds himself that he really ought to get that F.A.S.T. pass. His route is taking him here more frequently, and the F.A.S.T. pass could save him some time, especially at rush hour like now. Well, he doesn't have one today, so he veers into the right lane for all trucks.

As he approaches Indian Road, he notices that the VMS has amber letters instead of the usual green lane designation messages. The message warns of slow traffic 1.5 km away. The next VMS reinforces the queue message. And there it is - the queue end just as the signs warned.

3.2.3 GROUND RULES

The following ground rules are proposed for the VMS queue warning functionality:

- Lead lane designation VMSs to be configurable (default: VMS 6 and VMS 4);
- Lane-specific queue warning message to be configurable, using system-calculated distance variable parameter from VMS location to upstream queue detector location;
- System calculation of distance to queue end from VMS location to be migrated from current MTO QWS subsystem;
- Queue warning message for two adjacent lanes or three adjacent lanes, to be configurable, using system-calculated distance variable parameter from VMS location to upstream queue detector location;
- Based on above configurations, together with VMS configuration and lane cross-section configuration, the system is to be capable of automatically generating and implementing a default (modifiable) VMS queue warning plan, layered over the lane designation plan (see Appendix A for illustrative examples). Number of advance VMSs used in plan and/or maximum distance displayed to be configurable;
- Any VMS pertaining to a lane which splits into two to provide queue warning information for only for the continuing lane, even if no other VMS is available to provide this message to the lane splitting off (e.g., VMS 5 not to be used to warn of queue ends in Lane 3 in Zone 5 or Zone 4);

- In the event of equipment malfunction, system user to have capability of manually disabling queue warning function, or manually declaring queue end location;

Enhanced Features:

- System to have capability of proposing alternate lane designation plan for queue mitigation, in response to thresholds such as queue length, differential speeds among lanes, upstream demand by vehicle type, pollution mechanism input (if pollution detection integrated into the NGCS), etc.;

- System to have capability for user implementation of unscheduled VMS lane designation plans proposed by the system for queue mitigation;

- System to be capable of generating time lags for implementation of subsequent VMSs. VMSs to change from upstream to downstream under conditions where all lanes move at relatively the same speed, and from downstream to upstream when there is a more extreme difference in speeds among lanes;

- Two-part (system-generated) transition plan may be required for safely transitioning between radically different lane designations (radically different transitions are not recommended).

3.3 Incident Management

3.3.1 DESCRIPTION

Lane-blocking incidents in the Blue Water Bridge approach corridor present a special challenge, since circumventing the blockage affects the lane designation in place at the time the incident occurred, and may involve crossing buffer zones. Unsafe conditions may result if traffic switches lanes just upstream of an incident location, especially if queue differentials are in effect. It is therefore proposed that the incident lane(s) be closed for the entire approach corridor upstream of the incident location. A message such as “Lane(s) closed” would be displayed centred over the incident lane(s). The safety benefits of a clear closure message and pro-active lane designations enabled outweigh the loss of a relatively short distance of vehicle storage (a maximum of approximately 4 km).

Since closures are lane-specific, the short lane closure message (indicated in amber print) becomes part of the overall lane designation display. Queue warnings could still be displayed layered over the active lane designation messages (as discussed in Section 3.2). Since a lane closure is involved, and the potential exists for queues to form upstream of the incident, it is recommended that the new lane designations (including lane closure message) be implemented starting at the downstream-most VMS (i.e., VMS 1) and moving upstream as the speed differentials among lanes are reduced.

For long duration incidents, installing temporary physical barriers to prevent access to the closed lane(s) (e.g., coning) would better reinforce designated lane usage, by visually conveying the message that a lane is closed. Downstream of the closure, lane designation messages on VMSs can be used to direct traffic back into the lane(s) which becomes available downstream of the incident blockage. When directing vehicles into the open lane(s) downstream of the incident location, phasing may be required for safe, orderly merging, e.g., vehicles from Lanes 1 and 3 merging into Lane 2, more than one lane closed. This may be supplemented by Police physically directing the applicable vehicles back into the lane(s), especially where two or more lanes are closed.

If one lane is closed due to an incident, logical reassignment of lanes for each scenario is generally straightforward (see Figure 3-3). Two options are shown for the high car demand scenario, each of which favour different vehicle type demands.

Figure 3-3: Lane Reassignment for One Lane Closed

Scenario	Description	Lane 1	Lane 2	Lane 3
1	Default	C	F	T
			CF	T
		CF		T
		CF	T	
2	High Car Demand	C	CF	T
			CF	T
		CF		T
		CF	T	
	High Car Demand (F.A.S.T With All Trucks)	C	CF	T
			C	T
		C		T
		C	T	
3	High Non-F.A.S.T. Truck Demand	CF	T	T
			CF	T
		CF		T
		CF	T	
4	High F.A.S.T. Truck Demand	CF	F	T
			CF	T
		CF		T
		CF	T	

= closed lane

The closure of one centre lane would be signed until emergency personnel (e.g., patrols or crews) arrived on the site to close an adjacent lane. The incident would then be updated to be a two-lane closure incident, and corresponding VMS messages generated.

If two lanes are closed due to an incident, only one express stream lane is available for traffic to the U.S.A. The VMSs would indicate the closed lanes with a "Lane(s) closed" message and indicate "All traffic to U.S.A." for the one open lane. Under this scenario, F.A.S.T. trucks would not be separated from other trucks.

If three express stream lanes are closed due to an incident, the bridge could still be accessible using the collector lanes. VMSs could be used to channel traffic into the collector lanes or off the highway via an exit, and back onto the express stream downstream of the incident location. A VMS message such as “All lanes closed / All traffic must exit” centred across all lanes could be used, together with physical barriers. This type of major response would require coordination with Police and road patrols.

In the unlikely event that the Blue Water Bridge is closed, a message like “Bridge closed / All traffic must exit” centred across all lanes could be used.

3.3.2 DAY IN THE LIFE

In the following illustrative narrative, text pertaining to the driver perspective is shown in regular font, and text pertaining to the system perspective is shown in italics.

9:22 p.m.: *Jacqueline, the night operator is on shift again. Things are fairly calm along the Highway 402 corridor, and she is working on a routine equipment fault report when her computer beeps. She looks at the GUI map and sees a flashing incident icon roughly in Zone 3. She consults her CCTV monitor and sees it - a two-vehicle collision in Lane 1 just past Colborne. She quickly calls 911 and confirms the details on the electronic form the software system has already partially filled in for her. As she clicks on the “OK” button, the software displays the proposed VMS response it automatically generated for this incident.*

The system suggests displaying the “Lane closed” message and shifting the Lane 1 cars into Lane 2, together with the F.A.S.T. trucks. On the two VMSs downstream of the incident location, the messages indicate the default lane designation: cars back in Lane 1, F.A.S.T. trucks in Lane 2 and all trucks in Lane 3. The response also includes transition timing, for phasing in the displays starting from the VMS just upstream of the incident and moving upstream VMS by VMS. She thinks the proposed response looks perfectly reasonable, so she clicks the “Implement” button and watches the VMSs change on the CCTV monitor, and the vehicles begin shifting lanes.

9.28 p.m.: Kelsey is driving back home after a pleasant dinner out with her Canadian friends. As she gets close to the border, she notices amber text on the VMS over the left lane, which usually just says “cars”. This time it says “lane closed”. Instead, everyone is designated to drive in the right lane, and when the lane splits into two, the cars are assigned to the middle lane, together with the F.A.S.T. trucks. All the vehicles do what the signs tell them to and everything seems to be moving along fine.

“Why is the other lane closed?” she thinks, seeing only an empty road. Soon she finds out. She sees the flashing emergency vehicle lights and two crashed SUVs in the middle of the lane, with broken glass everywhere. Thankfully no one appears to be seriously injured. After passing the collision site, the next VMS indicates that the cars should now use the left lane. It feels a bit strange crossing those two painted lines on the pavement - usually nobody does that - but she is just following the signs.

3.3.3 GROUND RULES

The following ground rules are proposed for the VMS incident management functionality:

- Lane-specific lane closure warning message to be configurable;
- Lane designations to be configurable, based on pre-incident configuration, closure configuration and vehicle demand;

- Messages centred above all lanes to be configurable, based on type of incident (e.g., bridge closed, all express lanes closed), action, location of designated exit;
- Based on above configurations, together with incident start/end location, VMS configuration and lane cross-section configuration, the system to be capable of automatically generating a default (modifiable) VMS incident management plan (see Appendix A for illustrative examples), over which can be layered one or more queue warning plans;
- System to be capable of generating time lags for implementation of subsequent VMSs. VMSs to change from downstream to upstream;
- Two-part (system-generated) transition plan may be required for safe, orderly merging, e.g., vehicles from Lanes 1 and 3 merging into Lane 2, more than one lane closed;
- For multiple incidents, if the cumulative lane closure pattern is two lanes, VMS response upstream of the upstream incident to be based on the cumulative lane closure pattern. Lane restoration location to be based on last downstream location where the lane becomes clear;
- For multiple incidents, if the cumulative lane closure pattern is three lanes, with at least two lanes open in all zones, VMS response to be based on next upstream incident only. If the cumulative lane closure pattern in at least one zone is three lanes, on-site traffic management required to supplement VMS messages;
- System user to have capability of manually overriding the system-generated response plan.

APPENDIX A

ILLUSTRATIVE EXAMPLES

Appendix A

Illustrative Examples

1.0 Lane Designation Function

1.1 Default

Location	Lane 1 Cars	Lane 2 F.A.S.T.	Lane 3 Trucks	Lane 4 Local
Zone 1 VMS 1 to Toll Plaza				
VMS 1 E of Front 10+945	**CARS**	**F.A.S.T.**	**TRUCKS**	**CARS** **TRUCKS**
Zone 2 VMS 2 to VMS 1				
VMS 2 E of Christina 11+600	**CARS**	**F.A.S.T.**	**TRUCKS**	
Zone 3 VMS 3 to VMS 2				
VMS 3 At Colborne 12+100	**CARS**	**F.A.S.T.**	**TRUCKS**	
Zone 4 VMS 4 to VMS 3				
VMS 4 At Indian 13+115	**CARS**	**F.A.S.T.**	**TRUCKS**	
Zone 5 VMS 5 to VMS 4				
VMS 5 W of Murphy 13+500	**CARS**	**TRUCKS**		
Zone 6 VMS 6 to VMS 5				
VMS 6 E of Murphy 13+930	**CARS**	**TRUCKS**		

1.2 High Car Demand with NEXUS in F.A.S.T. Lane

Location	Lane 1 Cars	Lane 2 Cars, NEXUS, F.A.S.T.	Lane 3 Trucks	Lane 4 Local
Zone 1 VMS 1 to Toll Plaza				
VMS 1 E of Front 10+945	**CARS**	**CARS** **NEXUS** **F.A.S.T.**	**TRUCKS**	**CARS** **TRUCKS**
Zone 2 VMS 2 to VMS 1				
VMS 2 E of Christina 11+600	**CARS**	**CARS** **NEXUS** **F.A.S.T.**	**TRUCKS**	
Zone 3 VMS 3 to VMS 2				
VMS 3 At Colborne 12+100	**CARS**	**CARS** **NEXUS** **F.A.S.T.**	**TRUCKS**	
Zone 4 VMS 4 to VMS 3				
VMS 4 At Indian 13+115	**CARS**	**CARS** **NEXUS** **F.A.S.T.**	**TRUCKS**	
Zone 5 VMS 5 to VMS 4				
VMS 5 W of Murphy 13+500	**CARS**	**CARS** **NEXUS** **TRUCKS**		
Zone 6 VMS 6 to VMS 5				
VMS 6 E of Murphy 13+930	**CARS**	**CARS** **NEXUS** **TRUCKS**		

2.0 Queue Warning Function

2.1 Queue End in Lane 1 in Zone 3, Default Lane Designation

Location	Lane 1 Cars	Lane 2 F.A.S.T.	Lane 3 Trucks	Lane 4 Local
Zone 1 VMS 1 to Toll Plaza	Q			
VMS 1 E of Front 10+945	CARS	F.A.S.T.	TRUCKS	CARS TRUCKS
Zone 2 VMS 2 to VMS 1	Q			
VMS 2 E of Christina 11+600	CARS	F.A.S.T.	TRUCKS	
Zone 3 VMS 3 to VMS 2	Q			
VMS 3 At Colborne 12+100	SLOW NEXT X KM	F.A.S.T.	TRUCKS	
Zone 4 VMS 4 to VMS 3				
VMS 4 At Indian 13+115	CARS	F.A.S.T.	TRUCKS	
Zone 5 VMS 5 to VMS 4				
VMS 5 W of Murphy 13+500	SLOW NEXT X KM	TRUCKS		
Zone 6 VMS 6 to VMS 5				
VMS 6 E of Murphy 13+930	CARS	TRUCKS		

2.2 Queue End in Lane 1 Upstream of Zone 6, High Car Demand Lane Designation

Location	Lane 1 Cars	Lane 2 F.A.S.T.	Lane 3 Trucks	Lane 4 Local
Zone 1 VMS 1 to Toll Plaza	Q			
VMS 1 E of Front 10+945	**CARS**	**CARS** **F.A.S.T.**	**TRUCKS**	**CARS** **TRUCKS**
Zone 2 VMS 2 to VMS 1	Q			
VMS 2 E of Christina 11+600	**CARS**	**CARS** **F.A.S.T.**	**TRUCKS**	
Zone 3 VMS 3 to VMS 2	Q			
VMS 3 At Colborne 12+100	**CARS**	**CARS** **F.A.S.T.**	**TRUCKS**	
Zone 4 VMS 4 to VMS 3	Q			
VMS 4 At Indian 13+115	**CARS**	**CARS** **F.A.S.T.**	**TRUCKS**	
Zone 5 VMS 5 to VMS 4	Q			
VMS 5 W of Murphy 13+500	**CARS**	**CARS** **TRUCKS**		
Zone 6 VMS 6 to VMS 5	Q			
VMS 6 E of Murphy 13+930	**CARS**	**CARS** **TRUCKS**		

2.3 Queue End in Lane 1 in Zone 2, Queue End in Lane 3 in Zone 4, Default Lane Designation

Location	Lane 1 Cars	Lane 2 F.A.S.T.	Lane 3 Trucks	Lane 4 Local
Zone 1 VMS 1 to Toll Plaza	Q		Q	
VMS 1 E of Front 10+945	**CARS**	**F.A.S.T.**	**TRUCKS**	**CARS** **TRUCKS**
Zone 2 VMS 2 to VMS 1	Q		Q	
VMS 2 E of Christina 11+600	**SLOW** **NEXT** **X KM**	**F.A.S.T.**	**TRUCKS**	
Zone 3 VMS 3 to VMS 2			Q	
VMS 3 At Colborne 12+100	**SLOW** **NEXT** **X KM**	**F.A.S.T.**	**TRUCKS**	
Zone 4 VMS 4 to VMS 3			Q	
VMS 4 At Indian 13+115	**CARS**	**F.A.S.T.**	**TRUCKS**	
Zone 5 VMS 5 to VMS 4				
VMS 5 W of Murphy 13+500	**SLOW** **NEXT** **X KM**	**SLOW** **NEXT** **Y KM**		
Zone 6 VMS 6 to VMS 5				
VMS 6 E of Murphy 13+930	**CARS**	**TRUCKS**		

2.4 Queue End in Lane 2 in Zone 2, Queue End in Lane 3 in Zone 2, Default Lane Designation

Location	Lane 1 Cars	Lane 2 F.A.S.T.	Lane 3 Trucks	Lane 4 Local
Zone 1 VMS 1 to Toll Plaza		Q	Q	
VMS 1 E of Front 10+945	**CARS**	**F.A.S.T.**	**TRUCKS**	**CARS** **TRUCKS**
Zone 2 VMS 2 to VMS 1		Q	Q	
VMS 2 E of Christina 11+600	**CARS**	**SLOW** **NEXT** **X KM**		
Zone 3 VMS 3 to VMS 2				
VMS 3 At Colborne 12+100	**CARS**	**SLOW** **NEXT** **X KM**		
Zone 4 VMS 4 to VMS 3				
VMS 4 At Indian 13+115	**CARS**	**F.A.S.T.**	**TRUCKS**	
Zone 5 VMS 5 to VMS 4				
VMS 5 W of Murphy 13+500	**CARS**	**TRUCKS**		
Zone 6 VMS 6 to VMS 5				
VMS 6 E of Murphy 13+930	**CARS**	**TRUCKS**		

3.0 Incident Management Function

3.1 Lane-Blocking Incident in Lane 1 in Zone 2, Default Lane Designation

Location	Lane 1 Cars	Lane 2 F.A.S.T.	Lane 3 Trucks	Lane 4 Local
Zone 1 VMS 1 to Toll Plaza				
VMS 1 E of Front 10+945	**CARS**	**F.A.S.T.**	**TRUCKS**	**CARS** **TRUCKS**
Zone 2 VMS 2 to VMS 1	**X**			
VMS 2 E of Christina 11+600	**LANE** **CLOSED**	**CARS** **F.A.S.T.**	**TRUCKS**	
Zone 3 VMS 3 to VMS 2				
VMS 3 At Colborne 12+100	**LANE** **CLOSED**	**CARS** **F.A.S.T.**	**TRUCKS**	
Zone 4 VMS 4 to VMS 3				
VMS 4 At Indian 13+115	**LANE** **CLOSED**	**CARS** **F.A.S.T.**	**TRUCKS**	
Zone 5 VMS 5 to VMS 4				
VMS 5 W of Murphy 13+500	**LANE** **CLOSED**	**CARS** **TRUCKS**		
Zone 6 VMS 6 to VMS 5				
VMS 6 E of Murphy 13+930	**LANE** **CLOSED**	**CARS** **TRUCKS**		

3.2 Lane-Blocking Incident in Lane 2 in Zone 3, Queue End in Lane 3 in Zone 1, Default Lane Designation

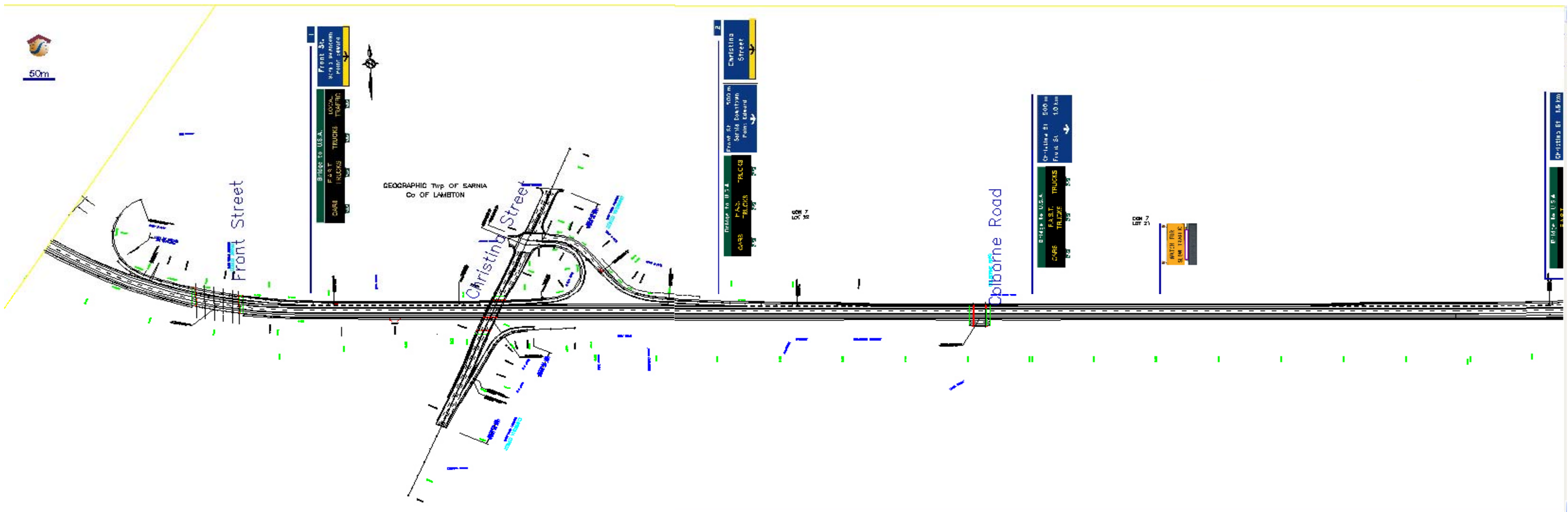
Location	Lane 1 Cars	Lane 2 F.A.S.T.	Lane 3 Trucks	Lane 4 Local
Zone 1 VMS 1 to Toll Plaza			Q	
VMS 1 E of Front 10+945	**CARS**	**F.A.S.T.**	**TRUCKS**	**CARS** **TRUCKS**
Zone 2 VMS 2 to VMS 1				
VMS 2 E of Christina 11+600	**CARS**	**TRUCKS**		
Zone 3 VMS 3 to VMS 2		**X**		
VMS 3 At Colborne 12+100	**CARS** **TRUCKS**	**LANE** **CLOSED**		
Zone 4 VMS 4 to VMS 3				
VMS 4 At Indian 13+115	**CARS** **TRUCKS**	**LANE** **CLOSED**		
Zone 5 VMS 5 to VMS 4				
VMS 5 W of Murphy 13+500	**CARS** **TRUCKS**	**LANE** **CLOSED**		
Zone 6 VMS 6 to VMS 5				
VMS 6 E of Murphy 13+930	**CARS** **TRUCKS**	**LANE** **CLOSED**		

3.3 Lane-Blocking Incident in Lane 1 in Zone 5, Queue End in Lane 3 in Zone 1, Default Lane Designation

Location	Lane 1 Cars	Lane 2 F.A.S.T.	Lane 3 Trucks	Lane 4 Local
Zone 1 VMS 1 to Toll Plaza			Q	
VMS 1 E of Front 10+945	**CARS**	**F.A.S.T.**	**SLOW NEXT X KM**	**CARS TRUCKS**
Zone 2 VMS 2 to VMS 1				
VMS 2 E of Christina 11+600	**CARS**	**F.A.S.T.**	**SLOW NEXT X KM**	
Zone 3 VMS 3 to VMS 2				
VMS 3 At Colborne 12+100	**CARS**	**F.A.S.T.**	**SLOW NEXT X KM**	
Zone 4 VMS 4 to VMS 3				
VMS 4 At Indian 13+115	**CARS**	**F.A.S.T.**	**TRUCKS**	
Zone 5 VMS 5 to VMS 4	**X**			
VMS 5 W of Murphy 13+500	**LANE CLOSED**	**CARS TRUCKS**		
Zone 6 VMS 6 to VMS 5				
VMS 6 E of Murphy 13+930	**LANE CLOSED**	**CARS TRUCKS**		

APPENDIX B

PROPOSED IMPROVEMENTS OPTION 2 (MARCH 29, 2007)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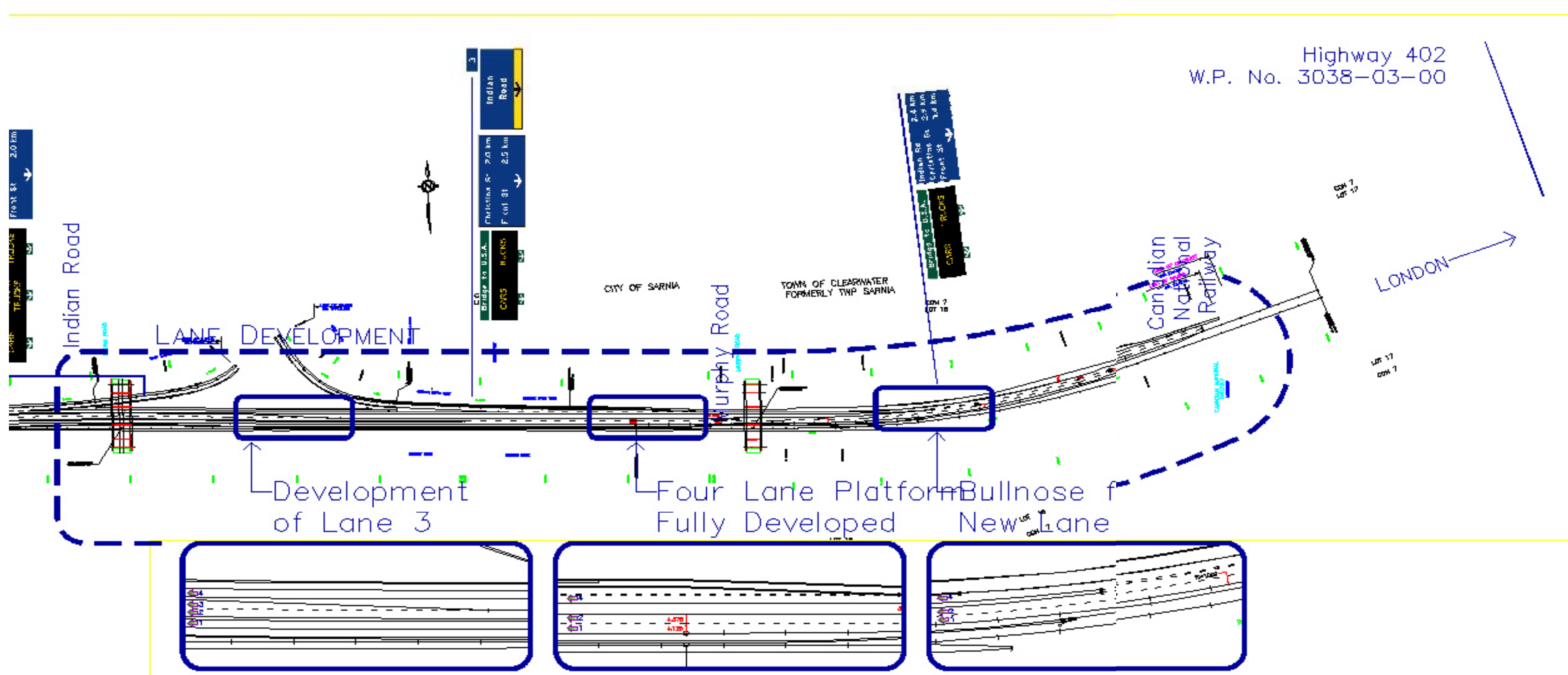
Co OF LAMBTON
Christina Street
Colborne Road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W.P. No. 3038-03-00
Indian Road
LANE DEVELOPMENT
CITY OF SARNIA
Murphy Road
TOWN OF CLEARWATER
FORMERLY TWP SARNIA
Canadian National Railway
LONDON
Development of Lane 3
Four Lane Platform Fully Developed
Bullnose f New Lane