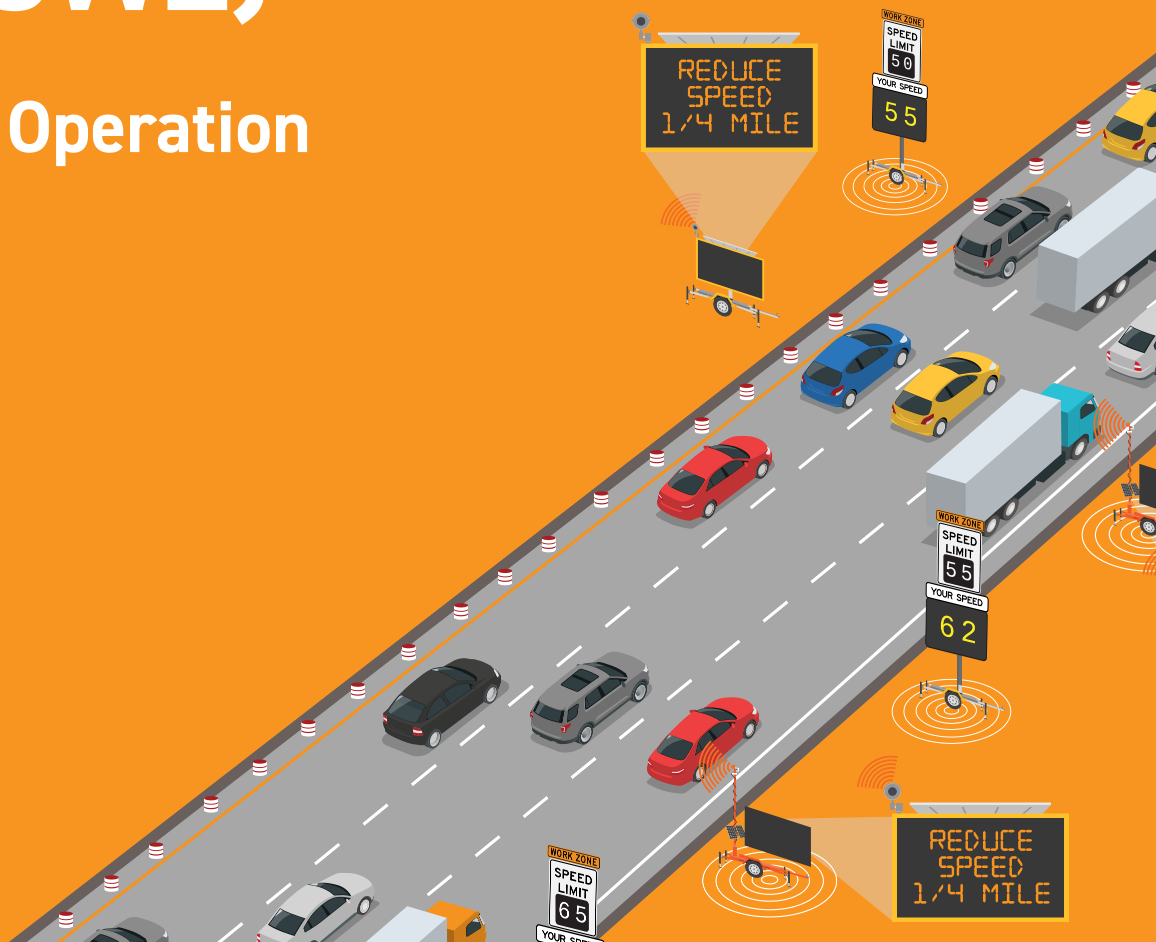
Guidebook

Smart Work Zone (SWZ)

Design and Operation



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Acronyms and Definitions

ADS	Automated Driving System
ARC-IT	Architecture Referenced for Connected and Intelligent Transportation
C-V2X	Cellular Vehicle to Everything
ConOps	Concept of Operations
CAV	Connected and Automated Vehicle
CEI	Construction Engineering and Inspection
dB	Decibel
DDC	Developmental Design Criteria
DevSpecs	Developmental Specifications
DLM	Dynamic Lane Merge
DQW	Dynamic Queue Detection and Warning
DSH	Dynamic Speed Harmonization
ESFS	Electronic Speed Feedback Sign
FHP	Florida Highway Patrol
FHWA	Federal Highway Administration
FDOT	Florida Department of Transportation
FDM	FDOT Design Manual
GPS	Global Positioning System
ITS	Intelligent Transportation Systems
LCIS	Lane Closure Information System
LCNS	Lane Closure Notification System
LED	Light-Emitting Diode
LEO	Law Enforcement Officer
MPH	Miles per Hour
OBU	On-Board Units
OSHA	Occupational Safety and Health Administration
P2P / P2M	Point-to-Point/Multipoint
PCMS	Portable Changeable Message Sign
PSEMP	Project Systems Engineering Plan
PIP	Public Information Plan
RTMC	Regional Transportation Management Center
RSU	Roadside Unit
SWZ	Smart Work Zone
TSM&O	Transportation Systems Management and Operations
TTC	Temporary Traffic Control
TTCP	Temporary Traffic Control Plan
VSL	Variable Speed Limit
WZDx	Work Zone Data Exchange

1.0 Introduction

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1.1 Purpose of the Smart Work Zone Guidebook

This Guidebook on Smart Work Zone (SWZ) Design and Operation provides criteria and guidance for the selection, design, and operations of SWZ strategies, systems, and technologies to improve traffic safety, worker safety, and traffic efficiency approaching and within work zones. The guidebook supports Florida Department of Transportation's (FDOT) overall goals of improving safety and enhancing mobility. Specifically, this guidebook complements:

Strategic Highway Safety Plan

Transportation Systems Management and Operations (TSM&O) Strategic Plan

Connected and Automated Vehicle (CAV) Business Plan

The Guidebook is in recognition that FDOT is simultaneously developing Developmental Specifications (DevSpecs), FDOT Design Manual (FDM), Developmental Design Criteria (DDC), and Developmental Standard Plans (DSP) to describe SWZ technologies and strategies that are intended to actively and safely manage traffic approaching and traveling through work zones.

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1.2 Characteristics of Smart Work Zones

SWZs have the following general characteristics:

REAL-TIME

The system obtains and analyzes traffic flow data in real-time, providing frequently updated information to motorists.

PORTABLE

The system is portable, allowing its installation at different locations (with configuration modifications, as necessary).

AUTOMATED

The system operates in an automated manner with minimal human supervision.

RELIABLE

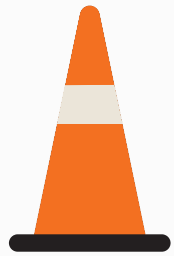
The system provides accurate and reliable information, keeping in mind the serious consequences of misinforming motorists in work zone situations.

1.3 Smart Work Zone Technologies

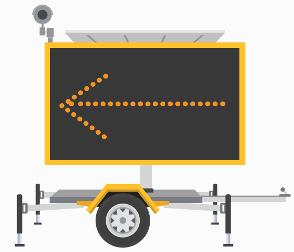
SWZs are used to augment and enhance traditional work zone traffic control measures. It is important to always comply with the Manual on Uniform Traffic Control Devices (MUTCD) and the FDOT Standard Specifications for Road and Bridge Construction when selecting SWZ technologies to use on a project. Developmental Specifications Dev102SWZ and Dev990SWZ provide specifications for technologies that support SWZ strategies.

SWZs use a variety of ITS technologies. Table 1 provides a list of SWZ technologies along with a visual representation of the associated device used for reference.

TABLE 1: SWZ TECHNOLOGIES

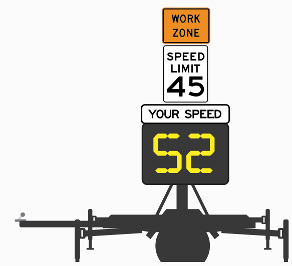


SWZ LOCATION DEVICES

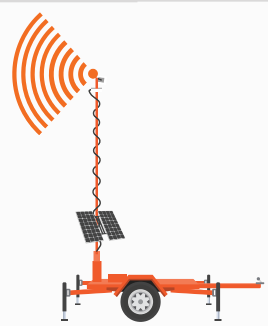


SWZ ARROW BOARD

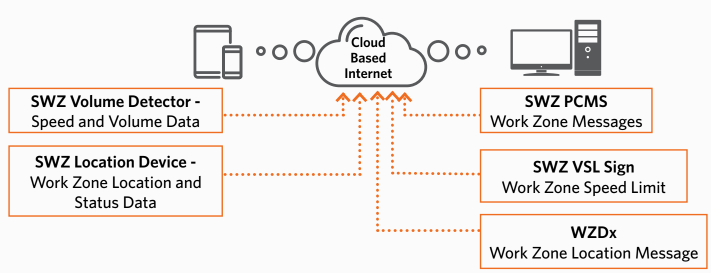
SWZ PORTABLE CHANGEABLE MESSAGE SIGN (PCMS)



PORTABLE VARIABLE SPEED LIMIT (VSL) SIGN WITH ELECTRONIC SPEED FEEDBACK SIGN (ESFS)



SWZ VEHICLE DETECTOR



SWZ CENTRAL PROCESSOR

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1.4 Smart Work Zone Strategies

The above SWZ technologies can be used separately for work zone monitoring and reporting, or for the purpose of this SWZ Guidebook, used in combination to create strategies or systems to address traffic impact scenarios. SWZs use combinations of the above technologies to create strategies or systems in response to work zone traffic impact scenarios.

Each of these SWZ strategies is addressed in more detail in Section 3.

See Specifications Dev102SWZ and Dev990SWZ, FDM DDC240, and Developmental Standard Plans for additional criteria.

SWZ STRATEGIES COVERED IN THE GUIDEBOOK INCLUDE:

- Work Zone Data Exchange (WZDx) SWZ Location Devices
- Dynamic Lane Merge (DLM)
- Dynamic Lane Merge (DQM)
- Dynamic Speed Harmonization (DSH)

Since SWZ strategies augment rather than replace other work zone traffic control devices, it is important to always comply with adopted design criteria for work zones, including, but not limited to, the Manual on Uniform Traffic Control Devices, FDOT Standard Plans, FDOT Design Manual (FDM), FDOT Standard Specifications for Road and Bridge Construction, and FDOT Speed Zoning for Highways, Roads, and Streets in Florida when selecting SWZ strategies to use on a particular project.

1.5 Smart Work Zone Operations

SWZ systems may operate in a closed environment or connect to either a cloud-based processor system or a traffic management center or both. A closed system will have preset and pre-approved algorithms for activating and updating SWZ elements such as Portable Changeable Message Sign (PCMS) or alarms. A connected system may have a combination of automatic, pre-approved elements and elements that require an engineer to provide input or approval before the system updates a SWZ PCMS or a Variable Speed Limit (VSL) sign. SWZ operations will need to be addressed in accordance with the FDM DDC240, Section 240.3 Transportation Operations Plan and Guidebook Sec. 4.1 - SWZ Active Management and Operations Plan. Guidebook Sec. 3 provides operational guidance and criteria for each of the above SWZ strategies.

2.0 Program and Scoping

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2.1 Work Zone Assessment for SWZ Priority

Work zones that negatively impact traffic safety and throughput are the highest priority for inclusion of SWZ strategies within the Temporary Traffic Control Plans (TTCP) (See FDM DDC240). Initial screening for determining if SWZ strategies would improve traffic safety and efficiency should ideally be conducted during project scoping and development of the work programming so that costs for SWZ can be properly considered.

The requirements for including SWZ strategies and technologies on the State Highway System can be found in FDM DDC240.

2.2 Design Scope of Services for SWZ Strategies

FDOT's standard design Scope of Services covers development of a TTCP for roadway projects.

- Section 4.9 Temporary Traffic Control Plan (TTCP) Analysis
- Section 4.10 Master TTCP Design Files
- Section 5 Roadway Plans
- Section 10.25 TTCP/Staged Construction Requirements
- Section 22.11 TTCP Signal (Temporary)
- Section 34.15 Temporary Traffic Control Plans

For projects including SWZ strategies and technologies, design scopes of services for design-bid-build projects and the RFP for design-build projects should address identification and design of SWZ strategies within the TTCP.

3.0 Identification and Selection of SWZ Strategies

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As mentioned earlier, there are four SWZ strategies described in this Guidebook. Each strategy can address one or more challenges affecting work zone safety and traffic

SWZ STRATEGIES MAY BE SELECTED TO:

- minimize traffic and safety impacts to the roadway planned for construction.
- minimize impacts to a network of roadways including the roadway under construction and roadways surrounding the work zone that may be impacted by detours or traffic diversions due to work zone congestion.

The following sections discuss the use case(s), concept of operations, anticipated benefits, technologies, and typical layouts for each of the four SWZ strategies. Select and implement SWZ strategies on a project-by-project basis based on their potential to impact safety and mobility on the project. Similar projects with similar impacts should use the same SWZ strategies to enhance driver familiarity.

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3.1 Work Zone Data Exchange (WZDx)

The Work Zone Data Exchange (WZDx) Specification enables infrastructure owners and operators to make harmonized work zone data available for third party use. The goal of the WZDx is to enhance the ability of vehicles equipped with automated driving systems (ADS) to safely and efficiently navigate through work zones.

3.1.1. WZDx Use Cases and Concept of Operations

The WZDx can be used for any project impacting roadway traffic or where workers may be present adjacent to open traffic lanes.

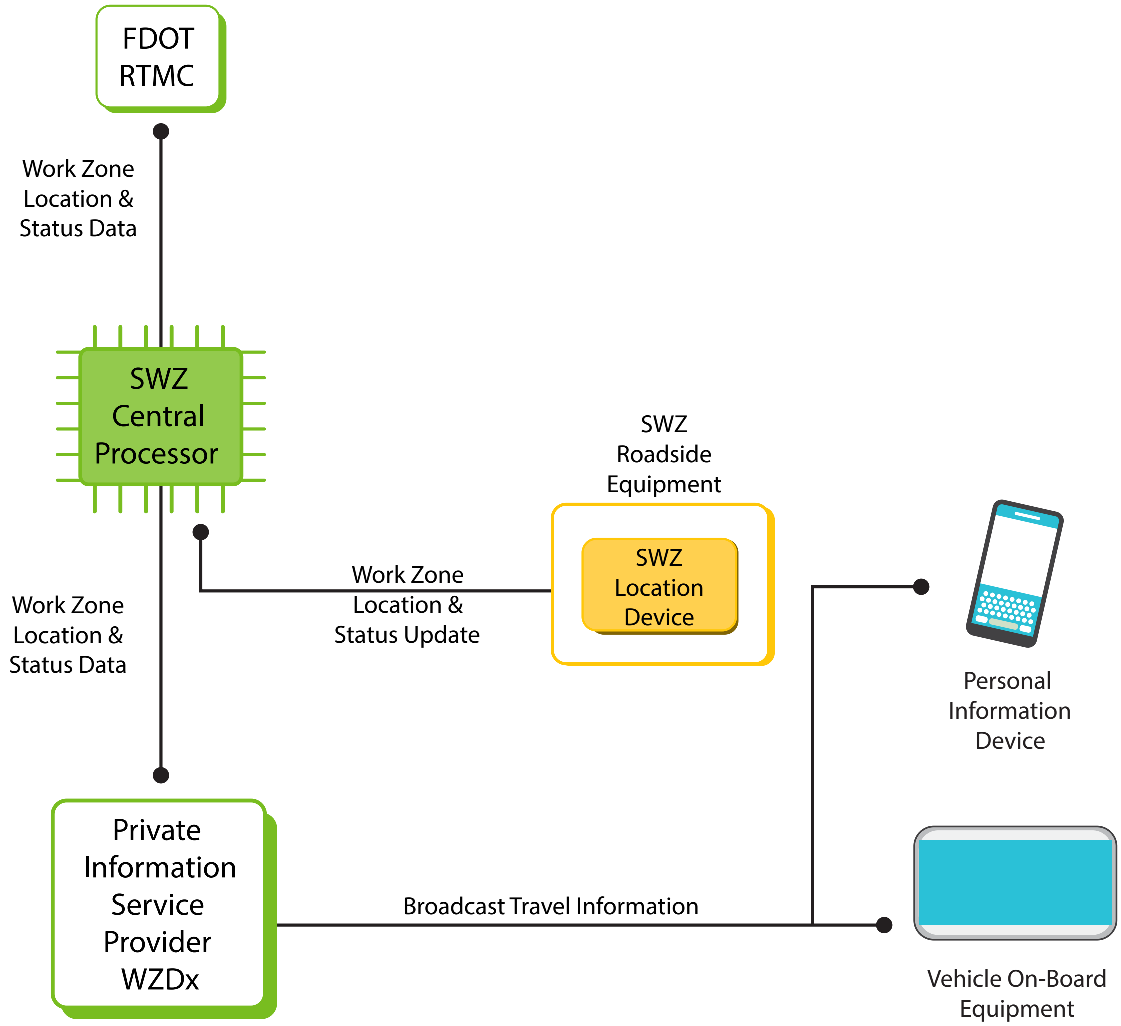
Properly placed SWZ Location Devices will allow work zone information providers to provide timely and accurate work zone information as work zone traffic control and traffic condition changes occur (e.g., speed limits, SWZ PCMS messages, lane closures).

3.1.2. WZDx Technologies

The primary roadside technology for WZDx is the SWZ Location Device, which is a global positioning system (GPS) based wireless communication device. This device sends messages to third party traveler information service providers through a SWZ Processor using WZDx specifications. The SWZ Location Device can be integrated into channelizing devices, SWZ arrow boards, and SWZ PCMS.

Figure 1 is a simplified architecture of a WZDx system showing WZDx equipment, communication connectivity, and information flows between equipment. See Figure 9 for additional WZDx data flow architecture details.

FIGURE 1: WZDx BASIC ARCHITECTURE



3.1.3. WZDx Basic Layout

The basic layout for the WZDx is to provide SWZ Location Devices at the beginning and end of lane closures, diversions, crossovers, and rolling roadblocks. For additional layout details, refer to Developmental Standard Plan Indexes 102-607, 102-608, 102-613, 102-620, and 102-655.

For longer and more complex projects, SWZ Location Devices should also be considered at the following locations:

- First/last channelizing device in lane closure(s)
- Flaggers using either flag paddles or flagger assistive devices
- SWZ Flashing Arrow Boards
- Vehicle mounted Flashing Arrow Boards
- Mobile work zone Shadow Vehicles and/or mobile work zone attenuator trailers
- Stop Here on Red Signs and/or on Portable Traffic Signals

3.2 Dynamic Lane Merge (DLM)

The National Work Zone Safety Information Clearinghouse Guidance for the **Use of Dynamic Lane Merging Strategies** (November 2012) describes how dynamic early merging and dynamic late merging can be used either individually or cooperatively to reduce delay and increase safety at highway lane closures.

The National Work Zone Safety Information Clearinghouse Guidance for the Use of Dynamic Lane Merging Strategies (November 2012)

3.2.1. DLM Use Case

Use DLM when traffic speeds and volumes typically and predictably change throughout the duration of the lane closure. When a lane closure is present, some drivers tend to move over immediately while others wait until the last possible moment to merge. This driver behavior causes speed differentials, hard braking, road rage, crashes, endangers workers, and reduces throughput in the lanes approaching the lane closure and in the open lanes past the closure.

3.2.2. DLM Concept of Operations

DLM has two modes of operations: DLM-Late Merge and DLM-Early Merge.

- DLM-Late Merge works best when approaching traffic volumes are nearing or exceed the capacity (1,500 vehicle/lane/hour) of the remaining open lanes.
- DLM-Early Merge works best for low traffic volumes to get all traffic into the open lanes early so that they are traveling at uniform speeds when they approach the closure.

Queues and delays may occur when traffic volumes approach the traffic capacity of the restricted roadway. These capacity reductions may occur at work zones with geometric restrictions, closed or narrow shoulders, lane closures, and speed reductions.

Use of DLM allows the maintenance of traffic manager to switch between early and late merge as traffic conditions change through the duration of the lane closure. DLM can use a SWZ Central Processor using pre-approved algorithms to switch between DLM modes. Planning for use of both Early and Late merge modes should be based on historical traffic volumes. Timing of switch between modes should be based on real-time traffic conditions, however, quickly switching back and forth between modes is not recommended.

DLM can create more orderly merging conditions at lane closures by communicating to drivers through SWZ PCMS or through vehicle on-board units (e.g., OBUs). The messages displayed direct drivers to merge early when traffic conditions are light and merge late when traffic conditions are heavy. When high traffic speeds are detected with low traffic volumes, DLM activates SWZ PCMS messages for the early merge mode. When low traffic speeds are detected and traffic volumes are high, DLM activates SWZ PCMS messages for the late merge mode. Timing of switching between modes will depend on traffic speed and volume trends.

Depending on the expected traffic volumes and length of queue, extend coverage of SWZ PCMS upstream to ensure the first SWZ PCMS is ahead of any slowed traffic caused by the work zone especially when traffic volumes and speeds suggest DLM Late Merge option is needed.

BENEFITS ANTICIPATED WITH DLM – LATE MERGE INCLUDE:

- Reduced stop and go flow
- Increased throughput through the work zone
- Fewer crashes
- Increased queue storage, reducing potential for backups into upstream ramps and intersections
- Fewer work zone intrusions

BENEFITS EXPERIENCED WITH DLM – EARLY MERGE INCLUDE:

- Fewer last moment “cut-ins”
- Increased throughput through the work zone
- Fewer crashes
- Fewer work zone intrusions

3.2.3. DLM Technologies

To manage traffic through temporary lane closures, Dynamic Lane Merge uses the following SWZ devices and systems:

- SWZ Location Devices
- SWZ Arrow Boards
- SWZ Vehicle Detectors
- SWZ PCMS
- SWZ Central Processor

SWZ Vehicle Detectors collect traffic speed and volume data and transmit the data to the SWZ Central Processor. The SWZ Central Processor determines the optimal DLM Mode of Operations and transmits messages to post on the SWZ PCMS.

SWZ PCMS messages vary depending on mode of operation. SWZ PCMS messages for DLM stored in the SWZ Central Processor must be approved by FDOT for use with DLM operational scenarios. Once the PCMS message library in the SWZ Central Processor is approved along with the usage algorithms for each message, no further FDOT approvals are needed unless a message or usage algorithm is changed. Tables 2 & 3 list PCMS messages that may be used for early and late operational modes. Other messages that convey the intent may be used and assessed for effectiveness.

TABLE 2: DLM - EARLY MERGE PCMS MESSAGES

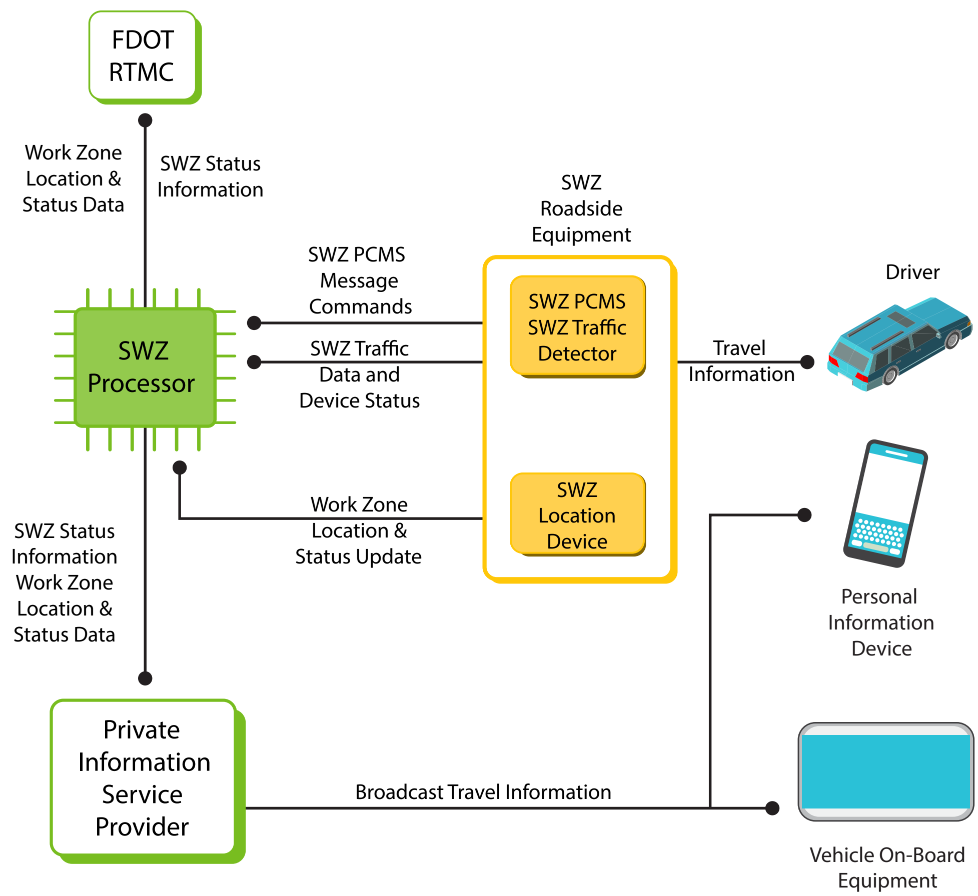
		OPTION 1 (Right Lane Closed)		OPTION 2 (Left Lane Closed)	
PCMS Position	PCMS Line #	PCMS Page 1	PCMS Page 2	PCMS Page 1	PCMS Page 2
First PCMS seen by traffic *(Use additional PCMS with applicable distances depending on length of traffic backup)*	1	RD WORK	PREPARE	RD WORK	PREPARE
	2	AHEAD	TO	AHEAD	TO
	3	1 MILE	MERGE	X MI (FT)	MERGE
Second PCMS seen by traffic	1	RIGHT	MERGE	LEFT	MERGE
	2	LANE	LEFT	LANE	RIGHT
	3	CLOSED		CLOSED	
Third PCMS seen by traffic	1	RIGHT	MERGE	LEFT	MERGE
	2	LANE	LEFT	LANE	RIGHT
	3	CLOSED		CLOSED	

TABLE 3: DLM - LATE MERGE PCMS MESSAGES

		OPTION 1 (Right Lane Closed)		OPTION 2 (Left Lane Closed)	
PCMS Position	PCMS Line #	PCMS Page 1	PCMS Page 2	PCMS Page 1	PCMS Page 2
First PCMS seen by traffic (Use additional PCMS with applicable distances depending on length of traffic backup)	1	RD WORK	SLOW	RD WORK	STOPPED
	2	AHEAD	TRAFFIC	AHEAD	TRAFFIC
	3	X MI (FT)	AREAD	X MI (FT)	AREAD
Second PCMS seen by traffic	1	LANE	STAY		
	2	CLOSED	IN		
	3	X MI (FT)	LANE		
Third PCMS seen by traffic (Last PCMS before the lane closure)	1	MERGE	TAKE		
	2	HERE	TURNS		
	3				

Figure 2 provides a simplified architecture of a DLM system showing DLM equipment, communication connectivity, and information flows between equipment. This architecture is identical for DQW.

FIGURE 2: DLM BASIC ARCHITECTURE



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3.2.4. DLM Conceptual Layout

DLM use two operational concepts: Early Merge and Late Merge. Figure 3 is conceptual layout of early merge while Figure 4 is a conceptual layout of late merge.

FIGURE 3: DYNAMIC LANE MERGE - EARLY MERGE OPERATIONS

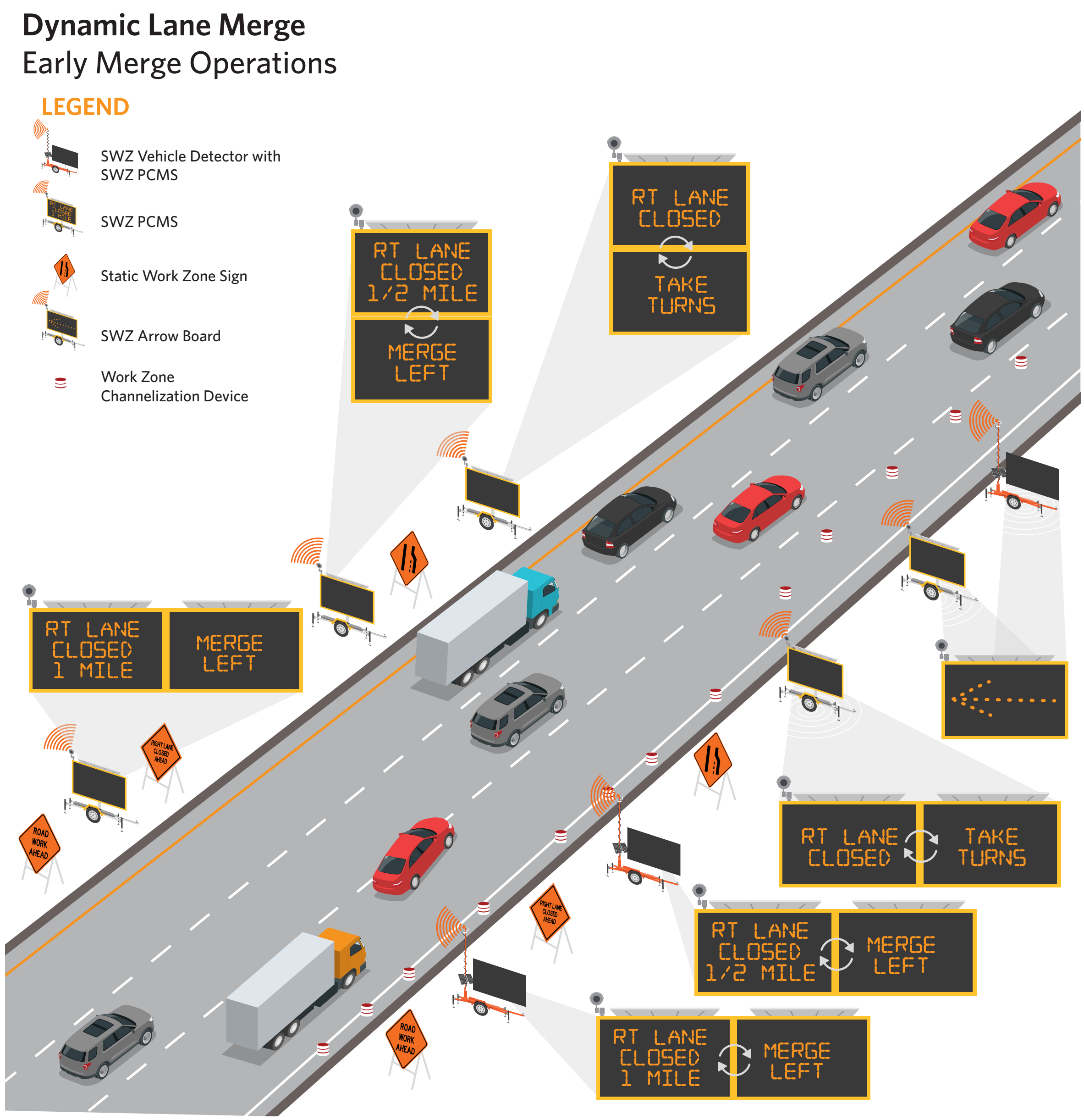
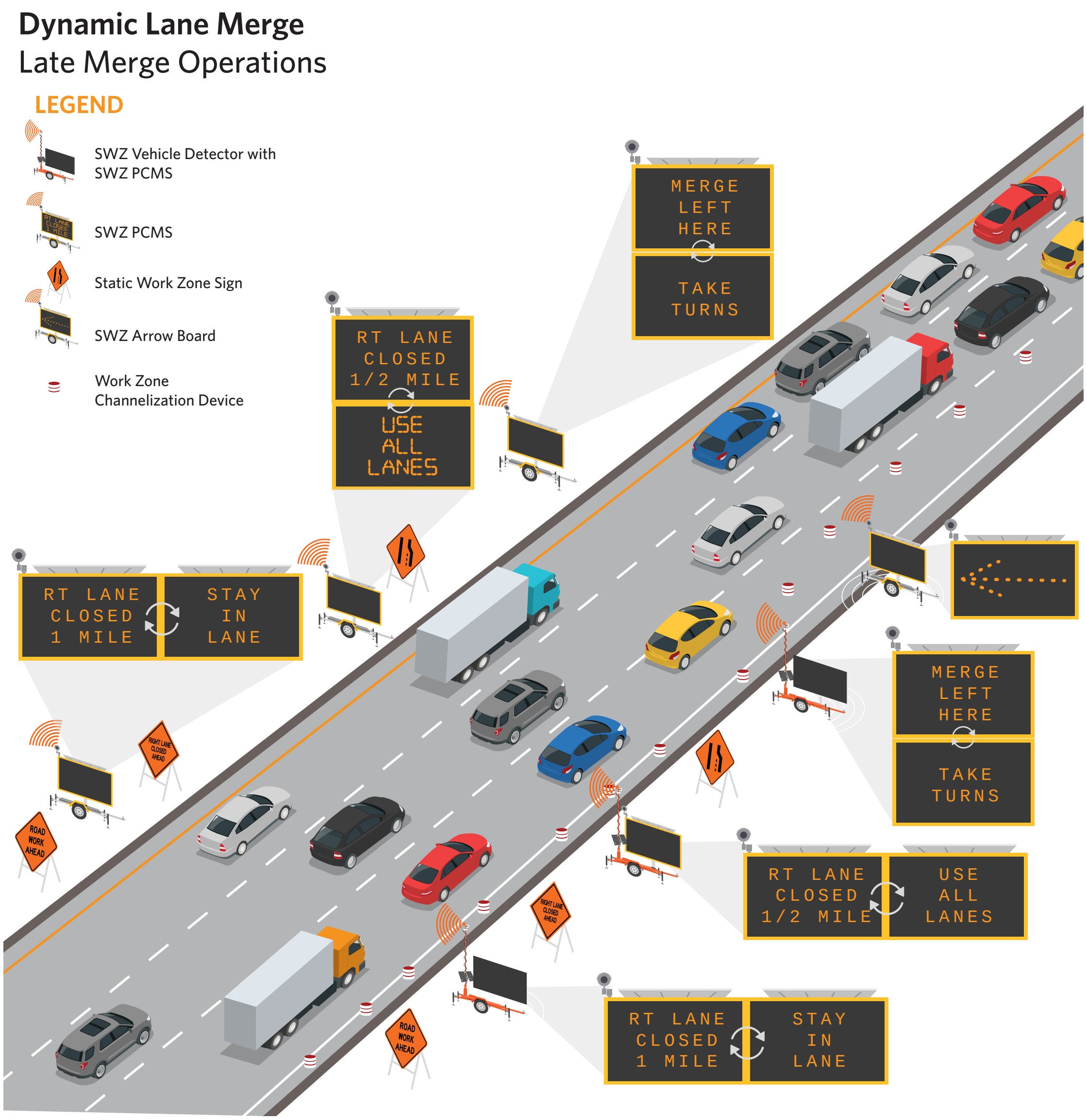


FIGURE 4: DYNAMIC LANE MERGE - LATE MERGE OPERATIONS



More DLM layout details are depicted in **Developmental Standard Plans for Indexes 102-613 and 102-620.**

3.3 Dynamic Speed Harmonization (DSH)

Per Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) Version 9.0, **Service Package TM21:** Speed Harmonization, the purpose of speed harmonization is to change traffic speed on links that approach areas of traffic congestion, bottlenecks, incidents, special events, and other conditions that affect flow. Speed harmonization assists in maintaining flow, reducing unnecessary stops and starts, and maintaining consistent speeds. The speed limits generated by the speed harmonization strategy can be provided to in-vehicle on-board equipment or through VSL signs as shown in Figure 5.

3.3.1. DSH Use Cases

There are two basic reasons to use DSH in work zones.

1. Use Dynamic Speed Harmonization (DSH) when traffic speeds vary through the work zone and/or where traffic speed approaching the work zone is considerably higher than speed through the work zone.

2. Use DSH when different speed limits are needed when workers are present, for example, compared to when workers are not present.

3.3.2. DSH Concept of Operations

This strategy requires active management of work zone regulatory speed limits based on approaching traffic speeds and 85th percentile speeds through the work zone. Speed Harmonization has been used to gradually slow or smooth traffic approaching the speed constriction based on real-time conditions rather than at one VSL sign in advance of the work zone. VSL speed limit messages are always presented in whole 5 miles per hour (MPH) increments. The SWZ Central Processor will generate speed limit messages based on VSL sign locations and traffic speeds. The SWZ Central Processor speed limit generation algorithms and tables must be approved in advance by the District Traffic Operations Engineer, or delegate, responsible for setting speed limits. See Table 4 for an example of a speed limit generation table based on speeds of approaching traffic and speeds in the downstream bottleneck. In accordance with the FDOT Speed Zoning Manual Section 10.1(3), a human operator approved by the Department must review and accept the SWZ Central Processor generated speed limits prior to posting them on the VSL signs.

Electronic speed feedback signs (ESFS) and presence of law enforcement officers have been shown to increase speed limit compliance. For DSH, ESFS are located with each VSL sign and integrated with the VSL sign either at the roadside or in the SWZ Central Processor so that any alerts the ESFS provides when a speeding vehicle is detected are based on the current speed limit posted on the VSL sign.

Depending on the expected traffic volumes and length of queue, coverage of SWZ PCMS should be extended upstream to ensure the first SWZ PCMS is ahead of any slowed traffic caused by the work zone.

Types of benefits anticipated with DSH include:

- Reduced stop and go flow
- Reduced speed variation
- Increased throughput through the work zone
- Fewer crashes
- Since uniform lower traffic speeds can increase throughput traffic volumes, DSH creates a possibility for increasing the volume allowable for a lane closure to be in effect and longer construction hours

TABLE 4: SAMPLE VSL MESSAGES BASED ON SPEED AND BOTTLENECK SPEED

85th Percentile Measured Speed with the Work Zone (Approach Speed 70 MPH)	**VSL #1**	**VSL #2**	**Additional VSL (Signs) Preceding and through WZ Lane Restriction**
	Posted Variable Speed Limit (VSL)		
65 MPH or greater	70 MPH	70 MPH	70 MPH
60-64 MPH	70 MPH	65 MPH	65 MPH
55-59 MPH	70 MPH	60 MPH	60 MPH
50-54 MPH	65 MPH	55 MPH	55 MPH
45-49 MPH	60 MPH	50 MPH	50 MPH
40-44 MPH	55 MPH	45 MPH	45 MPH
40 MPH or less	55 MPH	40 MPH	40 MPH

PCMS are used to warn drivers when speeds are reduced. Typically, PCMS are placed half-way between VSL signs, as follows:

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VSL sign spacing may be between one-half and one mile approaching and through the work zone depending on other signing, spacing for portable sign equipment, etc.

TABLE 5: SAMPLE DSH PCMS MESSAGES

		OPTION 1		OPTION 2	
PCMS Position	PCMS Line #	PCMS Page 1	PCMS Page 2	PCMS Page 1	PCMS Page 2
First PCMS seen by traffic *(Use additional PCMS with applicable distances depending on distance to traffic bottleneck)*	1	RD WORK	OBEY	RD WORK	REDUCE
	2	AHEAD	SPEED	AHEAD	SPEED
	3	X MI (FT)	LIMIT	X MI (FT)	
Second PCMS seen by traffic	1	SLOW	REDUCED	STOPPED	REDUCED
	2	TRAFFIC	SPEED	TRAFFC	SPEED
	3	AHEAD	AHEAD	AHEAD	AHEAD
Third PCMS seen by traffic (*Last PCMS before the speed bottleneck*)	1	SLOW	REDUCED	STOPPED	REDUCED
	2	TRAFFIC	SPEED	TRAFFC	SPEED
	3	AHEAD	AHEAD	AHEAD	AHEAD

3.3.3. DSH Technologies

To manage traffic through temporary lane closures and through lane shifts and traffic "cross-overs", Speed Harmonization uses the following SWZ technologies:

- SWZ Location Devices
- SWZ Arrow Board (at lane closure points)
- SWZ Vehicle Detectors
- SWZ PCMS
- VSL Signs with ESFS
- SWZ Central Processor

Since SWZ VSL posted speed limits may change from time to time, it is essential the VSL signs and ESFS function in an integrated manner in DSH. The ESFS speeding alerts are tied to the actual speed limit posted in the VSL sign so that the alerts become active when an approaching vehicle is detected traveling over the speed limited posted in the VSL sign. As the VSL sign message changes, the ESFS alarm adjusts at the same time. Figure 5 provides a basic architecture for DSH.

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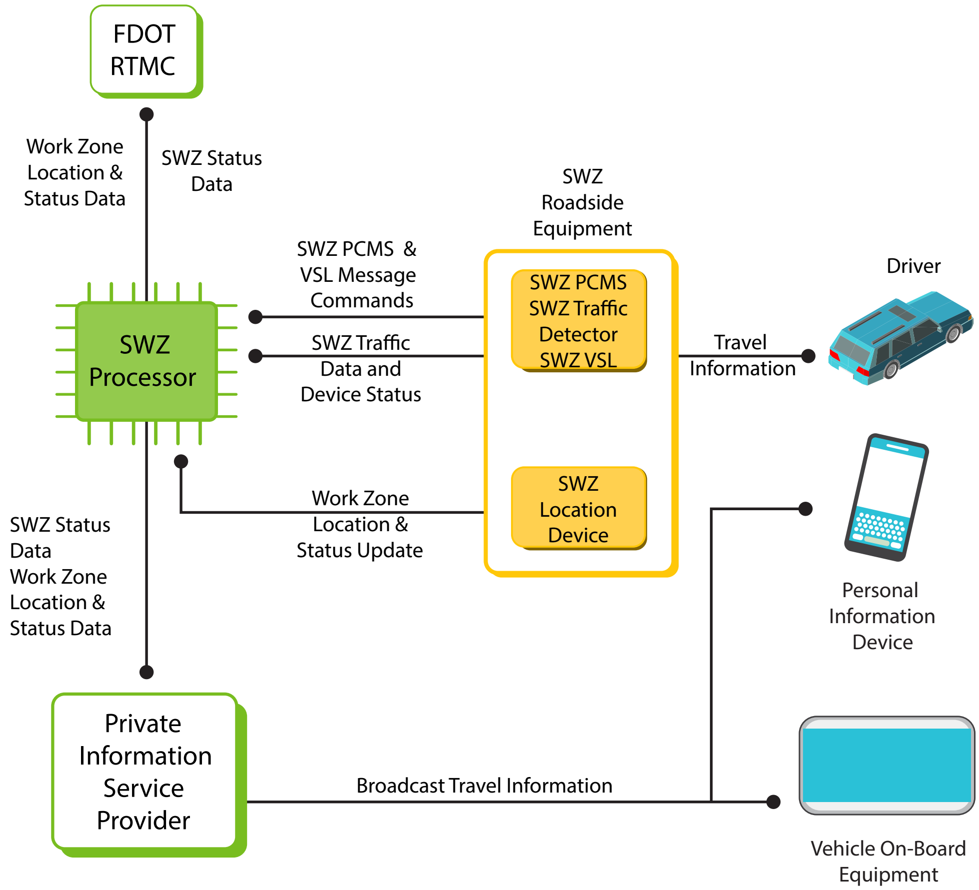
FIGURE 5: DSH BASIC ARCHITECTURE



3.3.4. DSH Layouts

Figure 6 provides a conceptual layout for DSH. Detailed layouts are provided in Developmental Standard Plans, Indexes D102-613 and 102-620.

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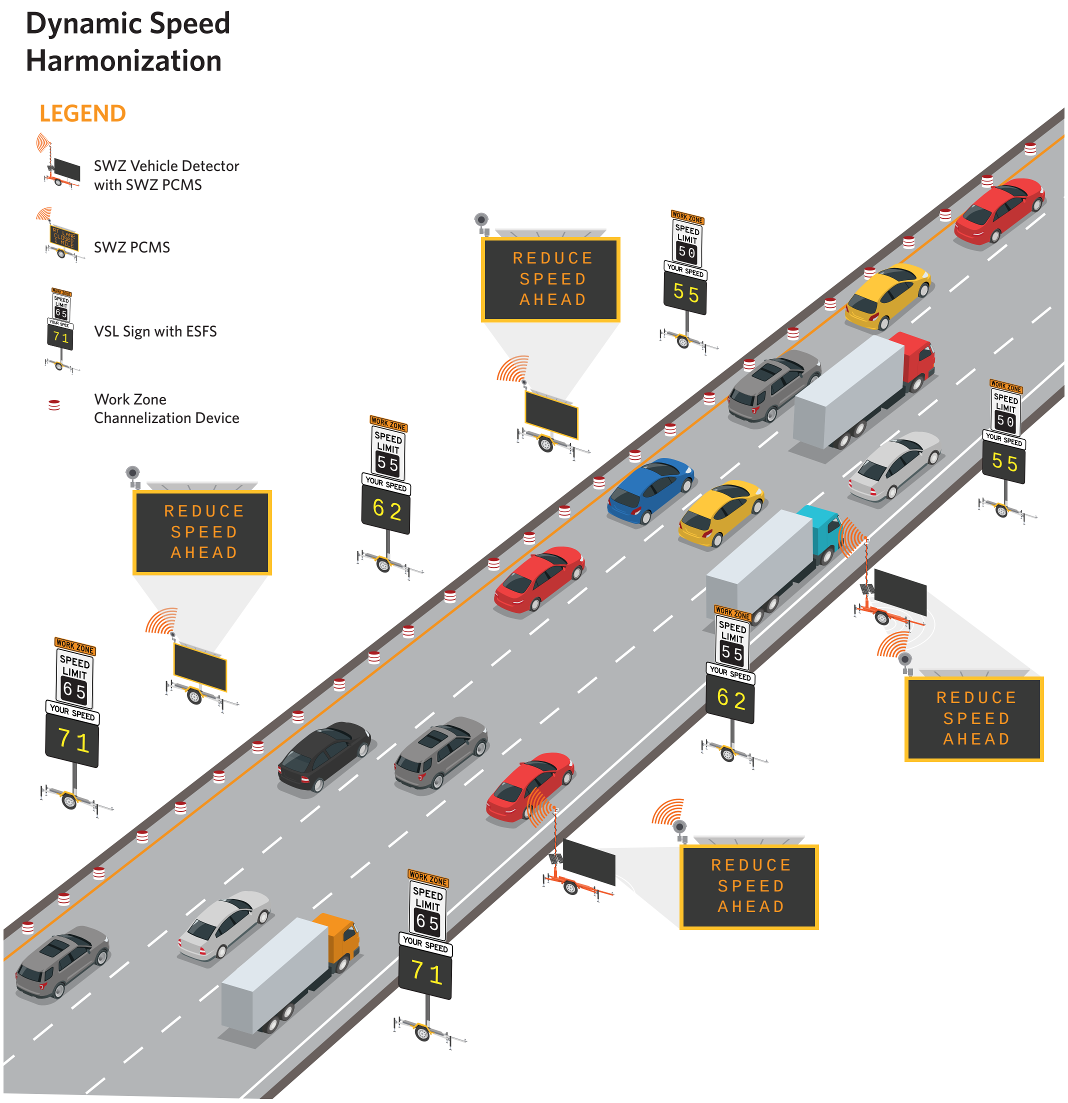
FIGURE 6: DYNAMIC SPEED HARMONIZATION



3.4 Dynamic End of Queue/ Slow Speed Warning

Dynamic End of Queue/Slow Speed Warning (DQW) systems follow the general layout of Standard Plans Index 102-613 except that SWZ traffic detectors and SWZ PCMS are added as indicated in Developmental Standard Plans, Indexes D102-613 and D102-620. The SWZ Traffic Detectors and SWZ PCMS communicate with the SWZ Central Processor. The SWZ Central Processor selects and posts SWZ PCMS messages from an FDOT approved PCMS message library based on real-time traffic conditions, speeds, and end of queue location when slow speeds or stopped traffic are detected downstream from each PCMS.

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3.4.1. DQW Use Cases

Use DQW systems to detect slow speed approaching and through the work zone. The slow speed could be caused by either the work zone traffic control or a traffic incident. Goal is to encourage traffic to gradually slow as it approaches a bottleneck impacting traffic speeds.

3.4.2. DQW Concept of Operations

Use SWZ Traffic Detectors to measure speeds and volumes of traffic approaching and through the work zone lane closure(s) and traffic constrictions. When speeds in the work zone are between 50% and 85% of approaching speeds, use SWZ PCMS to warn traffic of slow traffic ahead and distance to the back of the slow speed queue. When work zone speed is less than 50% of approaching traffic speeds, use SWZ PCMS to warn for "stopped traffic ahead", "stopped traffic xx miles". Manage DQW with the SWZ Central Processor, remotely, or through an Internet application in the traffic management center.

SWZ PCMS messages stored in the SWZ Central Processor must be approved by FDOT for use with DQW operational scenarios. Once the PCMS message library in the SWZ Central Processor is approved along with the usage algorithms for each message, no further FDOT approvals are needed unless a message or usage algorithm is changed. See Table 6 for a set of PCMS messages for specific algorithms.

Depending on the expected traffic volumes and length of queue, extend coverage of PCMS upstream to ensure the first SWZ PCMS is ahead of any congestion or queue caused by the work zone.

Benefits experienced with DQW include:

- Fewer work zone crashes
- Increased throughput through the work zone

TABLE 6: SAMPLE DQW PCMS MESSAGES - SLOW TRAFFIC AHEAD

PCMS Position	PCMS Line #	PCMS Page 1	PCMS Page 2
First PCMS seen by traffic *(Use additional PCMS with applicable distances depending on length of traffic backup)*	1	CAUTION	X MILES
	2	SLOW	AHEAD
	3	TRAFFIC	
Second PCMS seen by traffic	1	CAUTION	X MILES
	2	SLOW	AHEAD
	3	TRAFFIC	
Third PCMS seen by traffic *(Last PCMS before the end of queue)*	1	CAUTION	X MILES
	2	SLOW	AHEAD
	3	TRAFFIC	

TABLE 7: SAMPLE DQW PCMS MESSAGES - STOPPED TRAFFIC AHEAD

PCMS Position	PCMS Line #	PCMS Page 1	PCMS Page 2
First PCMS seen by traffic *(Use additional PCMS with applicable distances depending on length of traffic backup)*	1	CAUTION	X MILES
	2	STOPPED	AHEAD
	3	TRAFFIC	
Second PCMS seen by traffic	1	CAUTION	X MILES
	2	STOPPED	AHEAD
	3	TRAFFIC	
Third PCMS seen by traffic *(Last PCMS before the end of queue)*	1	CAUTION	X MILES
	2	STOPPED	AHEAD
	3	TRAFFIC	

3.4.3. DQW Technologies

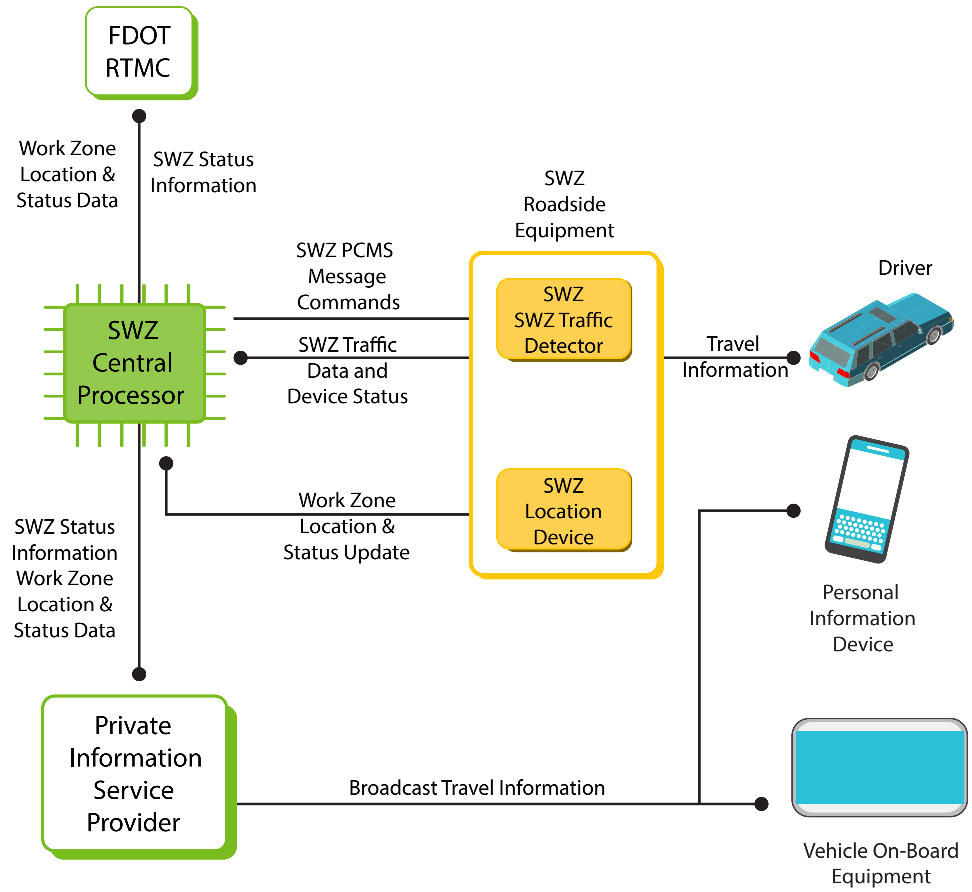
To manage traffic through temporary lane closures, DQW uses the following SWZ devices and systems:

- SWZ Location Devices
- SWZ Arrow Boards at lane closures
- SWZ Vehicle Detectors
- SWZ PCMS
- SWZ Central Processor

SWZ Vehicle Detectors collect traffic speed and volume data and transmit the data to the SWZ Central Processor. The SWZ Central Processor determines the distance from each SWZ PCMS to the end of the queued traffic ahead. The Processor also determines if the traffic is “stopped” or “slow” and transmits appropriate messages to post on the SWZ PCMS.

Figure 7 provides a basic architecture for DQW. The physical architecture is identical to DLM. The primary difference is that the SWZ Central Processor is determining SWZ PCMS messages based on the DQW operational concept.

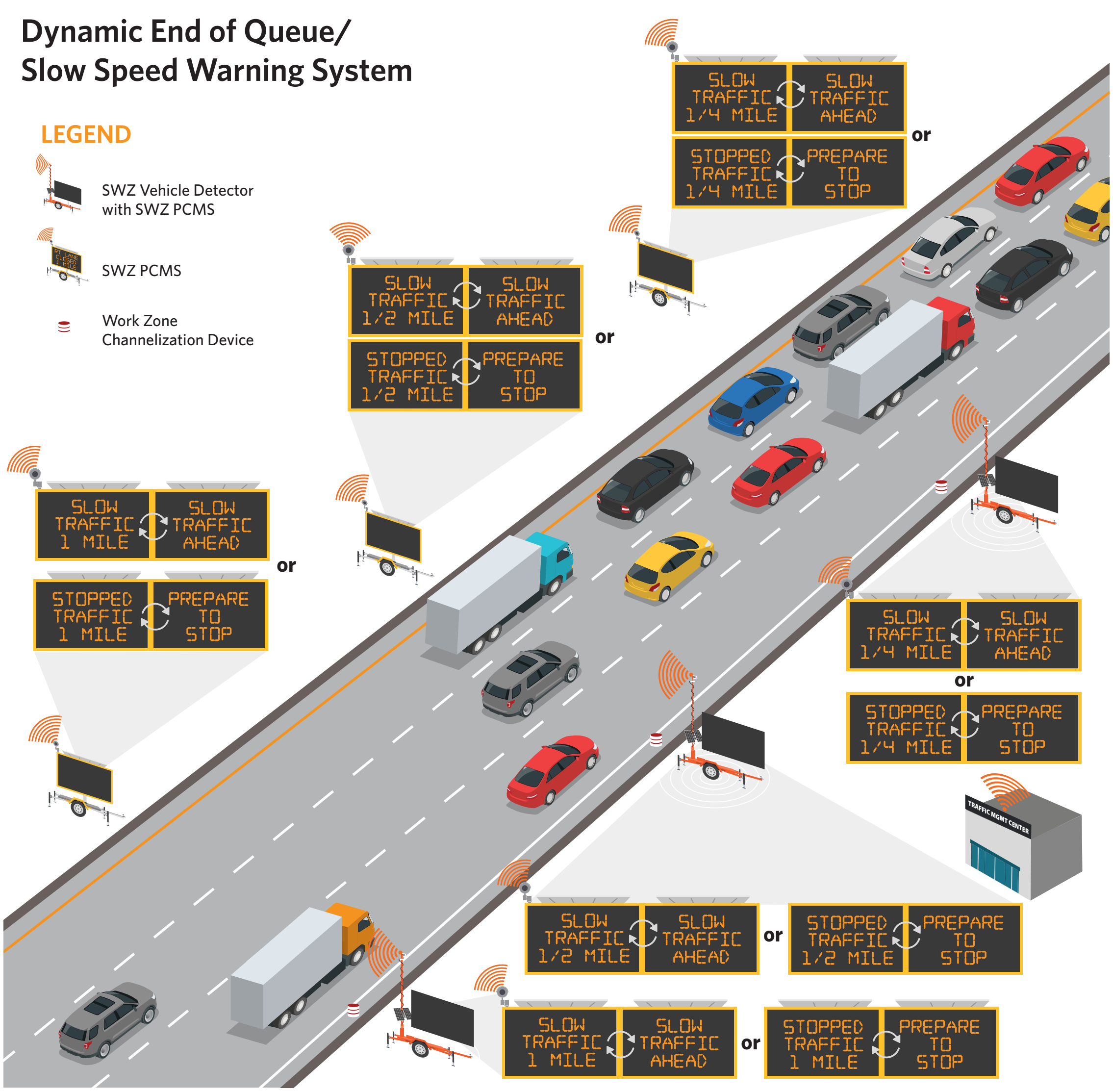
FIGURE 7: DQW BASIC ARCHITECTURE



3.4.4. DQW Layouts

Figure 8 provides a conceptual layout for DQW. Additional DQW design details are provided in Developmental Standard Plans, Indexes D102-613 and D102-620.

FIGURE 8: DYNAMIC END OF QUEUE/SLOW SPEED WARNING



4.0 SWZ Systems Engineering Analysis

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Either as a part of the overall project development or separately, SWZ systems engineering analysis should include, as a minimum, a concept of operations (ConOps), a system verification plan, a system validation plan, and a project system engineering management plan (PSEMP) as required by the FDOT Systems Engineering and Intelligent Transportation Systems (ITS) Architecture Procedure (Procedure # 750-040-003). The level of detail in the systems engineering analysis must be commensurate with the risk and magnitude of the SWZ elements planned for the project. As a minimum, a Project Risk Assessment and Regulatory Compliance Checklist (FDOT Form #750-040-05) should be completed to document the systems engineering analysis.

4.1 SWZ Management and Operations Plan

When using SWZ, development of the FDM Sec. 240.3 Transportation Operations Plan is mandatory. The SWZ Operations Plan identifies roles and responsibilities, user interfaces, software, and data storage to manage roadside data and manage SWZ roadside devices and cellular communications.

A Management and Operations Plan is required for projects using DLM, DSH, DQW, and other SWZ strategies where a SWZ Central Processor is used for SWZ Traffic Detector data collection, central data processing, real-time data sharing, and real-time management of SWZ-PCMS messages, VSL Sign speed limits, and alerts are part of the implemented SWZ plans.

The Management and Operations Plan will include the following at a minimum:

- Identification of SWZ technologies and strategies.
- Identification of safety and traffic operations goals for each SWZ strategy.
- Identification of all stakeholders with a role in design, procurement, set-up, management, operations, and adjusting of SWZ technologies and strategies.
- Identification of roles and responsibilities of each SWZ stakeholder.
- Identification of specific roles retained to FDOT for each SWZ strategy, if any.
- Formal or informal agreements, as needed, ensuring each stakeholder will meet their roles and/or responsibilities.
- Other operations and maintenance topics identified in the project ConOps.

The SWZ Management and Operations Plan should be approved by FDOT prior to finalization of SWZ strategy selection in the final design plans for design-bid-build projects and design-build projects.

4.1.1. SWZ Roles and Responsibilities

As a minimum, the SWZ Management and Operations Plan must address roles and responsibilities of the Contractor (both traditional Temporary Traffic Control (TTC) staff and SWZ staff), the Construction Engineering and Inspection (CEI) inspectors, the FDOT Regional Transportation Management Center (RTMC), and appropriate law enforcement agencies such as the Florida Highway Patrol (FHP), local agency police department, county sheriff's office. If the SWZ strategies impact traffic on roadways managed by local agencies, roles and responsibilities should be defined for the local agency or agencies as well. See Table 8 for example of SWZ roles and responsibilities. Not all Stakeholders in Table 8 will be involved with SWZ Management and Operations. The project's ConOps (See FDOT Procedure 750-040-003) will contain a complete list of Project Stakeholders and Roles.

TABLE 8: EXAMPLE SWZ MANAGEMENT AND OPERATIONS ROLES

Stakeholder	Project Role
Roadway and Temporary Traffic Control (TTC) Design Engineers	Select appropriate SWZ strategies based on specific project needs. Develop TTCP with SWZ technology elements to support TTC for the roadway construction projects. Develop SWZ Management and Operations Plan.
District TSM&O and ITS Engineers and Managers	Oversee SWZ systems engineering analysis, implementation, and coordination with RTMC operations.
Roadway Contractors, Traffic Control Subcontractors	Provide, implement, integrate, manage, and maintain SWZ deployments along with overall project traffic control.
SWZ Equipment Manufacturers and Vendors	Provide SWZ equipment that meet FDOT Standard Specifications for Road and Bridge Construction. Provide SWZ cloud-based processing, management, and real-time information dissemination system. Provide necessary user training and technical support to RTMC managers and operators.
Construction Inspection Engineers and Inspectors	Ensure SWZ technologies are implemented and functioning as intended.
RTMC Managers and Operators	Monitor and interact with SWZ applications to manage and approve specific outputs from the cloud-based processing and management system.
District Traffic Operations Engineer	Review and approve/deny suggested variable speed limit changes and PCMS messages based on established algorithmic calculations. Designate representative in their absence.
Evaluators and Researchers	Download SWZ Central Processor data and other traffic and safety data and conduct impact assessments per evaluation plans.
Law Enforcement Officers (LEO)	Park to be visible to traffic in the work zone and enforce the speed limits as need arises.
Third-Party Travel Information Providers	Disseminate SWZ info to motorists, bicyclists, and pedestrians.
Motorists, Bicyclists, and Pedestrians	Obtain SWZ information and respond accordingly.
Planners and Policymakers	Analyze SWZ Data to monitor deployment plans and policies and adjust as needed in the future.

It is important that each stakeholder with an active role is aware of their role(s) and has agreed to perform those roles and has adequate resources to do so. If necessary, a formal agreement should be executed documenting roles and responsibilities.

4.1.2. SWZ Central Processor, User Interface, Servers, and Data Storage

The SWZ Management and Operations Plan must provide requirements for the SWZ Central Processor processing software, user or operator interface with the processing software, server requirements, and data storage requirements. The SWZ Central Processor must have the following minimum capabilities and features plus any others identified through Stakeholder coordination:

- Two-way communication with roadside equipment including detectors, PCMS, VSL signs, and CAV Roadside Units (RSUs).
- Secure "cloud" environment
- Recommending and posting real-time VSL information based on traffic conditions and pre-approved criteria
- Generating PCMS messages using pre-approved messaging criteria based on a pre-approved message library
- Ability to provide opportunity for FDOT assigned person to review processor-generated VSL information and PCMS messages before posting them to the roadside devices
- Ability for speed limit and PCMS message generation criteria to be updated and approved by FDOT
- Ability for PCMS message library to be updated and approved by FDOT
- A user interface that is:
- Secure
- Internet-accessible
- Accessible by multiple FDOT-approved users
- Intuitive to users
- Ability to store data and provide access to data for FDOT and FDOT approved users as required by the Department's data retention policies
- Ability to timestamp all SWZ Central Processor collected data along with PCMS and VSL sign messages generated
- Clear electronic Operations Manual available to users

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4.2 SWZ Communication and CAV Plan

As noted in other sections, many SWZ roadside devices require real-time communication to function as intended. The SWZ Communication and CAV Plan will use cellular, or connected vehicle communication technologies. SWZ communication considerations include:

- Cellular communication to send roadside data to:
  - SWZ Central Processor
  - An FDOT RTMC
- Connected Vehicle communication to:
  - Transmit data between roadside equipment and RSU
  - Transmit data between vehicle-mounted on-board units (OBU) and RSU

For current wireless communication security protocol and connected vehicle security credentialing management system requirements, contact FDOT's CAV Program Manager in State Traffic Engineering and Operations Office.

4.3 Work Zone Data

Section 3.1 discussed the WZDx strategy. The WZDx strategy is supported nationally by the WZDX Specification and statewide through the Department's LCNS Lane Closure Notification System.

4.3.1. Work Zone Data Exchange (WZDx) Specification

The WZDx website (https://github.com/usdot-jpo-ode/wzdx) describes the WZDx Specification, as follows:

> "The Work Zone Data Exchange (WZDx) Specification aims to make harmonized work zone data provided by infrastructure owners and operators (IOOs) available for third party use, making travel on public roads safer and more efficient through ubiquitous access to data on work zone activity.
>
> The goal of WZDx is to enable widespread access to up-to-date information about dynamic conditions occurring on roads such as construction events. Currently, many IOOs maintain data on work zone activity. However, a lack of common data standards and convening mechanisms makes it difficult and costly for third parties such as original equipment manufacturers (OEMs) and navigation applications to access and use these data across various jurisdictions. WZDx defines a common language for describing work zone information. This simplifies the design process for producers and the processing logic for consumers and makes work zone data more accessible.

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> Specifically, WZDx defines the structure and content of several GeoJSON documents that are each intended to be distributed as a data feed. The feeds describe a variety of high-level road work-related information such as the location and status of work zones, detours, and field devices. ”

GeoJSON is an open standard geospatial data interchange format that represents simple geospatial features (such as work zone location devices) and their non-spatial attributes (such as messages).

4.3.2. Lane Closure Notification System

Districts are required to provide data from their respective regions in a format and database which is readable and accessible by the Lane Closure Notification System (LCNS). Data needs for each event needs to include:

- Roadway and Direction
- Start location
- End location
- Start date and time
- End date and time
- Each lane's closure status
- Last updated

FDOT is working to generate and publish a statewide WZDx feed that incorporates work zone plans and status from District Lane Closure Information Systems (LCIS), the Data Integration and Video Aggregation System (DIVAS) system fed by District SunGuide systems, and from a statewide lane closure notification system that allows construction site managers to enter real-time lane closure status from a mobile application. FDOT contracted with LCNS to provide their software as a service and to integrate with LCIS, LCNS, and DIVAS to provide Florida's official WZDx feed. This project started in June 2022 with data from all districts integrated in August 2022.

4.3.3. Data from SWZ Devices

DevSpecs 102 and 990 do not currently require the SWZ devices to push any alert to the SunGuide (as we are still in the early phases of such device deployment).

- SWZ devices are required to be supported by Smart Work Zone Central Processor (SWZ- CP)
- SWZ-CP will be a vendor-provided cloud-hosted service, e.g., iCone's R.O.A.D., that will do the following:
    - Collect operational status of smart work zone equipment, including but not limited to device location, on/off state, SWZ arrow board display message, SWZ PCMS message, SWZ VSL value, SWZ component status, traffic volume and speed data, communication status, power level

- Capable of acquiring traffic speed data and selecting and posting messages on SWZ arrow boards and SWZ PCMS automatically without operator intervention

- SWZ-CP will make a WZDx feed available to authorized subscribers, i.e., FDOT.
- FDOT may ingest and use SWZ data into SunGuide in a similar way as the LCNS data

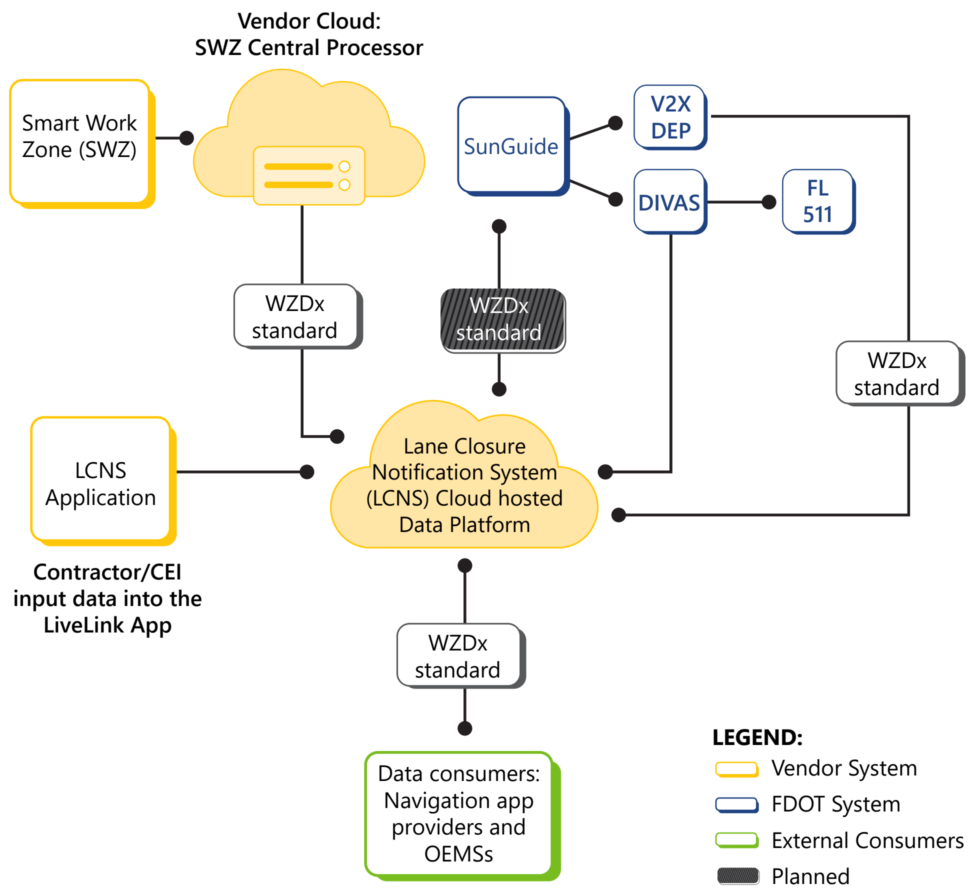
4.3.4. SunGuide, DIVAS, and V2X DEP Discussion

SunGuide was mentioned once in the LCNS scope "The data generated within the one. network system represents an authoritative, real-time record of active work zones and lane closures. This will be shared with other FDOT systems including SunGuide ATMS and the Florida 511 Travel Information System.".

- LCNS will make the standard WZDx compliant feed available to FDOT.
- If desired, FDOT may ingest the WZDx feed from LCNS. In that case, FDOT will need to enhance the SunGuide software to be able to ingest the feed. The LCNS information can be handled in one or more of the following ways as it is ingested into SunGuide:
  - Pass the WZDx feed on to the FL 511 for them to ingest, if desired, to show active lane or road closures on the FL 511 app (SunGuide as pass-through). This would avoid operator burden; however, it would bypass operator verification which is not precedented for other incident information sources.
  - Present to operators as an incident detection alert (pop-up alert) similar to FHP incidents alerts. Operators can handle the alerts and dismiss, create new active or planned events, or update existing events.
  - Display the lane closure information on the map in an unobtrusive manner without a pop-up alarm as a complimentary background information source. Operators can use this as a secondary lane closure information source for purposes of validation or to be validated prior to creating an event.

Figure 9 expands Figure 1 to provide additional details within the current WZDX data flow architecture. The architecture identifies the role of FDOT systems such as the LCNS, FL511, SunGuide, Vehicle to Everything (V2X) Data Exchange Platform (DEP) and DIVAS.

FIGURE 9: EXPANDED WZDX ARCHITECTURE



4.4 SWZ Training

Training is recommended for SWZ designers, installers, managers, and maintainers. Training is often specific to the SWZ technologies provided by the device manufacturer or vendor. For this reason, SWZ procurement documents must consider the need for training as a part of project delivery. Table 9 lists possible SWZ training objectives for various SWZ stakeholders. Training needs should be addressed in the ConOps, PSEMP, and procurement documents, as appropriate. It may be necessary to develop a Modified Special Provision or Technical Special Provision to ensure training is provided by manufacturers or vendors in traditional design-bid-build projects. Requests for proposals for design-build projects should also require contractors to provide training.

TABLE 9: POSSIBLE SWZ TRAINING OBJECTIVES

SWZ Stakeholders	Training Objectives
Designers, TTCP Developers	• Selection of SWZ strategies • SWZ Developmental Specifications • SWZ DDC • SWZ Developmental Standard Plan • Incorporation of SWZ into TTCP • SWZ Management and Operations Plan development • Systems engineering for SWZ • Requirements development for design/build projects
State and local traffic law enforcement officers	• Enforcement expectations, practices • Speed harmonization concept, current speed limits
Contractor Worksite traffic supervisor and SWZ operations personnel	• Installation, setup, and configuration expectations • Installation verification testing • Installation monitoring and oversight • Installation maintenance
Construction Engineers and Inspectors	• Installation inspection • Installation verification testing oversight • Installation monitoring and oversight
RTMC Managers and Operators	• Monitoring SWZ with permanent ITS and temporary ITS equipment and communication • Monitoring SWZ through Internet portals • Managing DSH applications, setting speed limits

5.0 SWZ Public Information Plan

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When using SWZ strategies and technologies in the TTCP, the Public Information Plan (PIP) described in FDM 240.4 should address SWZ elements included in the project. The PIP should communicate to the traveling public the intent, features, and duration of smart work zone strategies planned for the project. The PIP should take into consideration needs relative to multiple trip types such as daily commuters and tourists.

FDOT

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