CONCEPT OF OPERATIONS

# NDOT Active Traffic Management System

## Las Vegas, Nevada

2019 Update (March 2019 version)

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# REVISION HISTORY

| Filename | Vers | Date | Author/QC | Comment |
|---|---|---|---|---|
| NDOT ATM Preliminary ConOps - DRAFT.docx | 1.0 | 05/30/2014 | DH / IZ / PP | Draft Preliminary ConOps submitted to NDOT |
| NDOT ATM Preliminary ConOps – 6-12-2014.docx | 1.1 | 06/12/2014 | DH / IZ / PP | Addresses comments from client and stakeholders |
| NDOT ATM Preliminary ConOps – 6-23-2014.docx | 1.2 | 06/23/2014 | DH / IZ / PP | Addressed comments from client |
| NDOT ATM Preliminary ConOps – 7-2-2014.docx | 1.3 | 07/02/2014 | DH / IZ / PP | Addressed comments from client – Final Preliminary ConOps submitted to NDOT |
| NDOT ATM Updated Draft ConOps – 10-6-2014.docx | 1.4 | 10/06/2014 | DH / IZ / PP | Addressed updates with Design-Build process and refined scenarios |
| NDOT ATM ConOps – 10-14-2014.docx | 1.5 | 10/14/2014 | DH / IZ / PP | Addressed input from client and stakeholders |
| NDOT ATM ConOps – 12-16-2014.docx | 1.6 | 12/16/2014 | DH / IZ / PP | Addressed input from client and stakeholders regarding VSL |
| NDOT ATM ConOps – 6-8-2015.docx | 1.7 | 06/8/2015 | DH / IZ / PP | Addressing comments from client during software development |
| NDOT ATM ConOps – 4-10-2017.docx | 1.8 | 04/10/2017 | DH / PP | Reflected that the first-year baseline test will involve YELLOW X's instead of diagonal yellow Merge arrow prior to full concept use |
| NDOT ATM ConOps update-11.19.2018.docx | 1.9 | 11/19/2018 | AG / DH | Update of document to reflect updates made during implementation, updated roles and responsibilities, and new or updated concepts |
| NDOT ATM ConOps update_draft final_01.17.2019.docx | 1.10 | 01/17/2019 | AG / DH | Addressing comments on draft document |
| NDOT ATM ConOps_Final 2019 Update | 1.11 | 02/26/2019 | AG / DH | Addressing final comments from NDOT Ops Director – Final version of 2019 Updated ConOps |
| NDOT ATM ConOps_Final 2019 Update_03.27.2019.docx | 1.12 | 03/27/2019 | AG / DH | Updating to remove use of downward yellow arrow and yellow merge arrows as they are not currently approved for use and replace with yellow X. |

# 1 Overview

## 1.1 Background

The Federal Highway Administration (FHWA) defines Active Traffic Management (ATM) as:

"The ability to dynamically manage recurrent and non-recurrent congestion based on prevailing and predicted traffic conditions. Focusing on trip reliability, it maximizes the effectiveness and efficiency of the facility. It increases throughput and safety through the use of integrated systems with new technology, including the automation of dynamic deployment to optimize performance quickly and without delay that occurs when operators must deploy operational strategies manually. ATM approaches focus on influencing travel behavior with respect to lane/facility choices and operations. ATM strategies can be deployed singularly to address a specific need such as the utilizing adaptive ramp metering to control traffic flow or can be combined to meet system-wide needs of congestion management, traveler information, and safety resulting in synergistic performance gains."

In 2014, the Nevada Department of Transportation (NDOT) initiated the development of a Concept of Operations (ConOps) for their first ATM system that would initially be deployed on portions of Interstate 15 (I-15) and United States Route 95 (US-95) to support congestion management along a critical stretch of freeway through the heart of Las Vegas. After the ConOps that was completed in 2014, NDOT pursued the development of ATM software and construction of ATM components as part of NDOT's Project NEON.

In 2018, the ATM software system was completed and integrated into the operator workstations at the Regional Transportation Commission of Southern Nevada (RTC) Freeway and Arterial System of Transportation (FAST) Traffic Management Center (TMC). At the time of the document, the ATM system is being tested and operators are being trained prior to the system going live. Construction of the ATM system infrastructure components is anticipated to be completed in February 2019, at which time the ATM system will go live.

This ConOps update was undertaken to achieve the following purposes:

- Document updates and changes made to the ATM system during system development and integration;
- Update the Roles and Responsibilities for the ATM system to reflect current agency roles and initiatives, including identifying roles for the regional TIM Coalition; and
- Identify new or updated concepts and operational scenarios for the ATM system to provide an elevated level of support for public safety, incident management and traffic management.

## 1.2 Purpose of ATM

The Las Vegas metropolitan area is managed through a network of Intelligent Transportation System (ITS) technologies on the freeways and on the arterials through a central management system. With a need to put greater focus on congestion management on key freeway corridors, NDOT identified the opportunity to introduce its first ATM application in the state in coordination with Project NEON in Las Vegas.

**Figure 1.1** illustrates the recurring and nonrecurring factors that contribute to congestion in the United States.

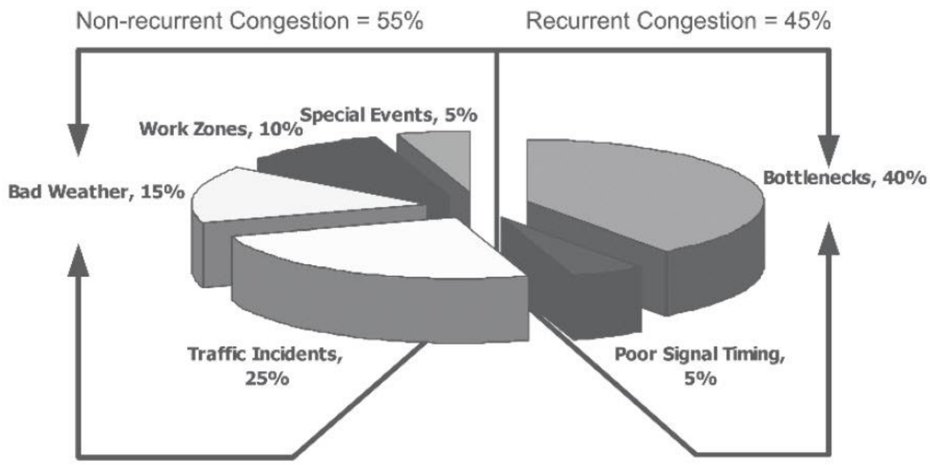



**Figure 1-1: Causes of Congestion in the United States *(Source: Congestion Mitigation FHWA)***

Recurring congestion accounts for about 45 percent of all congestion in the United States while nonrecurring congestion accounts for 55 percent of all congestion. Agencies conduct freeway management and traffic operations through policies, strategies, and actions that enhance mobility and to combat recurring congestion in the freeway environment. Strategies to address recurring congestion include roadway widening and bottleneck removal, operational improvements, ramp management and control, and managed lanes. Mitigation techniques for nonrecurring congestion include better management of incidents, work zones, road weather, and planned special events that impact the roadway. All of these strategies look to optimize the use of existing transportation facilities.

ATM techniques target collisions that result from both recurrent and non-recurrent congestion and is a tool that can improve safety and throughput and may be used as an interim strategy to enhance the efficiency of corridors that may ultimately receive major capital investments. ATM technologies and applications have been carefully chosen by NDOT and its partners to combat both recurrent and non-recurrent congestion that impacts the I-15 and US-95 freeways that serve the Las Vegas metropolitan area for commuters, visitors, long-haul truckers, and local traffic.

## 1.3 Scope

This ConOps describes the implementation of ATM strategies along I-15 north from I-215 to US-95 and along US-95 west to Valley View Boulevard. The project limits for this ATM deployment are shown as the purple line in **Figure 1-2**.

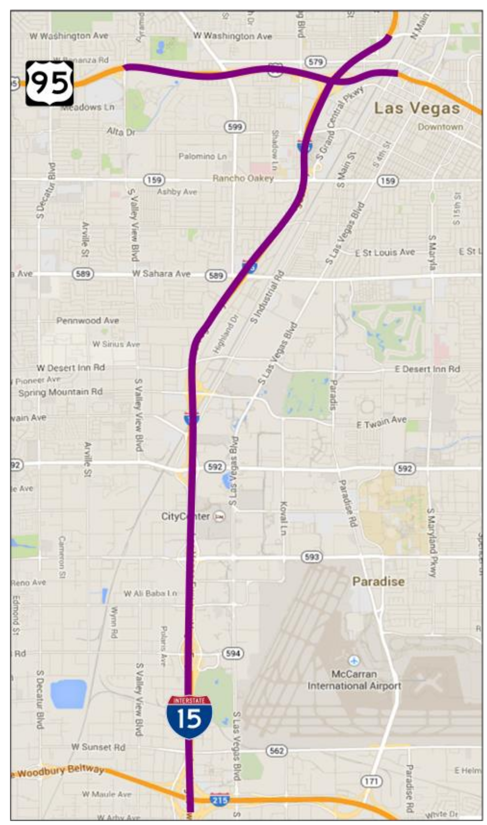



**Figure 1-2: NDOT ATM Project Limits**

ATM encompasses a variety of applications or strategies that range in complexity and functionality and can be used to provide spot improvements to the transportation system as well as corridor-wide benefits. The NDOT ATM system will use input from roadway sensors as well as human operators at the FAST TMC who are monitoring closed-circuit television (CCTV) cameras and coordination with field personnel and public safety personnel to collect traffic condition data. The data will be processed and used to actuate various roadside systems, such as lane control signs, in near real-time to dynamically manage traffic based on prevailing conditions.

The goal for this NDOT initiative in Las Vegas is to improve traffic flow and safety through the use of dynamic lane management, queue warning, and speed harmonization (variable speed limits). Within the corridor, NDOT plans to consider the use of strategies to improve merge control near the on-ramps to I-15 and US-95 as well as near the freeway-to-freeway interchange and to improve operation of existing metered entrance ramps using adaptive and dynamic control strategies.

In addition to deploying software and field equipment, this ATM deployment should be accompanied by outreach activities to introduce and integrate other agencies and the public to the ATM system. Updated incident management procedures should be developed by FAST, in partnership with NDOT, Nevada Highway Patrol (NHP), and other incident responders, that leverage the ATM deployment's data, traffic management capabilities, and traveler information dissemination capabilities. It is anticipated that NDOT and its operational partners, including FAST, NHP, and other incident responders will collaborate to develop and implement incident and event management protocols for the transportation network around the ATM deployment to allow for enhanced response and management of traffic-related incidents and events on the corridor.

Strategies for public outreach and education on the new ATM system are introduced and discussed in Section 6.

## 1.4 Best Practice Examples

ATM has been highly successful in Europe, notably in the United Kingdom, Netherlands and Germany. ATM improves traffic safety and traffic flow by dynamically managing vehicle speeds and roadway lane use based on prevailing traffic conditions and knowledge of downstream traffic blockages. Examples of ATM operating strategies used at these pioneer deployments are shown in **Figure 1-3**.

**Peak Operations**
(Speed Harmonization, Shoulder Running, Queue Warning)


**Capacity Reduction**
(Lane Closure, Speed Harmonization, Queue Warning)


**Weather-Related**
(Speed Harmonization, Weather / Queue Warning, Lane Closure if Any)


**Managed Lanes**
(Part-Time HOV Lane, Shoulder Running, Speed Harmonization, Queue Warning)

**Figure 1-3: Examples of Active Traffic Management Operational Strategies**

The following are references that were used to support the development of this ATM ConOps:

- Active Traffic Management: The Next Step in Congestion Management – FHWA 2007: http://international.fhwa.dot.gov/pubs/pl07012/
- Integrating Active Traffic and Travel Demand Management: A Holistic Approach to Congestion Management – FHWA 2011: http://international.fhwa.dot.gov/pubs/pl11011/pl11011.pdf
- Minnesota Active Traffic Management "Smart Lanes" Concept of Operations
- MUTCD Experimental Use Request for Active Traffic Management Signing: http://mutcd.fhwa.dot.gov/documents/pdf/2_09_4_ex_inc1.pdf
- Synthesis of Active Traffic Management Experiences in Europe and the United States – FHWA 2010: http://www.ops.fhwa.dot.gov/publications/fhwahop10031/sec4.htm
- Virginia Interstate-66 Active Traffic Management System – 2011: http://www.vdot.virginia.gov/projects/northernvirginia/i-66_atms.asp
- Washington Active Traffic Management Concept of Operations – 2008: http://www.wsdot.wa.gov/NR/rdonlyres/73AC9A17-6178-4271-B3A9-91911BD1C8C6/0/FinalATMConceptofOperations.pdf

## 1.5 Role within the Systems Engineering Process

Developing a ConOps is an initial, critical step in the Systems Engineering (SE) process. SE is a comprehensive planning and management process which encompasses all major phases of the system lifecycle. Focus areas of the SE process are: objective, needs-driven requirements development; and emphasis on ensuring that the requirements used to design the system can be traced to documented stakeholder needs and goals. The benefits resulting from the comprehensive nature of the overall SE process has led the FHWA to mandate the use of the SE process when using federal funding on certain types of transportation projects (23 CFR, Rule 940). An overview the SE process elements typically used in transportation projects is shown in **Figure 1-4**.

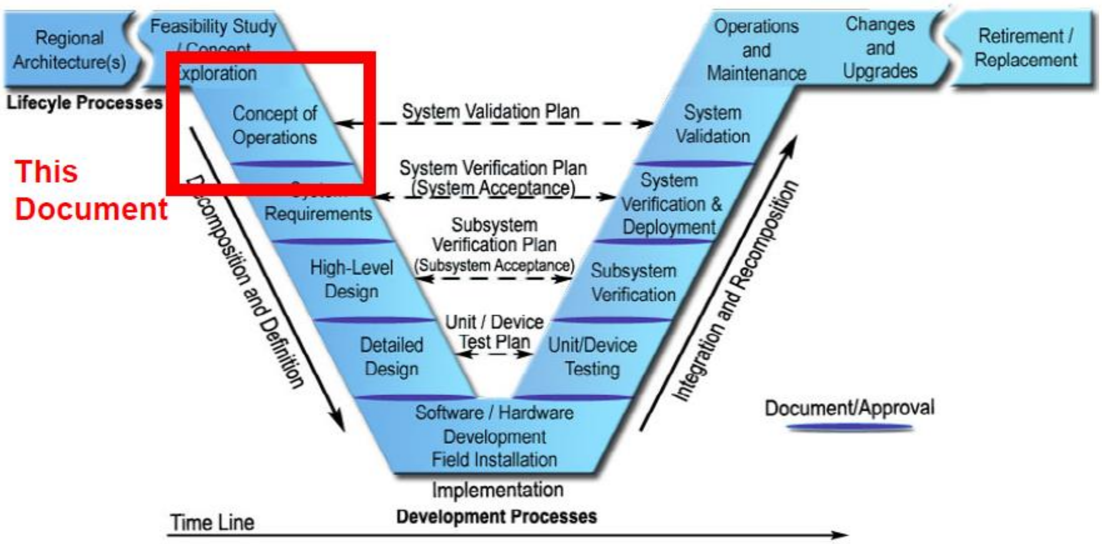



**Figure 1-4: The Systems Engineering "V" Diagram**

This ConOps serves as the basis of software functional requirements that provide additional details to direct ATM software development. For Federal funding to be authorized for the financing of major projects, the project must demonstrate to FHWA that it has been carefully planned out. Project requirements include the development of a Project Management Plan (PMP) and a Systems Engineering Management Plan (SEMP).

- The PMP defines the roles and responsibilities of the relevant parties in the management of the project through the planning, design, and implementation phases.
- The SEMP demonstrates that systems engineering analysis has been done to outline practices that must be included to most effectively implement the project.

Both the PMP and the SEMP for this ATM project have been developed to meet FHWA requirements for applying Federal funding assistance in implementing the project. As part of the System Validation and Verification processes, this ConOps has been updated to reflect the current state of the system and its intended uses prior to live operation.

## 1.6 Goals and Objectives

The NDOT ATM goals and objectives address the current and near term operational conditions, deficiencies, and needs. They also provide the framework for defining the ATM concepts and strategies.

*In its initial deployment, the two main goals of the ATM system are to improve safety and create more reliable travel conditions for the freeway.*

Focusing on two goals for ATM allows NDOT to prioritize measures of effectiveness that are well understood by the traveling public and by decision makers. **Table 1-1** identifies the two categories of goals and their associated objectives as well as potential measures of effectiveness that could be applied to define the performance and measure progress toward achieving the goals.

It will be important for NDOT to define the specific performance metrics that will be used and potentially incorporated into the FAST Dashboard and the State's 511 system. Calculating and tracking specific performance metrics, such as for law enforcement and operations purposes, will require the ATM system to have specific reporting requirements.

**Table 1-1: NDOT ATM Goals, Objectives and Measures of Effectiveness**

| Goals | Objectives | Measures of Effectiveness |
|---|---|---|
| SAFE | Reduce Primary, Secondary, and the Severity of Crashes | • Incident / crash rate (e.g., per person-hours or vehicle – miles of travel), and/or total number of crashes by segment<br>• By type (e.g., primary/secondary)<br>• By severity (e.g., fatal, injury)<br>• By vehicle type (car / truck, enforcement / emergency service)<br>• By weather type (e.g., clear / dry, rain, snow, fog)<br>• By lane type (shoulder, HOV / HOT) and corresponding ATM displays |
| | Reduce Incident Duration | • Average time to for responders to clear crash scene (e.g., by starting points, time-of-day, responder type, crash type) |
| | Support Work Zone Management | • Incident / crash rate in work zones (e.g., by severity, weather type)<br>• Average speed through work zones<br>• Maximum speed through work zones<br>• Average throughput through the work zone<br>• Reduced cost of work zone traffic control |
| RELIABLE | Improve Throughput | • Volumes (e.g., monthly, maximum and average weekday by direction and period, by segment, by lane type / shoulder use)<br>• Annual vehicle-miles traveled<br>• Average capacity<br>• Average speed<br>• Percentage of trucks in the traffic stream |
| | Reduce Congestion | • Average Travel Time / Link (by time of day/day of week, scenario / event type)<br>• Average Delay per Person (this can be segregated by time of day / scenario / event type)<br>• Travel Time Index – a ratio of travel times in the peak period to a target or acceptable travel time (typically free-flow conditions). The travel time index indicates how much longer a trip will take during a peak time.<br>• Congestion levels by link<br>• Average time of day that segment becomes congested<br>• Duration of congestion (by peak period and link) |
| | Improve Travel Time | • 90th or 95th percentile travel times - reported in minutes and seconds, and indicate how bad delay will be on the heaviest travel days<br>• Buffer Index - This uses the 95th percentile travel time to represent a near-worst case travel time. It is computed as the difference between the 95th percentile travel time and average travel time, divided by the average travel time. It represents the extra buffer time a traveler should allow to arrive on-time for 95 percent of all trips<br>• Planning Time Index - Computed as the 95th percentile travel time divided by the free-flow travel time, this measure represents the total travel time that should be planned when an adequate buffer time is included. |
| | Improve Traveler Information | • Accuracy of posted travel times (compared to actual)<br>• Types of information posted (e.g., speed limits, lane closures, shoulder open), by time of day<br>• Average time to post updated information<br>• Number of driver comments regarding posted information |

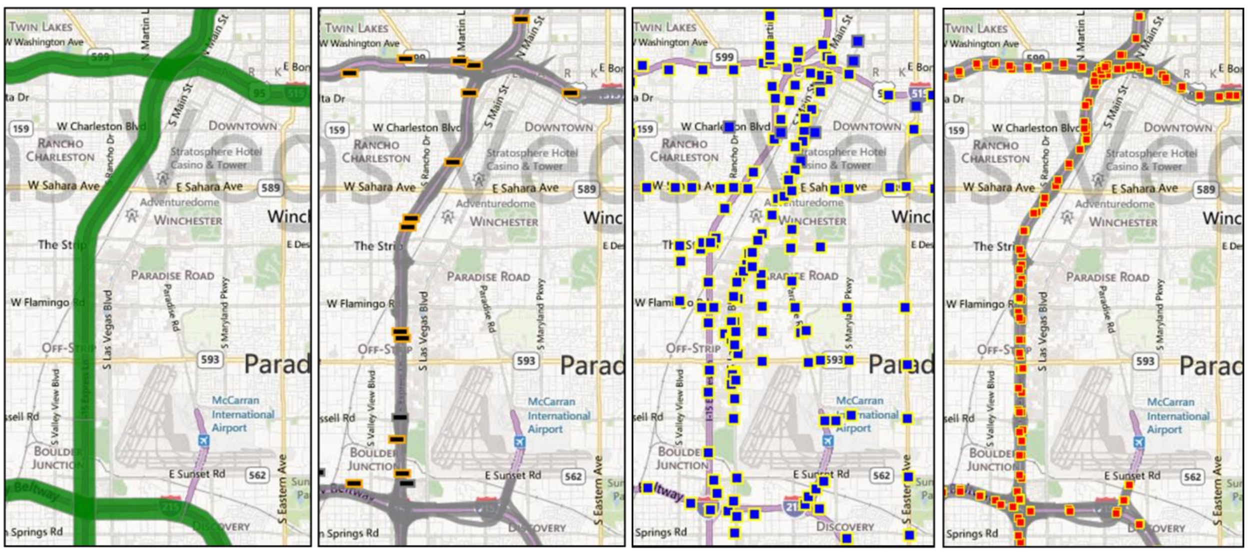
# 2 Current Conditions

## 2.1 Existing ITS Infrastructure

The new NDOT ATM system will work within the environment of the existing freeway management system. Existing freeway management components include:

- CCTV cameras;
- Ramp metering;
- Dynamic message signs (DMS);
- Communication systems; and
- Traffic detectors.

NDOT owns the ITS technology deployed on the freeway and RTC FAST operates, manages, and maintains the freeway system along with the arterial network infrastructure as an integrated regional system from the FAST TMC. The existing ITS infrastructure along the I-15 and US-95 corridors where ATM technologies are being proposed is shown in **Figure 2-1**.




Freeway Management System Coverage | Dynamic Message Sign Coverage | Closed-Circuit Television Camera Coverage | Mainline Detection Coverage

**Figure 2-1: Existing ITS Infrastructure on I-15 and US-95**

The ATM techniques discussed in this document are consistent with the NDOT and FAST traffic management philosophy and provide NDOT and FAST with another set of tools to help actively manage traffic conditions. For example, the hardware required for a lane management system and variable speed limits aligns with the existing ITS infrastructure.

- There are existing fiber optic communication cables through the ATM proposed corridors to connect to controller equipment that will be provided on the roadside for ATM technologies.

- Traffic detectors used for current traffic management systems are the same as those to be used for the variable speed limit detectors. In most locations, existing detector stations can be used to provide the data needed for the queue warning, dynamic ramp metering, and variable speed limit system.
- Cameras will allow TMC operators to monitor the lane control and DMS on the freeway.
- The DMS used to support ATM are similar in operation to those already used by NDOT and FAST. New signs will be using NTCIP communication standards.
- NDOT manages and maintains its own ITS central software. The existing FAST central system software already communicates with NTCIP signs; therefore, the ATM central software update to integrate ATM application management makes integration much easier than if NDOT used only proprietary communication protocols.
- NDOT currently orchestrates an incident management program with incident response patrols. ATM techniques, such as queue warning, could complement the existing ramp metering system when addressing mainline congestion.

## 2.2 FAST TMC

The FAST TMC is an integrated and co-located operations center between NDOT, RTC, and the Nevada Highway Patrol (NHP). Transportation strategies that the FAST TMC will implement, operate, and maintain are discussed during the Operations Management Committee (OMC) comprised of the RTC, Clark County, NDOT and the cities of Henderson, Las Vegas and North Las Vegas. FAST is a multi-jurisdictional integrated traffic management system that streamlines the efficiency of metropolitan area traffic operations. A photo of the FAST TMC is provided to the right in **Figure 2-2**.

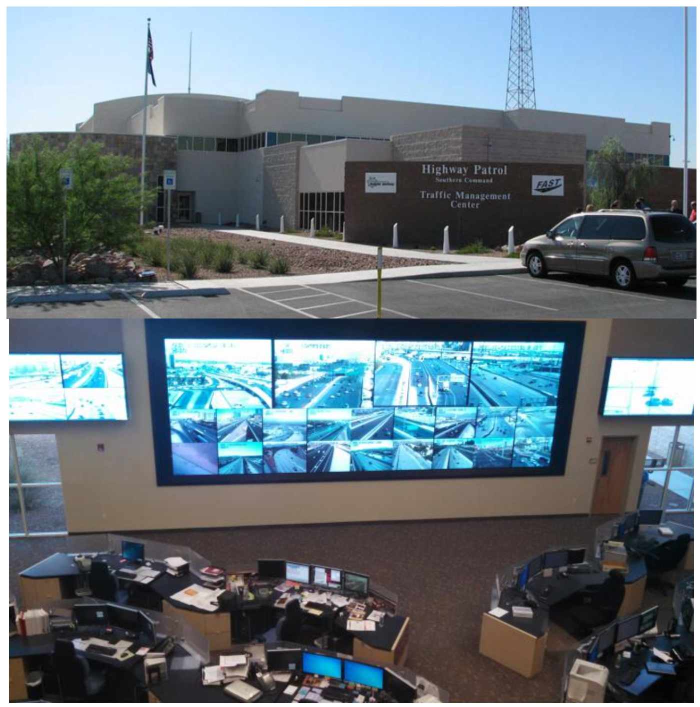



**Figure 2-2: Las Vegas FAST TMC**

FAST has a comprehensive program of ITS infrastructure program that includes CCTV cameras; DMS; non-intrusive performance monitoring devices that detect vehicle volume, speed and occupancy; ramp meters at freeway entrances; and a distributed traffic signal system on a number of arterial corridors. FAST has created a regional signal coordination network that currently has more than 1,500 traffic signals, with an average of 3-5 new signals added to the network every month. FAST has established communications at approximately 1,300 of those signals. FAST continually works with area agencies to install fiber optics and new or upgraded signal controllers across the Valley. The FAST signal network is designed to monitor and control the traffic signals, and local agencies are responsible for required maintenance. Freeway ramp meters have been deployed in the Las Vegas Valley on portions of US-95, I-515, and I-15 through a successful joint project between RTC and NDOT. FAST controls the ramp meters and consistently monitors and adjusts the ramp meter timing, if needed, to ensure that the ramp meters do not create congestion on adjacent surface streets. NDOT operates and manages a Freeway

Service Patrol (FSP) to improve safety and mitigate non-recurring traffic congestion on the heavily-traveled sections of the metropolitan freeway system by reducing the time required to remove incidents that disrupt traffic flows and cause secondary incidents. The FSP also assists other public safety organizations including law enforcement, fire, paramedics, and towing and recovery professionals to rapidly and safely address more complex traffic incidents. The FPS program is sponsored by State Farm, a partnership which helps create a long-term, supplemental funding source for the program.

The core purpose of FAST is to operate and maintain a diverse array of ITS devices to support the safe, efficient, and effective movement of vehicles through both the arterial street system and the freeway networks in the region. DMS provide drivers with information about roadway conditions and travel times. Many CCTV cameras are linked into NVRoads.com and RTC's website so that travelers may view freeway conditions and many signalized arterial intersections in real time.

The FAST Dashboard (Performance Monitoring and Measurement System) is a software program that provides a web-based user interface to enable the public to access real-time and historical freeway network monitoring and performance information. FAST collects lane-by-lane data on the freeways and uses this information along with other raw data automatically gathered by the ITS that NDOT has implemented on its freeway network in Southern Nevada, plus incident-specific data logged by FAST's technicians. By integrating these data, the FAST Dashboard develops maps, charts and graphs showing trends and 'report cards' on freeway performance and enables the user to quantitatively characterize the discrete traffic flows.

NDOT, RTC, and NHP also collaboratively use the Waycare platform system to enhance interoperable communications and optimize traffic incident response measures. Waycare is an artificial intelligence web-based platform system that provides real-time incident detection and notifications based on a multitude of sources such as traffic loop detectors, microwave vehicle detectors, on-board vehicle devices, navigation apps, telematics, weather data, special event data, dynamic message sign data, construction and road closure data, roadway camera feeds, and traffic incident information through crowdsource data.

The ATM measures of effectiveness provided in **Table 1-1** provide guidance on the types of expanded metrics that could be incorporated into the FAST performance dashboard or NDOT performance reporting in relation to ATM. Measures identified in this document are provided as examples; it is important that any measures ultimately selected should be those where data to calculate the measure are available. Before and after data should also be collected as ATM applications are used to track benefits of ATM implementation and use.

## 2.3 Local Agencies

The City of North Las Vegas, in conjunction with FAST, has deployed a number of new ITS devices along the highways including DMS, CCTV cameras, traffic monitoring stations, loop detectors and communications infrastructure and devices at several key intersections. These ITS devices will serve as tools for FAST to use to better manage traffic associated with incidents along Craig Road between US-95 and Las Vegas Boulevard.

Based on current policy, the City of Las Vegas traffic engineering staff does not respond to incidents on arterial streets unless requested by Las Vegas Metropolitan Police (Metro). Metro typically calls the City traffic engineering staff when there are equipment needs related to incidents, such as when a pole or sign is knocked down or when there is malfunctioning equipment in the field. There is not currently a formal

City process for incident management. The City typically relies on FAST to coordinate incident management activities. For incident diversions and road closures that affect City arterials, NHP will typically coordinate with FAST.

Incidents on the freeway are key contributors to arterial congestion in the Las Vegas area. The adjacent arterials do not have capacity to accommodate vehicles diverting off the freeway as a result of incidents; when such diversions do occur, Henderson staff are given little or no advanced notice.

## 2.4 Stakeholder Roles and Responsibilities

Several stakeholders will be involved in the operation of the ATM components along I-15 and US-95, and their roles and responsibilities are listed in **Table 2-1**.

**Table 2-1: Stakeholder Roles and Responsibilities**

| Stakeholder | Operations Roles and Responsibilities | Management Roles and Responsibilities |
|---|---|---|
| **FAST TMC** (during business hours) | • Operate and manage the traffic management system ATM components<br>• Monitor corridor for congestion and incidents<br>• Activate lane closures during congestion or incidents and as requested by NHP<br>• Activate approved speed limits for work zones<br>• Monitor system status<br>• Provide traffic video images to general public and the media through active CCTV video streams<br>• Train new staff on the ATM system and procedures | • Integrate and manage operation of ATM system<br>• Develop and refine ATM operational strategies and incident management plans using the ATM system with participation from partner agencies<br>• Management of fiber<br>• Maintenance of ITS technologies on freeway<br>• Support automated dissemination of ATM information to partner agencies for lane closures activated on an ATM gantry<br>• Traffic management planning during construction (if requested by an agency)<br>• Develop, track, and report on performance measures for ATM system<br>• Support public education campaign related to ATM system |
| **NDOT District 1** (24/7) | • Provide dispatch support for FSP<br>• Manage regional traffic control efforts and assist in coordinating traffic across boundaries<br>• Post work zone information on NDOT web page in advance of scheduled construction<br>• Train new staff on the ATM system and procedures | • Dedicated dispatch at the FAST TMC<br>• Participate in development of incident response protocols for ATM use<br>• Interface with entities seeking information about Project Neon and ATM<br>• Maintains portable HAR stations for special event use<br>• Support automated dissemination of ATM information to partner agencies for lane closures activated on an ATM gantry<br>• Update traveler information for dissemination through 511 system<br>• Verify manual operator speed limit entries into ATM system<br>• Support public education campaign related to ATM system |
| **NDOT District 1** (after-business hours operating from FAST TMC) | • Operate and manage the traffic management system ATM components<br>• Monitor corridor for congestion and incidents<br>• Activate lane closures during congestion or incidents and as requested by NHP<br>• Activate approved speed limits for work zones<br>• Receive regular system status reports<br>• Provide traffic video images to general public and the media<br>• Train new staff on the ATM system and procedures | |

| Stakeholder | Operations Roles and Responsibilities | Management Roles and Responsibilities |
|---|---|---|
| **TIM Coalition** | • Conduct after-action debriefs for events that involve use of the ATM system and invite operators involved in ATM actions to debriefs<br>• Provide a forum for providing training to incident responders on the ATM system | • Participate in receiving and sharing education on ATM system management and operations<br>• Participate in development of incident response protocols for ATM use<br>• Document findings from after action debriefs and support implementation of updated procedures<br>• Support public education campaign related to ATM system |
| **NDOT Headquarters** | • Manage Freeway Service Patrol program for freeway corridors<br>• Customer service<br>• Statewide 511 Nevada program<br>• Safety management<br>• Develop and manage operational policy for FAST TMC<br>• Update the JOPS for the ATMS System<br>• Update FAST Agreement for TIM Coalition<br>• Work with FAST to support dissemination of ATM information | • Implement and manage software for ATM system management<br>• Funding support for FAST TMC operations and management of ATM system<br>• Review performance measures<br>• Implement safety mitigation<br>• Public relations<br>• Technical support<br>• Provide FSP for corridors<br>• Update HAZMAT agreement to include new provisions (NDOT Traffic Ops)<br>• Statewide guidelines on Active Traffic Management<br>• Statewide regulations on use of lane closures and ramp meters<br>• Statewide data sharing program<br>• Statewide DMS guidelines and policies<br>• Support public education campaign related to ATM system |
| **Nevada Highway Patrol** | • Request lane closures from FAST TMC for incidents or blockages in traffic lanes<br>• Receive alerts for lane closures that have been activated on an ATM gantry<br>• Receive alerts from NDOT and FAST TMC regarding maintenance activities that may impact incident management and response<br>• Enforce lane closure regulations (e.g., tickets to drivers traveling in restricted lanes), new HOV restrictions, and other traffic laws<br>• Incident scene management if Fire/Rescue services not present<br>• Enforce regulatory displays at ramp meter signals<br>• Notify Clark County Traffic Management in the event of a fatality on the County 215 Beltway<br>• Special authority for trucks as motor carrier enforcement | • Partner in developing FAST ATM operational and incident management procedures<br>• Participate in receiving and sharing education on ATM system management and operations<br>• Develop client view of incidents through the statewide archive database, Nevada Data Exchange (NVDEX) |

| Stakeholder | Operations Roles and Responsibilities | Management Roles and Responsibilities |
|---|---|---|
| **Clark County** | • Receive alerts for lane closures that have been activated on an ATM gantry<br>• Receive alerts from NDOT and FAST TMC regarding maintenance activities that may impact incident management and response<br>• Investigates all fatal crashes in the County | • Participate in development of incident response protocols for ATM use, particularly for coroner involvement in fatal incidents<br>• Participate in receiving and sharing education on ATM system management and operations |
| **Local Cities – Transportation** | • Receive alerts for lane closures that have been activated on an ATM gantry<br>• Coordination of operations during construction after-hours<br>• Support function to FAST/RTC with respect to signal coordination | • Participate in development of incident response protocols for ATM use<br>• Participate in receiving and sharing education on ATM system management and operations |
| **Local Cities – Public Safety** | • Management of incident scenes in partnership with NHP if Fire/Rescue services<br>• Provide emergency care and rescue services at incident sites<br>• Provide fire containment and initial HAZMAT response and containment on their facility jurisdiction<br>• Provide emergency medical care<br>• Transport injured from incident scene to hospital<br>• Receive information about traffic impacts (incidents, slowdowns, etc.) that have been activated on an ATM gantry and respond appropriately | • Participate in development of incident response protocols that include ATM use<br>• Participate in receiving and sharing education on ATM system management and operations |
| **Traveler** | • Travel through the corridor<br>• Use and apply knowledge of ATM, ramp metering, other operations<br>• Receive information about traffic impacts (incidents, slowdowns, etc.) that have been activated on an ATM gantry and respond appropriately | • Participate in receiving and sharing education on ATM system management and operations |

# 3 NDOT ATM Applications

## 3.1 ATM Technologies

The ATM system will be composed of several different ITS components. Each component provides specific capabilities to meet the requirements of the system.

### Gantries with Information Displays

Provided at approximate ½-mile spacing, each station (or "gantry") will differ slightly in sign quantities and content based on the number of lanes and the gantry configuration. Each location will require a new cabinet and communications link. Each gantry location requires 1,000 feet of clear visibility in advance of the gantry, and a motorist will be able to see the next gantry while passing under the upstream gantry. A speed limit display is located on the right pole of the gantry immediately upstream of each entrance ramp onto the freeway.

There are two types of ATM gantry displays that will be used to display speed limits, lane control signals, and traveler information messages, shown in **Figure 3-1**.

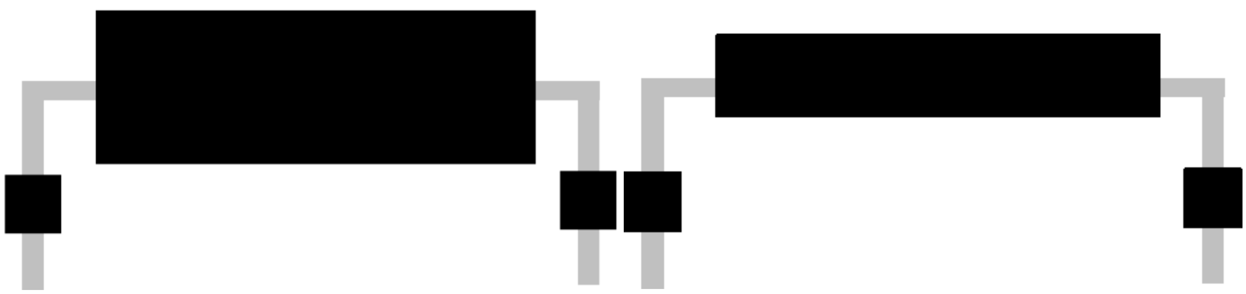


**Figure 3-1: Type 1 (left) and Type 2 (right) ATM Gantry Display**

Type 1 displays can provide a traveler information message at the top with lane use control or speed limit indications at the bottom. The Type 2 displays can provide lane use control or speed limit indications on the overhead sign.

Gantries will generally be located immediately downstream of any interchange entrance ramp to be able to provide immediate traveler information to merging traffic onto the freeway. Fixed speed limit signs are being removed from the I-15 corridor and variable speed limit notice messages will be provided on right side of the gantry located near each entrance ramp, within approximately ½-mile of the gore. Gantries will replace any existing legacy DMS locations along the corridor.

### Traffic Flow Detectors

Traffic flow detection currently exists at approximately 0.33 mile spacing to collect vehicle volumes, speeds and congestion (occupancy). This allocates one or two detectors offering vehicle detection related to each approaching gantry between each of the approximately ½-mile spaced gantries. HOV lanes along I-15 and US-95 are detected separate from general purpose lanes.

### CCTV Cameras

CCTV cameras are used to verify current queuing and congestion conditions and to verify that lanes are clear of vehicles prior to opening the lane. CCTV cameras are generally mounted on the top of approved NDOT standard poles, which are typically High Mast CCTV poles or poles attached to DMS. Each DMS along the corridors are viewable by at least one camera with a maximum distance of approximately ½-mile, although there may be some occlusions because of existing infrastructure. CCTV cameras are already prevalent throughout the corridors, but some locations have been added as part of recent Project Neon construction with the goal of providing the ability to see a stopped vehicle almost anywhere on the roadway. CCTV cameras are positioned to be able to see most freeway on- and off-ramps and have partial view of arterial crossroads at interchanges.

### Ramp Meters

Ramp meters are already in place along I-15 and US-95 at strategic locations and include vehicle presence detection for the ramp. Ramp meters are connected to the freeway management central operating system managed from the FAST TMC.

### Other Types of Technologies

<u>Highway Advisory Radio</u> **–** these types of information dissemination devices are mainly used by FAST and NDOT in rural areas, although could be considered for urban deployment in the future.

<u>Anonymous Re-Identification (ARID) Device</u> – includes Bluetooth or other types of technologies that could support the calculation of travel times and are currently used by FAST.

<u>Wrong Way Detection and Warning Systems</u> – this type of technology and application is used widely around the Country for safety at freeway off-ramp locations and are being considered for these corridors.

<u>Connected Vehicle In-Field Devices</u> – FHWA will be considering full deployment of Connected Vehicle technology within the next ten years, including vehicle-to-vehicle applications and vehicle-to-infrastructure applications. Vehicle-to-infrastructure applications may require DSRC radios or another wireless device to be deployed on the roadways so that vehicles could receive instantaneous status of road conditions for travel. The FAST infrastructure is well positioned to support a deployment of Connected Vehicle technology; deployment of this technology needs to be considered in the development of the ATM software in terms of the needs related to data processing and storage for the future.

<u>HOV +3 or High Occupancy Toll (HOT) Lanes</u> – because there is already a dedicated HOV lane through the entire corridor and Project Neon will add an HOV bypass through the Spaghetti Bowl interchange, an upgrade to an HOV +3 lane or transitioning the lane into a HOT lane may be feasible in the future, although there is currently no legislation in place to move this forward.

## 3.2 ATM Applications

There is a myriad of potential ATM applications that NDOT considered to improve operations along I-15 and US-95 near the Spaghetti Bowl. These strategies can be applied to address both recurrent and non-recurrent congestion to more effectively combat their impacts on trip reliability. Although these strategies are described individually, it is the combined, holistic application of the strategies for an entire network or region that will provide the most benefit.

FHWA identifies the following as ATM strategies that can be considered:

- Dynamic lane use control (including junction control)
- Variable speed limits (speed harmonization)
- Queue warning
- Dynamic lane reversal or contraflow lane reversal
- Dynamic (or adaptive) ramp metering
- Dynamic shoulder lanes
- Adaptive traffic signal control
- Transit signal priority

Of all the available ATM applications that have shown value in deployment along a freeway network, the following ATM applications were selected by NDOT to be implemented on Las Vegas I-15 and US-95 freeway corridors.

### Dynamic Lane Use Control

This application uses variable traffic signs and overhead lane use control to direct traffic to specific lanes (general purpose, HOV, or ramp) based on roadway conditions and traffic demand. This supports effective use of available roadway capacity and management traffic flows in response to congestion, crashes, and lane restrictions or closures.

One specific application of lane control is *junction control*, where the freeway lane adjacent to a freeway on-ramp is closed to eliminate conflicts between freeway vehicles and vehicles entering the freeway and support improved flow of traffic onto the freeway. This strategy is not going to initially be implemented with the I-15 and US-95 ATM system, but the ATM software will provide the functionality to perform junction control if desired in the future because the technologies to perform this function will already be in place as part of other ATM strategy applications.

### Regulatory Variable Speed Limits (Speed Harmonization)

This application dynamically and automatically reduces posted vehicle speed limits approaching areas of congestion, accidents, or special events. This speed harmonization technique delays the onset of congestion under normal operating conditions by maintaining flow, providing advanced warning to travelers of congestion ahead, and reducing risk of primary and secondary crashes.

## Driver Warning

There are two applications related to driver warning that will be included in the initial ATM deployment in Las Vegas.

A Q*ueue Warning* application warns motorists of downstream queues that are detected in either a single travel lane or multiple travel lanes. Queue warning messages displayed on overhead signs should be implemented at regular intervals to warn drivers of upstream queues based on dynamic traffic detection. Lane use control indications can help merge motorists to available lanes, in the case of a single lane queue. This facilitates the most effective use of available roadway capacity and reduces the likelihood of speed differentials and collisions related to queuing.

A *Driver Caution* application will be used to warn drivers of conditions ahead that warrant using extreme caution while proceeding, such as moving police activity where it is challenging to isolate a specific closure point. The driver caution application will include traveler information messages encouraging awareness and caution but will not provide specific direction to drivers in terms of lane use. Caution messages will be displayed at all gantries downstream of the event, with the goal of reducing driver speeds and heightening driver awareness as they travel the corridor.

## Applications Not Chosen

The following ATM applications were not chosen to be implemented for this NDOT ATM:

- **Dynamic (or Adaptive) Ramp Metering –** Although adaptive ramp metering is a technology application that NDOT is utilizing in other areas of the Las Vegas metropolitan area freeway system, there are no adaptive ramp meters within the ATM project limits and no detection will be added to ramp meters to provide adaptive capability.

- **Dynamic Shoulder Lanes –** There are no freeway shoulders suitable to accommodate the level of traffic that travels an I-15 or US-95 general purpose lane within the ATM project limits.

- **Emergency or Maintenance Access Pull Outs –** There are some designated pullouts on US-95, but no new pull outs are being included within the ATM project limits.

# 4 Concepts of the Proposed System

This section describes the physical and functional components of each of the ATM concepts that are included in the NDOT ATM deployment in Las Vegas – Dynamic Lane Use Control, Speed Harmonization, and Driver Warning. What makes these ATM concepts different from one another is the combination of field devices used, the types of information provided, and the level and type of software functionality and automation that is needed.

While each of the ATM concepts are described and developed independently, it is the ability to simultaneously implement and combine concepts within a corridor that results in an effective ATM system. **Figure 4-1** shows the general progression of how ATM concepts would be implemented in progression. It is the seamless implementation of these concepts that will ultimately support the effective management of recurring and non-recurring traffic events on a corridor through ATM. There are exceptions to this implementation progression concept, which are demonstrated in the Operational Scenarios in Section 5, but in general, this evolution of information provided to drivers using the ATM system holds true.

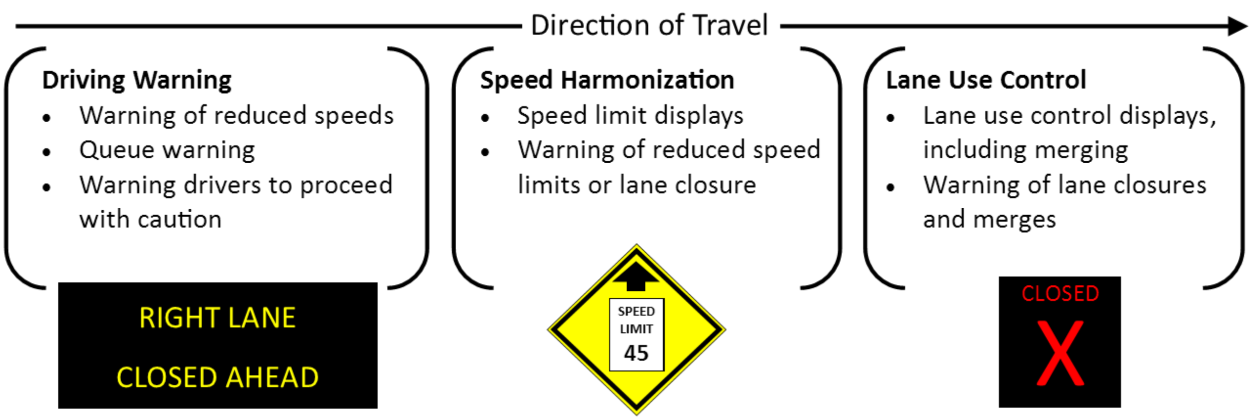



**Figure 4-1: Implementation Progression of ATM Concepts**

## 4.1 Overarching ATM Guidelines

Traveler compliance with the ATM system will be supported by the travelers' perception of the accuracy and timeliness of the system. To support accuracy and timeliness, the overarching guidelines listed in this section are to be followed when using the ATM system applications.

- All defined thresholds for speed, time periods, etc. will be user definable in the ATM system, but will be set at default conditions.
- All speeds limits displayed on gantries are enforceable.
- Speed harmonization application can be activated after hours or scheduled for time-of-day or day-of-week.
- Only TMC operators will be authorized to manually enter lane closures into system, per direction of NHP or a TMC supervisor.
- All message signs will allow for two or three panel message creation when multiple messages are warranted (incident information in addition to displaying travel times).

- On Type 1 signs, message can only be placed on the top portion of the sign, consistent with where messages would be displayed if used in conjunction with lane use control or speed limits.
- System will allow manual override for any automated function by identified System Administrators.
- Congestion conditions exist when speeds on the freeway are being detected below the speed limit. Recurring and non-recurring congestion should be treated similarly for ATM applications.
- A default of two gantries will be used to reduce speeds when speed harmonization threshold is met during congestion periods.
- Speed harmonization can be manually activated in conjunction with a planned closure. Manually activating a speed limit will automatically populate upstream gantries to incrementally reduce speed limits displayed on gantries at a user defined increment, up to the point of the planned lane closure. For example, a speed limit reduction from 55 mph to 35 mph will take two gantries (or one mile), with the first gantry displaying a 45 mph speed limit and the second gantry displaying a 35 mph speed limit.
- A specific user-defined speed as an average of all general purpose lanes will be the threshold to activate speed harmonization, initial set at 55 mph. The lowest speed allowable for display is 35 mph. The highest speed allowable for display is 65 mph. Lowest and highest speed are user definable values by System Administrators.
- Speed harmonization will treat HOV lanes separate from general purpose lanes; therefore, if detected speeds in the HOV lane are different from those the general purpose lanes, the lane control sign over the HOV lane may show a speed limit different from what is shown for the general purpose lanes. The highest speed differential between the HOV lane and general purpose lanes upon initial ATM deployment is a 15 mph differential, although this threshold is user definable in the ATM system.
- Default conditions during the HOV restriction period in the Las Vegas area, which will be 24/7 starting in 2019, will be black signs providing DIAMOND 2+ ONLY on left pole display and speed limit on right pole display. During certain incident or work zone scenarios within the ATM system, the HOV lane may be opened to all traffic; during these times, the signs will display DIAMOND OPEN TO ALL on left pole display and speed limit on right pole display. All displays and time periods will be user definable in the ATM System.
- If the HOV left pole display is showing DIAMOND OPEN TO ALL, then the HOV lane control display shall read the same speed as the other general purpose lanes.
- Operators will use CCTV camera images to verify that automated speed limit and lane use control displays that are generated from the ATM system are displaying the intended messages to the travelers.
- Camera pre-sets are needed to quickly verify lane control displays on gantries and provide TMC operators with images immediately upstream of the back-of-queue to allow operators to monitor where speeds are being detected below the speed threshold.
- Type 1 gantry information displays will have three operational modes, shown in **Figure 4-2.** Mode 1 is a blank overhead sign with the dynamic speed limit on the right pole display and HOV restriction message on the left pole display. Mode 2 includes use of the overhead sign to provide a traveler information message on the top portion of the sign. Overhead information displays can be used outside of ATM-specific applications to provide travel times, public service announcements, and advanced information to support the arterial networks adjacent to I-15 and US-95. In Mode 2, the left and right pole displays remain dynamic as available in Mode 1. Mode 3 includes use of both the

overhead information display as well as the overhead lane use control or speed limit displays on the bottom portion of the overhead sign. The right and left gantry pole displays are operational in their respective roles during all three operational modes.

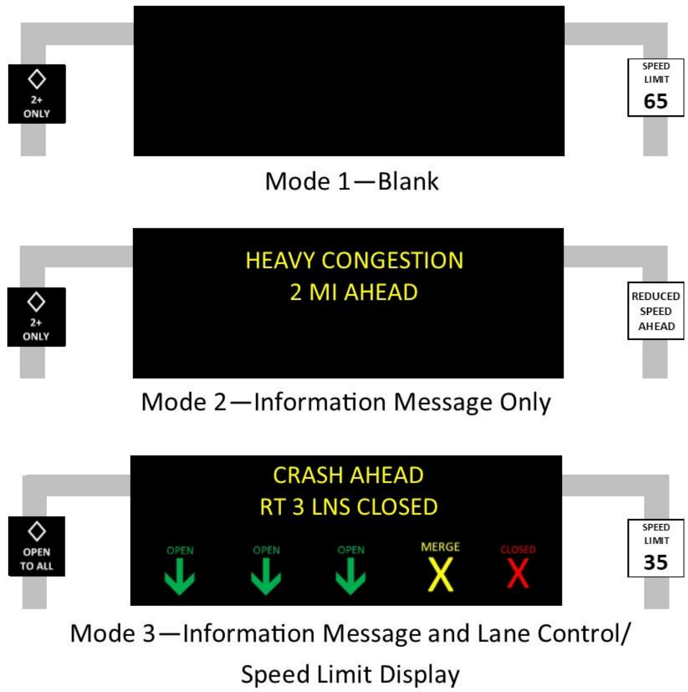



**Figure 4-2: Type 1 Information Display Modes**

- Type 2 gantry information displays will have two operational modes, shown in Figure 4-3. Mode 1 is a blank overhead sign with the dynamic speed limit on the right pole display and HOV restriction message on the left pole display only. Mode 2 is activation of the overhead sign to provide lane use control or speed limit displays. The right and left gantry pole displays are operational in their respective roles during all three operational modes.


**Figure 4-3: Type 2 Information Display Modes**

- Any new lane control display over a lane or on a gantry pole must be submitted to FHWA for approval for experimentation.
- A DMS message library will be available in the software that will aggregate all pre-set traveler information messages associated with the ATM system applications. The message library will also allow for new messages to be added, as new messages become available.
- In cases where the necessary number of gantries to perform an ATM function are not available, such as if a planned or unplanned closure occurs at the first gantry along the ATM-equipped corridor, then traditional traffic control devices and procedures should be utilized.

## 4.2 Lane Use Control System Concept

### ATM Technologies Used:

- When lane blockages are manually entered into the ATM software system, the system will automatically populate the sign sequence upstream of the identified location.
- Lane control signs
- Information display

### Functional Parameters:

- Lane control signs will be blank as the default message during "normal conditions". Travelers will be able to see the ATM gantries in use at all times in the form of the HOV restriction display and the speed limit display on the poles of gantries, as warranted.
- Managing individual freeway lanes as they are closed or re-opened will be a manual process facilitated by a TMC operator trained on the ATM system.
- All lane control designations are shown in **Figure 4-4** and include:
  - A green down arrow indicating that the ATM system is active and that the traveler is coming up on a traffic event, or that the traveler has passed through a traffic event and is returning to normal traveling conditions.
  - A red X for a closed lane.
  - Merge lanes will include a yellow merge X.
  - A yellow caution X to indicate drivers to use caution when traveling in that lane due to circumstances such as slower speeds or upcoming hazard being detected in that lane.

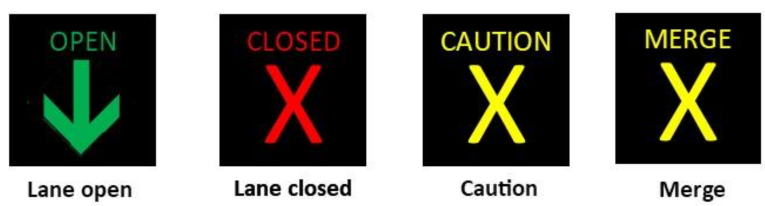



**Figure 4-4: Lane Use Control Displays**

- Merge indications will be used to allow traffic to move over one lane at a time in advance of a lane closure or slow traffic/queue in a single lane.
  - Two yellow merge Xs will not be offered at one gantry in advance of two lane closure because this would not allow proper time for traffic to move over two lanes away from the closed lanes.
  - If speeds in a single travel lane are detected at 35 mph or lower (i.e. a single lane queue), then a yellow merge X will automatically be displayed above that lane on the gantry upstream of the queue to direct drivers out of that lane.

- HOV lanes will have the two designations available for operators to choose from that would be displayed on the left pole of the gantry (not over the travel lanes). These are shown **Figure 4-5**.


**Figure 4-5: HOV Restrictions Displays**

- The HOV restriction sign should be posted on the left pole gantry display indicating "DIAMOND 2+ ONLY" as the default message.
- The HOV restriction message will be available for display on the lane control sign over the HOV lane.
- The HOV restriction sign "DIAMOND OPEN TO ALL" should be posted on left pole gantry display only in conjunction with two or more right lanes being closed on the freeway. The first instance of this "DIAMOND OPEN TO ALL" display will be on the first gantry that provides a yellow merge X display over a lane. If congestion is detected due to the lane closure(s), the first instance of this "DIAMOND OPEN TO ALL" display will be on the first gantry upstream that provides a reduced speed on lane displays.
- Gantries should have a highly visible number identifier on each physical sign or pole. The identifier must be visible from a CCTV camera image and should help support public safety and other responding agencies in communicating the gantry at the incident location.
- No lanes will be closed for planned special events. If lane closures are required, they will be implemented in the form of Junction Control.

## 4.3 Dynamic Lane Use Control – Junction Control Concept

Junction control is a specific concept of dynamic lane use control. While it is not going to be initially be pursued for implementation by the I-15 and US-95 ATM system, the ATM software should account for the ability to perform dynamic lane merging or junction control because ATM technologies will already be deployed that can support this application.

### ATM Technologies Used:

- Automated queue detection/warning on freeway mainline; if congested conditions are detected by mainline detectors, Junction Control should not be considered
- Ramp meter presence detection (if applicable)
- Lane control signs
- Information displays

### Functional Parameters:

- The junction control application will mimic the closure of one travel lane for an incident or construction event, although the application's purpose is to allow ramp traffic to freely enter the freeway mainline with no oncoming traffic. Dynamic lane merging may be warranted in the following conditions:

  - Fast mainline speeds approaching an entrance ramp merge are detected.
  - Slow entrance ramp speeds are detected.
  - Queuing occurs on the entrance ramp resulting in a backup onto arterial system.

- Dynamic junction control should only be used in unique and isolated circumstances and with management approval of the lane closure. Locations where junction may apply include service interchanges or system-to-system interchanges that have on-ramp traffic merging in with mainline traffic.
  - To support driver compliance with junction control when it is activated, it should not be used when there are incidents, construction, or other circumstances that could cause the traveling public to consider it a "normal" use of the system.
- To apply dynamic lane merging, an operator will manually close the right-most lane on the gantry immediately upstream of the freeway entrance ramp merge location. Only utilize gantries with information display signs that are immediately upstream of freeway entrance ramps. The ATM System is designed to have gantries with information display signs located downstream of freeway entrance ramps; however, the ATM software needs to accommodate gantries both immediately upstream and downstream of freeway entrance ramps in case of a change gantry design.
- Once a lane closure is in effect, the operator will verify that the system automatically overrides the dynamic ramp metering application and turns off the ramp meter. This will allow ramp traffic to flush onto the freeway mainline.
- This application will request ramp meter evaluation by a TMC operator to determine if the ramp meter should be turned off or if the rate of metering should be increased.
- The ATM system will automatically populate the gantry upstream from the location of the lane closure for dynamic lane merging with the yellow merge X display to merge oncoming vehicles away from closed lane.
- When operating conditions return to normal, the TMC operator will manually remove the lane closure upstream of on-ramp.
- An information display that would support junction control is provided in **Figure 4-6**.

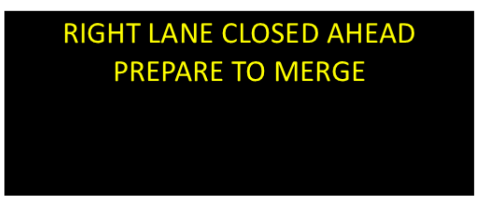



**Figure 4-6: Information Display Message Example to Support Junction Control System**

- When designing the ATM system, the placement of a gantry in relation to its distance from the on-ramp gore point should be carefully considered. In normal traffic conditions, the ATM gantry will show the freeway lane as OPEN at the same time as on-ramp traffic is merging onto the freeway, which introduces a potential movement conflict. The placement of a gantry that will be used for dynamic lane merging may need to be directly prior to the merge point to eliminate this conflict.

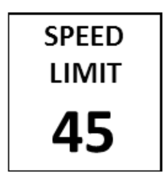
## 4.4 Speed Harmonization (Regulatory Variable Speed Limit Concept)

### ATM Technologies Used:

- Automated queue detection/warning on freeway mainline
- Lane control signs

### Functional Parameters:

- Speed harmonization will be automatically activated when operating speeds detected downstream of the gantry are below the user defined threshold, initially set at 55 mph. This is done to slow freeway speeds as they approach the reduced speeds.
- Speed limits will be automatically updated at a user defined increment, defaulted to 30 seconds, based on real-time detection of mainline travel lanes.
- Speed limits can be manually or automatically activated in advance of a construction zone.
    - Manual entry of a speed limit will be completed by TMC operators at the speed identified in the project's Transportation Management Plan (TMP) and with approval of the project's Resident Engineer (RE).
- Automatic activation of speed limits for work zones will be computed by the ATM system, down to the identified work zone speed per the TMP, based on the manually-entered lane(s) closures for the work zone.
- Right pole displays will be limited to speed limit displays (MUTCD R2-1 signs). The speed limit display will include words "SPEED LIMIT" above the numerical value of the speed and shall have a black border to match the legend of the sign, per MUTCD and shown in **Figure 4-7**.




**Current speed limit**
**MUTCD R2-1**

**Figure 4-7: Speed Limit Displays**

- MUTCD W3-5 signs, shown in **Figure 4-8**, are displayed on the overhead lane displays directly upstream of a gantry showing a reduced speed limit. When MUTCD W3-5 signs are displayed overhead, the right pole display on the same gantry would display the currently posted speed limit at that location.

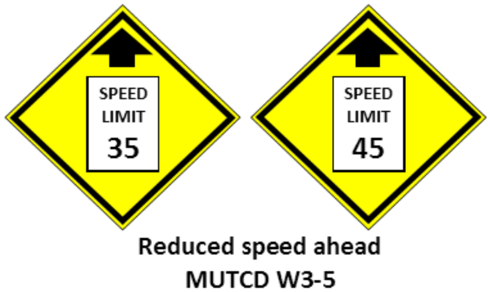



**Figure 4-8: Reduced Speed Ahead Overhead Display**

- Speed harmonization should only be implemented in response to detected conditions. If users do not believe the system is legitimate, compliance rates will be low. Therefore, if the reason for the reduced speed limit is not apparent to travelers, the associated information display signs should provide information about the travel conditions, with information displayed at a minimum of every other gantry in the direction of travel, similar to the **Figure 4-9**. The ATM system that provides travel times will also provide supplemental information regarding the extent of delay caused by congestion.


**Figure 4-9: Information Display Message Example to Support Speed Harmonization Lane Display**

- Speed limits will be provided between 35 mph and 65 mph in 5 mph increments, as the default condition.
- Speed limits will be automatically adjusted based on the detected speeds in mainline general purpose lanes. Speeds detected in HOV lanes will not influence the calculated general purpose lane speeds for the ATM system.
- Speed limits will be reduced based on actual operating speeds at the gantry experiencing lowered speed conditions to the nearest increment ABOVE the current operational speed. The first display for speed harmonization will be upstream of the detected reduced speed.
- Each gantry upstream (in advance of) the gantry experiencing the congestion will sequentially lower speed limits. Reducing the speed limit will occur over two gantries, as the default condition. For example:
  - If at Gantry B, the operating speed is 57 mph, the speed limit will show 65 mph on the right pole display. No lane control signals will be active, and Gantry A upstream would not show a variable speed limit.
  - If at Gantry B, the operating speed is 52 mph, the speed limit will show 55 mph both on the right pole display and the overhead lane display, along with a REDUCED SPEED ZONE message. Gantry A directly upstream would show a MUTCD W3-5 signs overhead, indicating drivers are approaching a 55 mph speed limit, and 65 mph speed limit on the right pole display.
  - If at Gantry B, the operating speed is 20 mph, the overhead and right-pole displays will show a speed limit of 35 mph and a REDUCED SPEED ZONE message. Gantry A upstream would

show a MUTCD W3-5 signs overhead, indicating drivers are approaching a 35 mph speed limit zone, and 65 mph on the right pole display.

- Speed harmonization will treat HOV lanes separate from general purpose lanes; therefore, if detected speeds in the HOV lane are different from those the general purpose lanes, the lane control sign over the HOV lane may show a speed limit different from what is shown for the general purpose lanes. The maximum speed differential between the HOV lane and general purpose lanes will initially be set at 15 mph, although this threshold will be user definable in the system.
    - Example, if the general purpose lanes are experiencing reduced average vehicle speeds, but the HOV lane is not experiencing reduced speeds, the HOV speed may be displayed as 50 mph while the general purpose lanes will have a speed limit display of 35 mph.

## Enforceability of Variable Speed Limits:

Variable speed limits are enforceable, per Nevada Revised Statutes (NRS) 484B.613, which states “The Department of Transportation may establish the speed limits for motor vehicles on highways which are constructed and maintained by the Department of Transportation under the authority granted to it by chapter 408 of NRS. Except as otherwise provided by federal law, the Department of Transportation may establish a speed limit on such highways not to exceed 80 miles per hour and may establish a lower speed limit where necessary to protect public health and safety and for trucks, overweight and oversized vehicles, trailers drawn by motor vehicles and buses.”

To support speed limit enforcement along the ATM corridor, the ATM system retains a history of all posted messages along the corridor, including speed limits, lane use control, and DMS messages. NDOT, FAST TMC, and NHP staff can query from the system a report that identifies the posted speed limit at any gantry (via the gantry ID number) within the system by date and time and by direction of travel (which is indicated in each gantry’s name in the system).

## 4.5 Driver Warning Concepts

**<u>Queue Warning Concept</u>**

### ATM Technologies Used:

- Automated queue detection/warning on freeway mainline
- Lane use control
- Information displays

### Functional Parameters:

- Queue warning should be automatically activated both as an individual ATM strategy and as a companion to speed harmonization or lane use control activation to provide advanced warning to drivers of changing conditions upstream.
  - As an individual strategy, a yellow caution X, as displayed in **Figure 4-10**, will be displayed over a single travel lane if speeds detected in that lane downstream of the gantry location are below 45 mph (or other user definable threshold) but average detected speed for the corridor in that location is above 60 mph (or other user definable threshold), indicating that there is a queue in a single lane. If speeds under 45 mph are being detected in more than one lane, the regulatory variable speed limit application will be activated.


**Figure 4-10: Caution Lane Use Display**

  - As a companion to speed harmonization or lane use control, information displays, such as **Figure 4-11,** should be displayed at a minimum of every other gantry in the direction of travel**.**


**Figure 4-11: Information Display Message Example to Support Queue Warning**

- Queue warning should only be activated in response to detected conditions and should provide information to travelers about conditions, such as upcoming queues, congestion, and reduced speeds, that may not be immediately apparent at that location. If users do not believe the system is legitimate, compliance rates will be low.

## Driver Caution Concept

### ATM Technologies Used:

- When a driver caution scenario is manually entered into the ATM software system, the system will automatically populate all lane controls signs upstream of the identified location.
- Lane control signs
- Information displays

### Functional Parameters

- Driver Caution will be manually activated by an operator per the direction of NHP for a TMC Manager in response to a hazardous condition where it would be infeasible or inappropriate to use dynamic lane use control or speed harmonization. Potential scenarios for the use of the Driver Caution application could include a detected wrong way driver or other police activity on the roadway where drivers should be asked to use extreme caution if proceeding as to reduce potential impacts.
- A yellow caution X, shown in Figure 4-10, will be displayed over all travel lanes on all signs downstream of the activation location.
- A traveler message indicating the reason for the Driver Caution should be displayed on all traveler information displays along the corridor that are downstream of the initial event location. **Figure 4-12** provides an example of a traveler information sign that may be used during the driver caution application.


**Figure 4-12: Driver Caution Display**

- Driver Caution should only be implemented under extreme circumstances that require high levels of driver awareness, as determined by NHP. If users do not believe the system is legitimate, compliance rates will be low.
- Posted speed limits will be automatically adjusted based on the actual detected speeds in the mainline general purpose lanes at the gantry location. The Driver Caution scenario will not include a speed limit function that overrides that system's automated speed limit function.
- The HOV restriction sign on the left pole of each gantry will not change as a result of the activation of the Driver Caution application and will continue to display the HOV restriction display that was activated prior to activation of Driver Caution.

## 4.6 Software Interface Concept

All ATM functions and related equipment will be operated from the FAST TMC. The existing central management system software used at the FAST TMC includes a module to allow for operation of the ATM application. The following are basic software needs for the for ATM application management:

- Software should provide a user-interface for operators that provides the following visual indications to support operations and management of specific applications:
  - Provide the exact layout of gantries along the corridor, gantry identifier number, the number of lane displays available on each gantry, and the availability of additional information signs on the gantry.
  - For the purpose of displaying the sequence of gantries within one display, gantries should be “flattened” to be able to show lane control signs next to one another.
  - Provide real-time indication of exactly what is being displayed at any given moment, including DMS display, lane control display, HOV status, or posted speed limit.
  - Color-coded bars or highlights over freeway travel lanes to show green, yellow, and red congestion conditions as they relate to each gantry and interchange location.
- Allow for manual entries onto specific displays based on ATM application in place and provide a visual identifier of which ATM applications are in use at any given time.
- Software needs to support the ability to display lane control displays (lane open, lane closed, merge, caution, and speed limit display) either through a system-stored or system-generated response strategy or through manual operator request.
- ATM software should provide the flexibility to implement shoulder-running strategies, at a future time if NDOT desires. This application should be available for all or specific roadway segments, using pre-developed plans and would require the use of consecutive green arrow and RED X displays.
- ATM software should automatically respond to congestion or other event triggers and formulate or select an appropriate traffic response plan (e.g., open HOV lanes to all traffic for short stretches beyond the ends of entrance ramps in response to traffic congestion in general purpose lanes).
- ATM software should provide the ability to view historical summary and detailed reports for of ATM activities, including messages/speed limits/lane use controls posted at any gantry within the system for any previous date, time, and direction of travel.
- ATM equipment (overhead lane management displays for queue warning, advisory messages, cameras, additional detection, etc.) is to be incorporated into the inventory of “As-Built ITS Devices” and incorporated into appropriate operational and inventory systems.
- Inventorying of field equipment is to be facilitated through standardized identification schemes, such as equipment bar coding, unique ID coding, and gantry numbering.
- The ATM system should have the ability to push data to third party platforms (such as Waycare) that support a broader dissemination of information generated by the ATM system (lane closures, speed limits, ramp metering status) to other transportation agency partners and the public.

The design and construction of all new ITS applications shall meet interface requirements allowing for expansion of the existing ITS and freeway and arterials management systems network using the correct revision of device firmware. All new ITS technologies shall operate without requiring the installation of new device interface software in the existing FAST TMC central software.

The interface between the FAST central management system and the new ATM platform needs to be seamless. All ITS technologies mounted on the ATM gantries and flow detectors will be utilized by the central software provided to implement the ATM functionality. The ATM central software will use the existing FAST TMC device interfaces to receive data from detectors and control the signs on the ATM gantries. The ATM System will provide the ability to add new gantries and devices as expansion occurs.

## 4.7 Other Concept Considerations

### ATM Not in Use

When the ATM technologies are not in use, the following will apply to the system:

- Lane control signs will be blank as the default message to travelers. The right pole displays on gantries will display speed limits and the left pole displays on gantries will display an HOV 2+ ONLY message (see Figure 5-2).
- Information Display Signs will provide travel times as a default message along the corridor. When instances warrant additional information, that information will be posted instead of travel time messaging.
- Public service announcements (PSA) consistent with NDOT policies may be added to Information Display Signs while ATM systems are not active.

### Resource Considerations

- Training will be required for operators to close lanes through the ATM system.
- An underlying assumption is that the ATM central software will have logic and decision support capabilities to automatically generate sign displays based on real-time traffic flow data (as collected by the system) and manual operator verification and input. The following decision-making process applies to all ATM scenarios, with the level of operator involvement varying depending on the scenario and type of information required by the system. Operator involvement will include:
    - Determining and/or verifying problems, via CCTV and/or communications with State Police and Service Patrols, that may necessitate changes to the ATM sign displays (e.g., incident reported by other sources, including identifying the nature and severity of the problem/number of lanes to be closed).
    - Inputting additional information to the system (e.g., number and which lanes closed, estimated duration of blockage, need for emergency vehicle access), when available, to facilitate the development of a “recommended” signing plan by the ATM logic.
    - Continuously monitoring operations (i.e., traffic flow, incidents, system) and adjusting the sign displays (with system assistance), as conditions change.
- NDOT needs to update the FAST Agreement to develop operational, maintenance, and developmental policies for ATM System.

- In the near-term, FAST will provide ATM operations during normal FAST business hours, and after-business-hours coverage will be performed t by NDOT District 1 operations staff. FAST maintenance staff will provide maintenance during normal FAST maintenance business hours.

# 5 Operational Scenarios

This section provides an overview of the proposed ITS/Operations systems requirements, architecture, and components for the NDOT ATM program, based on a summary of expected operational scenarios. The recommended systems components will assist NDOT and FAST in meeting the goals and objectives set forth in Section 1 of this ConOps.

## 5.1 Context Diagram

Functionality for the proposed ATM implementation will be achieved through deploying and integrating of new and existing roadside monitoring and control equipment for collecting data and managing traffic operations, providing traveler information systems that will provide roadway condition information, and implementing ATM decision support and control software at the FAST TMC. The context diagram shown in **Figure 5-1** provides an operational overview of the system.

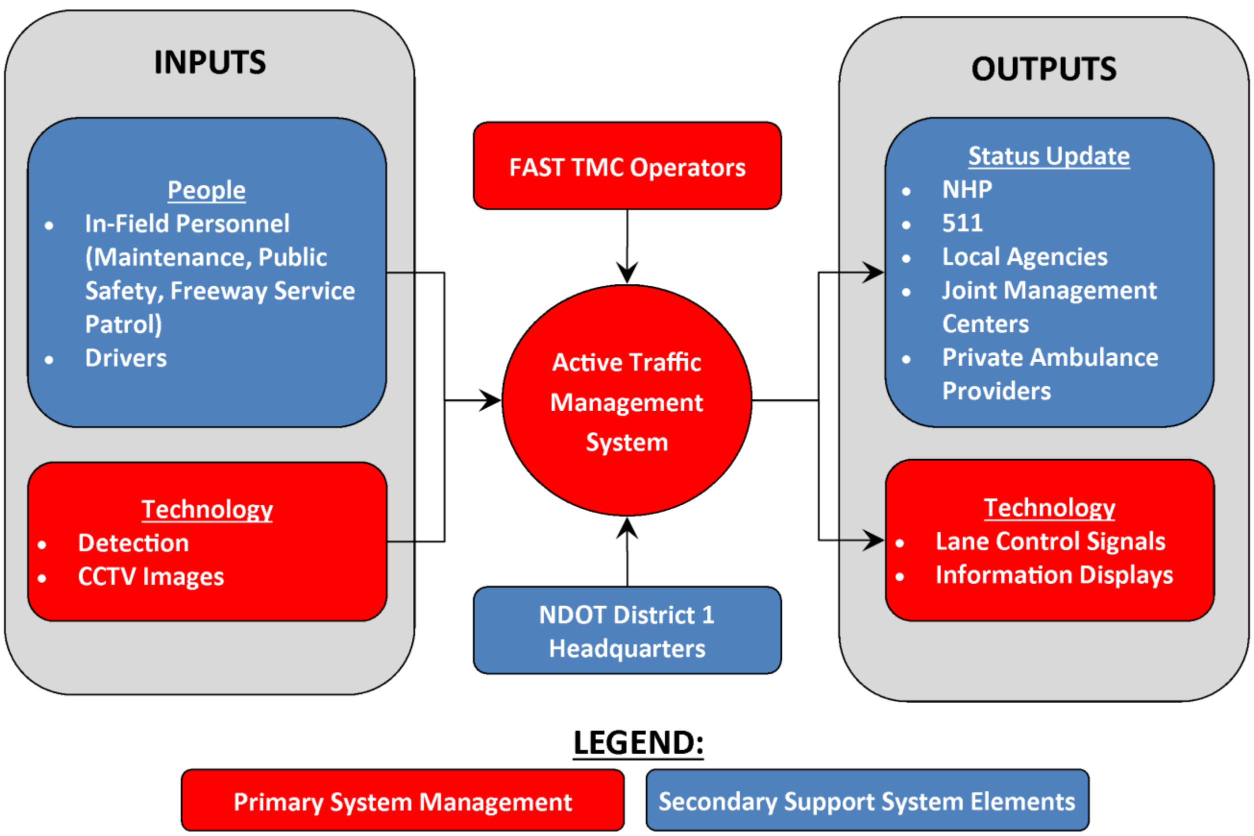



**Figure 5-1: NDOT ATM System Operation Context Diagram**

The ATM system will collect or react to the following information:

- Current roadway condition data, work zone status, and incident status
- Flow data – speed, volume, and occupancy data from freeway traffic lanes

- Roadside images – capture of real-time traffic images from specific freeway locations
- Manual request from operator (activation of display, selection of response plan, editing of plan, etc.)

The ATM system will then generate the following information:

- Request for a traffic image– request specific real-time traffic images from field devices at specific locations
- Request operator confirmation for an ATM response– alerts operator of system-generated recommended response (including operations plan, displays) based on roadway, situation and other inputs
- Traveler information – posted speed limit, lane use status, and queue warning displays (for control, regulatory, and advisory information displayed on the roadway) per gantry
- Road status – Provision of traffic flow, lane status, and queue information (for traveler information)

## 5.2 ATM Scenarios

This section provides examples of representative scenarios for the proposed NDOT ATM system to identify how the various concepts and the associated informational messages will be implemented and operate simultaneous under a variety of circumstances. It should be noted that, in cases where the necessary number of gantries to perform an ATM function are not available, such as if a planned or unplanned closure occurs at the first gantry along the ATM-equipped corridor, then traditional traffic control devices and procedures should be utilized.

The ATM scenario examples are not meant to be all-inclusive, but they do provide an understanding of ATM operations, given likely events. Operational scenarios addressed in this section include the following:

- Free Flow – no ATM applications
- General Congestion – speed harmonization
- Queue warning – lane use control and driver warning
- Incident with a Lane Closure with congestion – speed harmonization and lane use control
- Incident with a Lane Closure without congestion – lane use control
- Planned Closure – speed harmonization and lane use control
- Full Roadway Closure – speed harmonization and lane use control
- Junction Control – lane use control
- Driver Caution – driver warning

Each scenario includes a spatial sequence of ATM signs/DMS mounted on ATM gantries, with the direction of travel being from the bottom of the figure to the top. For the purpose of the scenarios, gantries were "flattened" to be able to show lane control signs next to one another. Because the number of travel lanes, varies across the corridor, five travel lanes are shown for all of the scenarios.

## Free Flow Scenario

**Figure 5-2** provides an example of the default ATM gantry display usage during free flow conditions where there is no congestion, incidents, or events that are impacting traffic on the freeway. As shown in the figure, no display (a blank sign) is provided over the general purpose lanes, HOV 2+ display will be active on the left pole display on the gantry, and the current speed limit of the roadway is provided on the right pole display on the gantry.

During free flow conditions when ATM applications are not active, the travel time system will be active on gantries as the default messaging.

Manual processes:

- None.

Automatic processes:

- None.


**Figure 5-2: Free Flow Scenario**

## General Congestion Scenario

Bottlenecks and congestion can occur outside of peak-periods, especially in Las Vegas near the I-15/US-95 Spaghetti Bowl area. Weekend traffic can become heavy during certain hours, and middle of the night peak periods can impact traffic operations. Under these circumstances, the ATM system can warn drivers about traffic impacts in advance of congestion, using a combination of driving warning (specifically queue warning messages) and speed harmonization. The scenario depicted in **Figure 5-3** describes the ATM applications that should be in effect during peak period congestion conditions on the freeway.

Manual processes:

- None.

Automatic processes:

- Congestion (i.e. reduced speeds and prolonged occupancy) is detected by mainline detection.
- Regulatory speeds are calculated for general purpose lanes and separately for HOV lanes (with an initial maximum differential of 15 mph between the posted speed limits for the two-lane types).
- Variable speed limit displays are generated for general purpose lanes and separately for HOV lanes based on prevailing conditions
- Queue warning messages are generated for DMS.

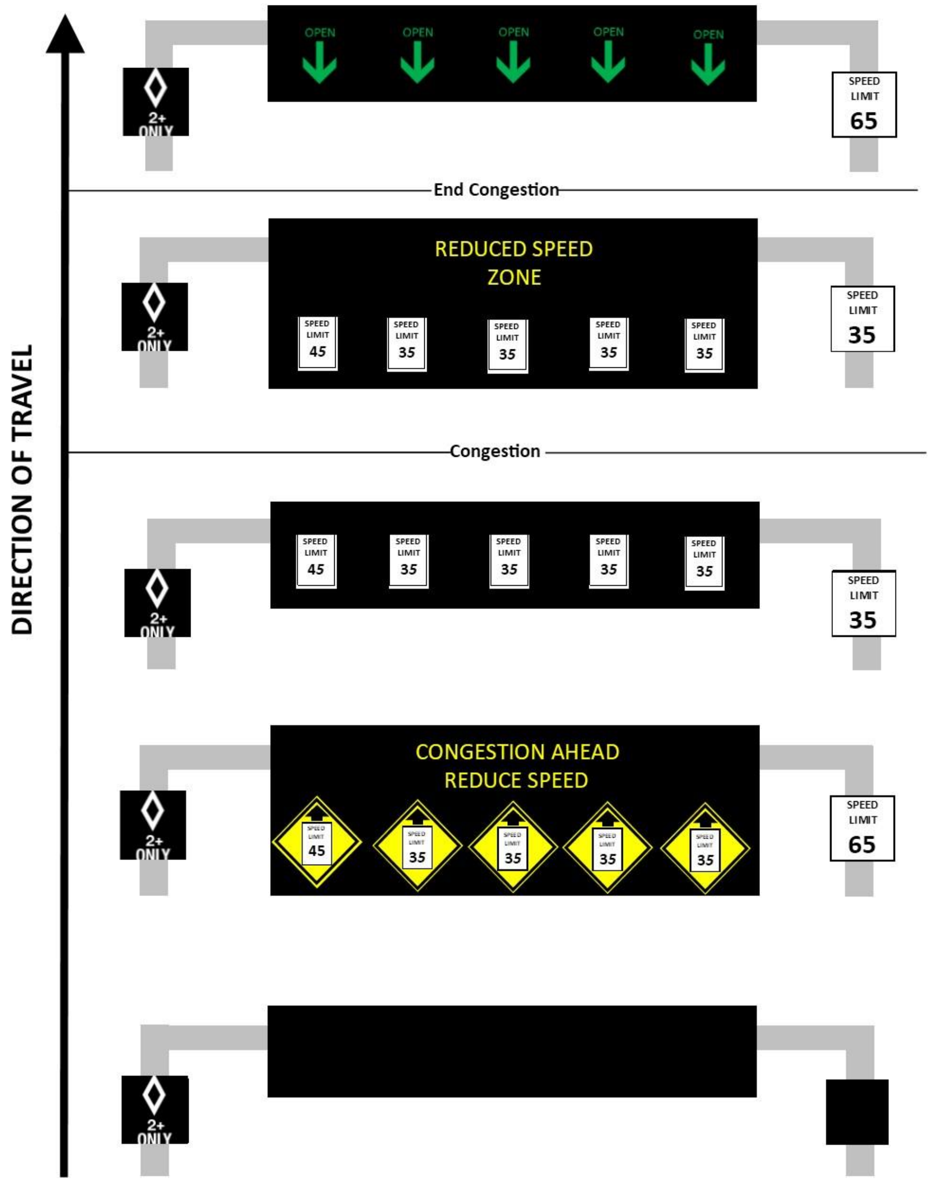



**Figure 5-3: General Congestion Scenario**

## Queue Warning Scenario

**Figure 5-4 and Figure 5-5** depict scenarios where a queue and slower vehicle speeds are detected in a single travel lane, including the HOV lanes, as opposed to the general congestion shown in Figure 5-3. Detection of a queue in a single lane will trigger either a driver caution application, with a yellow caution X and warning messages, or a yellow merge X and a warning message, alerting drivers of the queue and encouraging higher alert or merging to avoid collisions.

Manual processes:

- None

Automatic processes:

- Speeds lower than 45 mph are detected by mainline detection for a single travel lane (general purpose or HOV), although average speed across all lanes remains above the 55 mph threshold:
    - If single-lane detected speeds are between 36 mph and 45 mph, a yellow caution X display is presented over the affected lane at the gantry immediately upstream of detected queue (Figure 5-4).
    - If single-lane detected speeds are 35 mph or below, a yellow merge X lane use control display is presented over the affected lane at the gantry immediately upstream of the detected queue (Figure 5-5).
- Queue warning messages are generated for DMS.

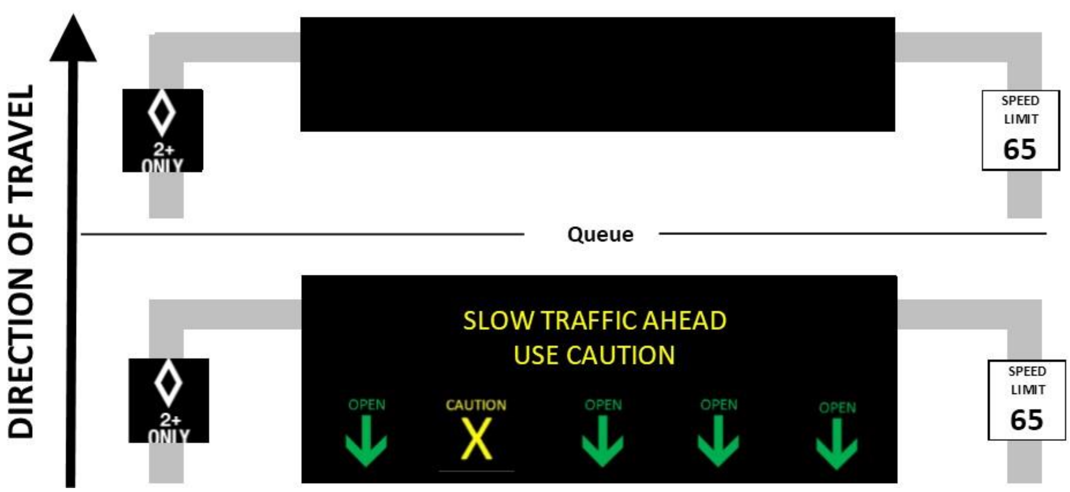



**Figure 5-4: Single-Lane Queue Warning Scenario (Speeds detected between 36 mph and 45 mph)**

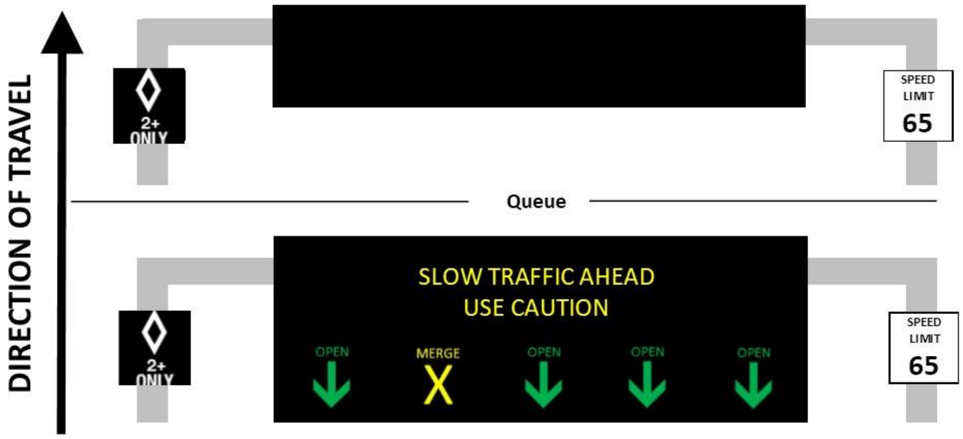



**Figure 5-5: Single-Lane Queue Warning Scenario (Speeds detected 35 mph or below)**

## Right-Lane Incident Scenario

**Figure 5-6** shows the progressive implementation of driver warning, speed harmonization, and lane use control to address a scenario where a crash is blocking the right lanes during a congested condition with speeds lower than 45 mph detected. Based on operator input, the ATM lane use control application closes the right lane and merges traffic to the left in advance of the crash location using lane use control. In advance of the closure and merge location, the speed harmonization application is activated to reduce the speed limit, and the driver warning application provides queue warning messages leading up to the location where vehicles will be forced to merge out of the closed lane.

**Figure 5-7** shows the sequence of driver warning, speed harmonization, and lane use control during a crash blocking the same right lanes, but during non-congested conditions. Because there are two or more lanes closed in this scenario, HOV restrictions are lifted (i.e., the HOV lane is opened to all traffic) through the merge and closure event are and are returned to HOV 2+ after passing the crash location.

Manual processes:

- Operator identifies blocked lane(s) and selects RED X for lanes that are closed to traffic.
- Operator sets time value for lane closure(s) with option to extend.
- Operator creates traveler information message or uses available messages to identify the purpose of the lane closure near location of closure.

Automatic processes:

- Lane indication displays are generated based on the location of the blocked lane(s) that were identified by the operator.
- HOV restriction message is changed to “OPEN TO ALL” if at least 2 right lanes are indicated as closed.
- Messages are generated for DMS based on the messages provided or selected by the operator and based on the location of the blocked lane(s).
- Variable speed limits are generated.

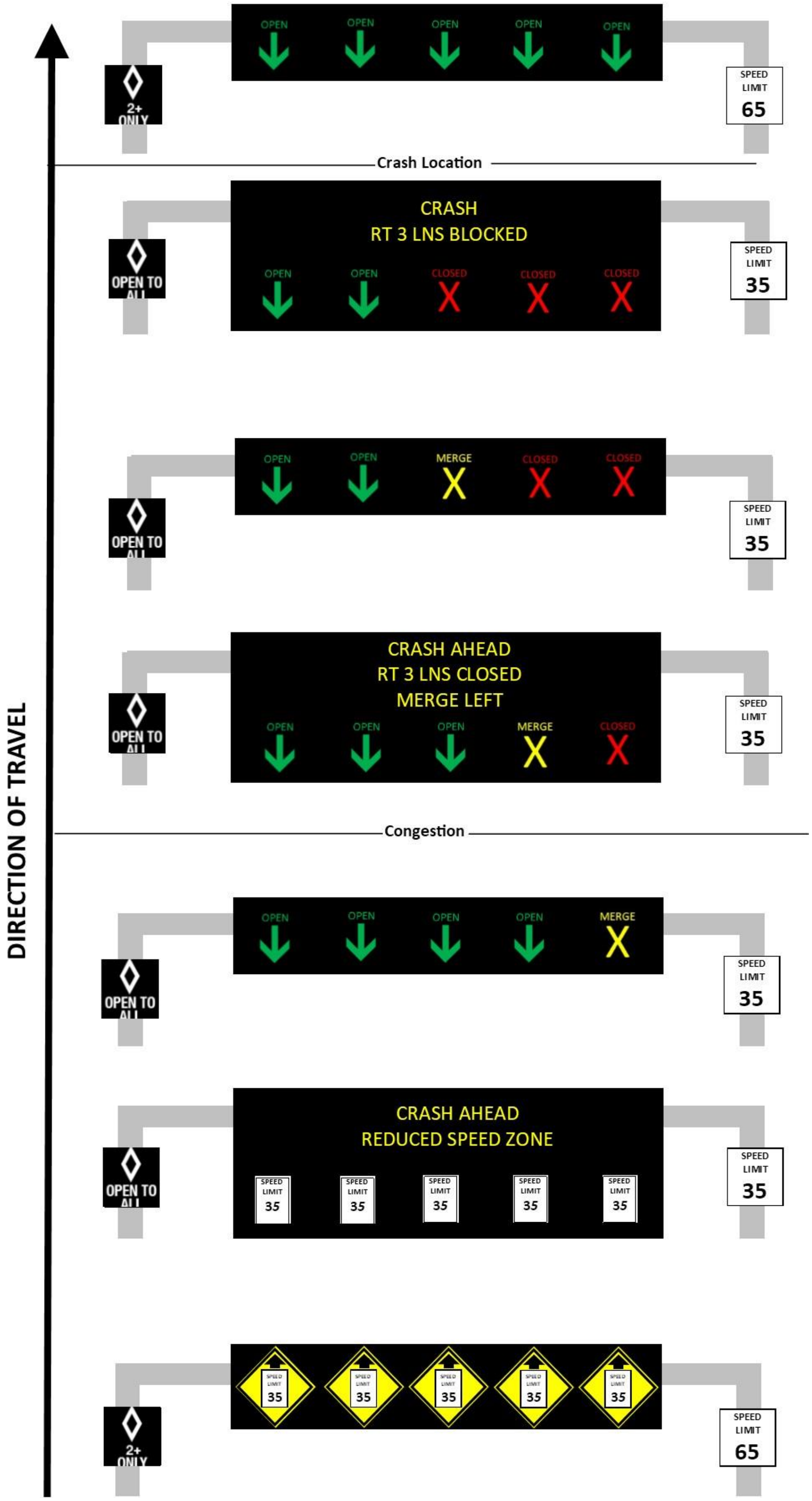



**Figure 5-6: Right-Lane Incident with Congestion Scenario**

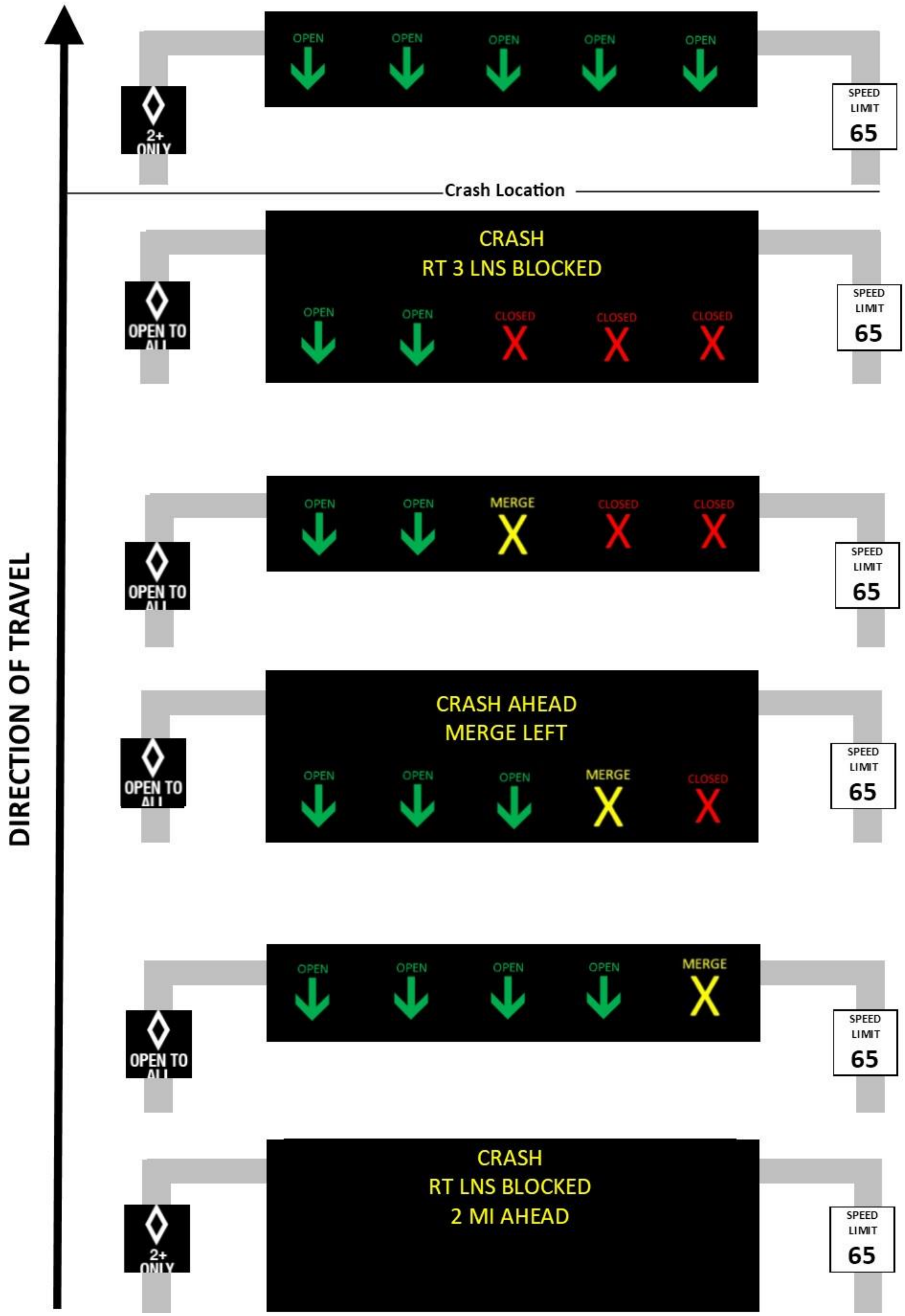



**Figure 5-7: Right-Lane Incident without Congestion Scenario**

### Planned Closure Scenario

Planned closure events include known lane restrictions that can be planned for in advance, such as work zone-related lane closures or temporary restrictions for special events. This scenario is shown in **Figure 5-8**. The scenario depicts planned lane closures for a work zone and the intended use of message displays, lane control, and speed limit displays to support traffic management through the work zone.

Manual processes:

- Operator identifies blocked lane(s) and selects RED X for lanes that are closed to traffic.
- Operator sets time value for lane closure(s) with option to extend.
- Operator creates traveler information message or uses available messages to identify the purpose of the lane closure near location of closure.
- If provided in the TMP and approved by the RE, operator sets work zone speed limit for gantries within the work zone.

Automatic processes:

- Lane indication displays are generated based on the location of the blocked lane(s) that were identified by the operator.
- Messages are generated for DMS based on the messages provided or selected by the operator and based on the location of the blocked lane(s).
- If not manually set, variable speed limits are generated.

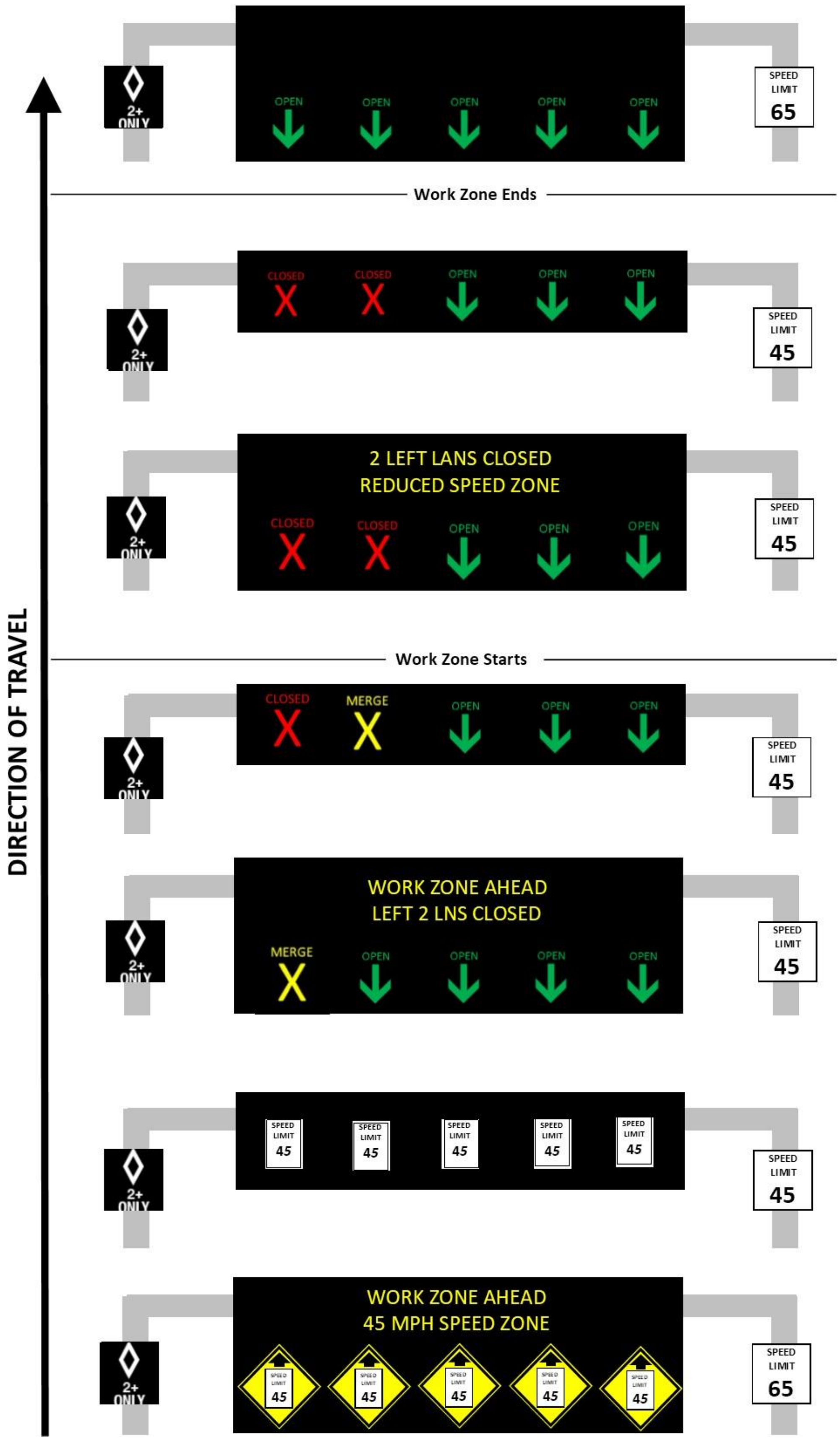



**Figure 5-8: Planned Closure Scenario**

### Full Freeway Closure Scenario

In the event of a major crash or other event necessitating a complete closure of the freeway, the ATM system can provide information to motorists well in advance of the closure and encouraging motorists to exit the roadway at exit ramps locations. This scenario is shown in **Figure 5-9** and includes utilization of information displays, lane control, and speed limit displays to warn travelers of full closure.

Manual processes:

- Operator identifies blocked lane(s) and selects RED X for lanes that are closed to traffic.
- Operator sets time value for lane closure(s) with option to extend.
- Operator creates traveler information message or uses available messages to identify the purpose of the lane closure near location of closure.

Automatic processes:

- Lane indication displays are generated based on the location of the blocked lane(s) that were identified by the operator.
- Messages are generated for DMS based on the messages provided or selected by the operator and based on the location of the blocked lane(s).
- Variable speed limit messages are generated for general purpose lanes only.

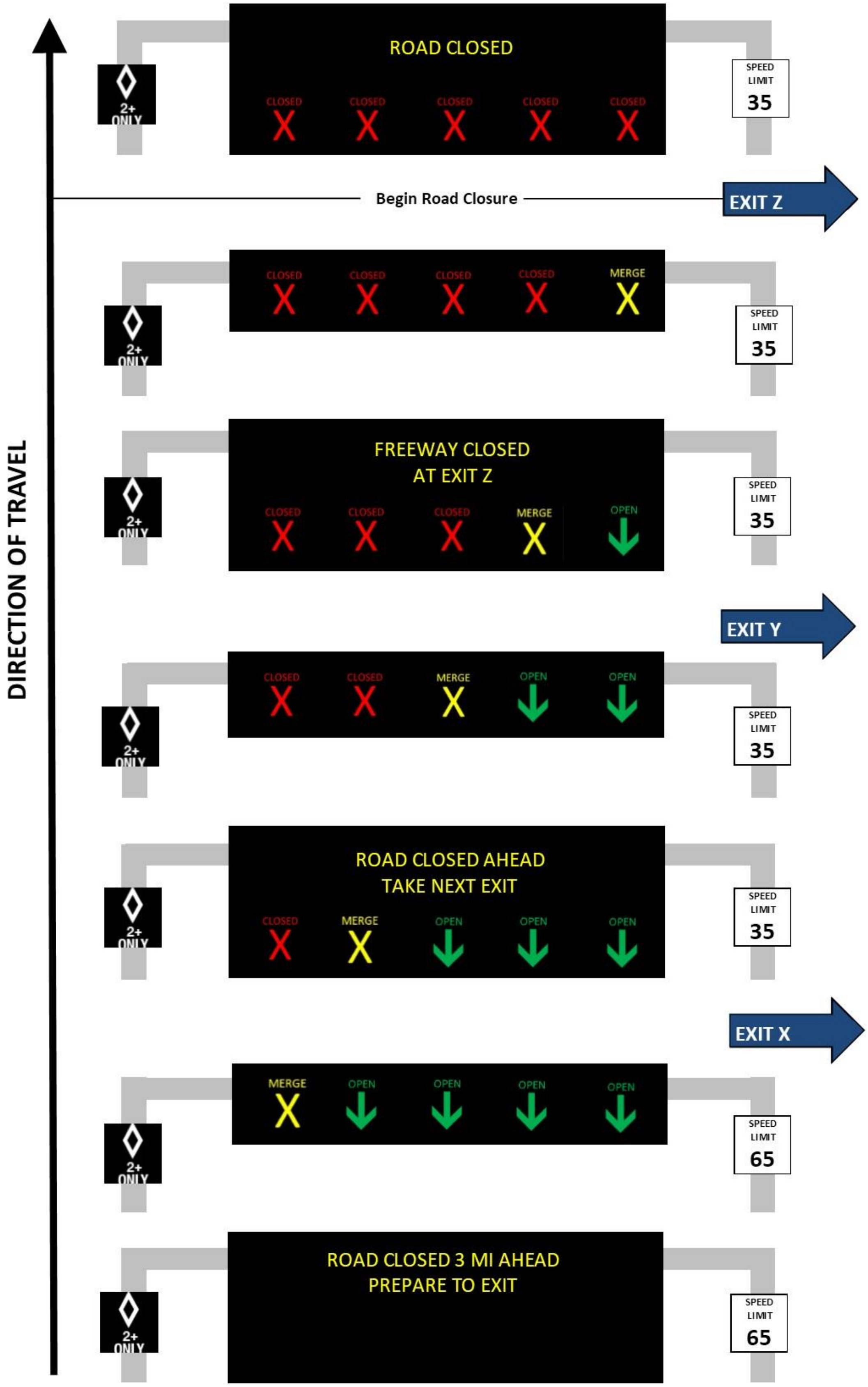



**Figure 5-9: Full Freeway Closure Scenario**

## Junction Control Scenario

Junction Control is a specific lane use control strategy that changes lane control messages at interchanges based on mainline conditions and traffic volumes at freeway entrance ramps. **Figure 5-10** show an example of this ATM function where freeway mainline lanes are closed to facilitate merging of traffic from the freeway entrance ramp onto the freeway during a congested period. This application creates a longer merge distance for merging vehicles by allocating the right general purpose lane of the freeway to merging vehicles.

Manual processes:

- Operator identifies need for junction control based on real-time traffic conditions and requests manager approval for use of system.
- Operator identifies blocked lane(s) and selects RED X for lanes that are closed to traffic.
- Operator sets time value for lane closure(s) with option to extend.
- Operator creates traveler information message or uses available messages to identify the purpose of the lane closure near location of closure.

Automatic processes:

- Lane indication displays are generated based on the location of the blocked lane(s) that were identified by the operator.
- Messages are generated for DMS based on the messages provided or selected by the operator and based on the location of the blocked lane(s).

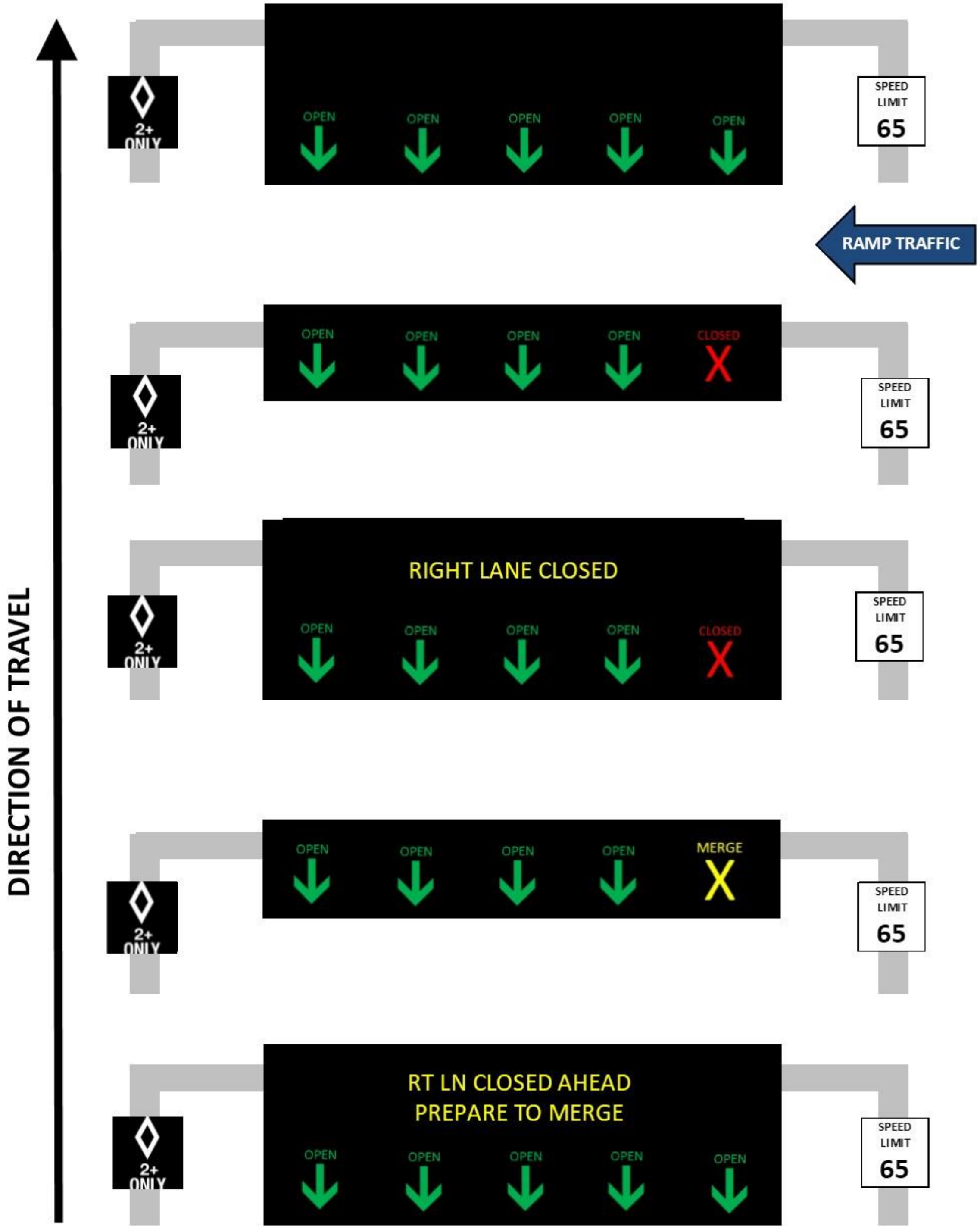



**Figure 5-10: Junction Control Scenario**

## Driver Caution Scenario

The Drive Caution scenario, shown on **Figure 5-11**, will only be activated upon request from NHP during hazardous conditions where lane use control and/or speed harmonization are inappropriate or undesirable but where driver awareness and caution are imperative for driver safety. One example of this type of condition could be the presence of a wrong-way driver on the roadway, where directing drivers to a specific location is not desired, but it is critical that drivers are aware of the hazard so that they can react appropriately, if needed.

Manual processes:

- Operator activates Driver Caution application at a specific location, per NHP request.
- Operator sets time value for application with option to extend.

Automatic processes:

- Upon activation, all information displays downstream of activation location are populated with yellow caution X lane indication displays.
- Caution messages are generated for DMS based on the default message or the message selected by the operator based on NHP direction.
- Speed limits are provided based on automated speed limit calculation from real-time data.

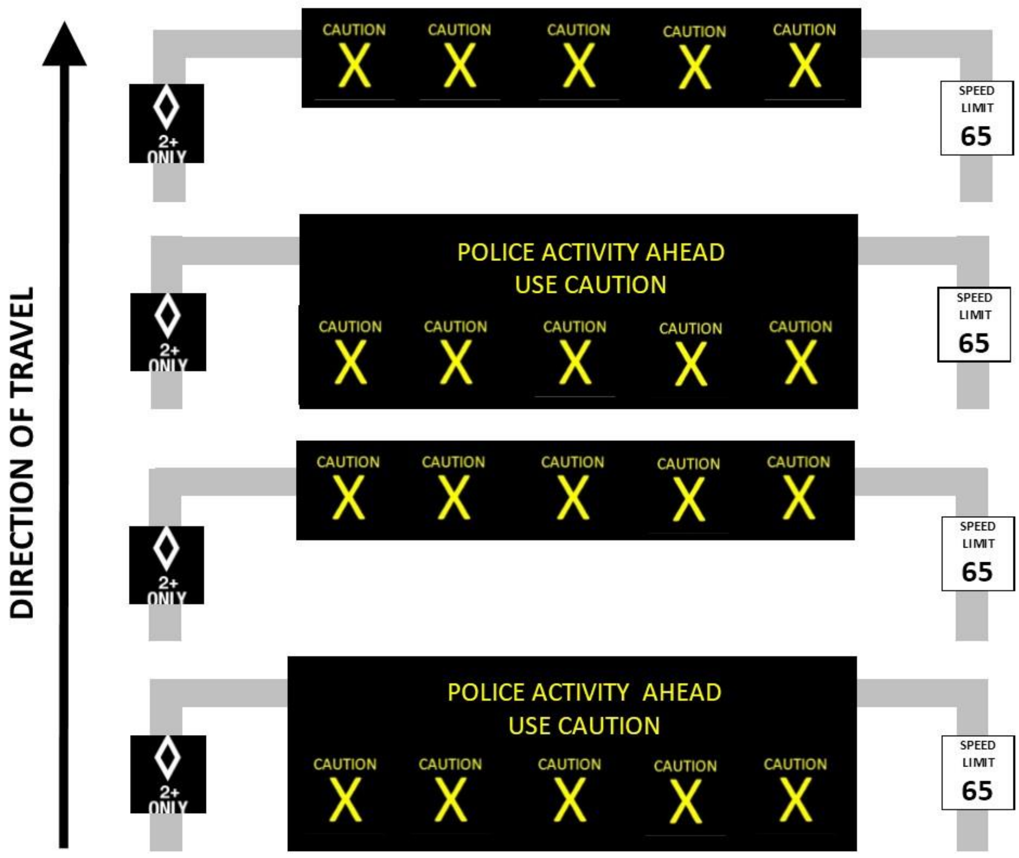



**Figure 5-11: Driver Caution Scenario**

## Failure Conditions

The reliability of ITS hardware has continually improved over time, and the ATM system and software will be designed, integrated, and operated to minimize operational problems. This includes monitoring diagnostics to immediately notify the TMC operator when and where a problem has occurred, and the nature of the problem (loss of communications, loss of power).

When failures do occur, ATM signs will go "blank". The ATM system can also be designed to continue to function, even if its operation is considered degraded. Potential failure scenarios and the resulting system operation conditions include:

- Loss of power at a gantry – All ATM displays will be blank. Power redundancy, at a minimum, should be considered for the right pole display so that the signs will continue to display speed limits. This is particularly important because static speed limit signs are being removed and replaced by ATM gantries. NDOT will pursue redundancies in power and communication for each ATM gantry to mitigate potential failure.

- Loss of communications at a gantry – As noted above, the current communications network incorporates a self-healing ring, which can continue to provide system communications in the event of a failure at a single node or segment. In the event of multiple communication failures, the signs should automatically go to blank out condition. This is particularly important if a loss of communications occurs during a lane closure scenario.

- Sign Controller failure – Assuming that all of the signs for a single sign gantry are operated by a single controller at the gantry, it may be feasible to include a second controller at the gantry as a "hot" standby should the primary controller fail. If there is no hot standby, the sign should go blank, (same as loss of communication).

- Traffic flow detector failures – Algorithms for calculating and displaying speed limits and advisories will be able to function effectively with missing data up to an identified threshold. An administrator will set a threshold for the percentage or number of failed detectors that will trigger the algorithm inadequate; when this level is reached, speed calculations are considered unreliable, the system-calculated speeds will not be posted, and the system will revert to a blank out message. If two consecutive lane detectors between gantries fail, speed harmonization will not remain active and will require a TMC manager to override the system to adjust speed limits based on prevailing conditions.

The FAST TMC is in charge of maintenance of all ATM components along the corridor. When maintenance is required, they will alert appropriate agencies (NDOT and NHP) of the intent to repair and will manage appropriate lane closures or other restrictions required allow for maintenance to occur.

# 6 Public Relations and Education

Prior to activating the ATM system, NDOT, in partnership with RTC FAST, should consider implementing a public relations and education campaign to alert travelers and visitors to the upcoming change to the way they travel along freeways through Las Vegas. The public relations and education campaign should include strategies within three categories: smart branding, focusing on users rather than technology, and communications methods. Examples of strategies in each category are provided below:

**Smart branding:**

- Create a title or phrase that would help travelers recognize the changes on their highways. Avoid acronyms and engineering jargon.
- Consider a logo or style to use in outreach about the new system.

**Focus on users rather than technology:**

- Work with the media to provide television and radio commercials providing education on the new system that focuses on the driver experience, explains why this technology is needed, and how it will improve drivers lives – television version could show corridor flyover.
- Develop and disseminate YouTube videos to describe the use of ATM and give examples of situations that it can be used.
- Deploy an interactive website posted on the NDOT website, NDOT 511 website, and FAST website that steps drivers through what to expect and how they should react.

**Communication methods:**

- Consider ways to most effectively communicate the various applications of the ATM system – for example, speed harmonization may be a term that is challenging for the public to understand, so exploring other terms that are more easily understood by the public will be important.
- Develop and distribute pamphlet/brochures.
- Provide photo updates on Flickr, Twitter, or Facebook showing the progress of sign testing and a photo album from the inaugural implementation of the program.
- Develop and populate an ongoing blog for updates.
- Identify a process for the public to provide feedback and ask questions.
- Broadcast a live video feed along ATM corridors.