



# Interstate 77

## Corridor Improvement Plan



March 2021

# Table of Contents

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Table of Contents .....	i
Figures .....	ii
Tables .....	iii
Introduction .....	4
Study Purpose .....	4
Multimodal Corridor Characteristics .....	5
Challenges in the Corridor .....	6
Existing Conditions .....	10
Performance Measures .....	11
Supplementary Data .....	12
Operations Improvements Plan .....	14
Foundational Operations Strategies .....	15
Innovative Operations Strategies .....	19
Special Facilities Operations .....	20
Capital Improvements .....	21
Detour Routes and Improvements to Parallel Facilities .....	21
Summary of Proposed Improvements .....	24
Return on Investment .....	25
Appendix A .....	26
Appendix B .....	28
Appendix C .....	30
Appendix D .....	32

# Figures

---

Figure 1 Study Area ..... 5

Figure 2 Grade Profile ..... 6

Figure 3 Causes of Congestion along the Corridor (2016, 2017) ..... 7

Figure 4 Estimated Causes of Congestion by Day of Week (2016, 2017) ..... 7

Figure 5 Average Speeds on Northbound I-77 All Days of the Week (2019) ..... 8

Figure 6 Average Speeds on Southbound I-77 All Days of the Week (2019) ..... 8

Figure 7 Average Speeds I-77 Northbound Saturday during June, July, August (2019) ..... 8

Figure 8 Equivalent Property Damage Only (EPDO) Crashes (2015, 2016, 2017, 2019)..... 10

Figure 9 Annual Person Hours of Delay (2015, 2016, 2017, 2019) ..... 10

Figure 10 Annual Person Hours of Incident Delay (2015, 2016, 2017, 2019) ..... 11

Figure 11 Annual Person Hours of Delay by Day of Week (2015,2016,2017,2019) ..... 11

Figure 12 Statewide Origin-Destination Patterns By Interchange (2019) ..... 13

Figure 13 Lane Impacting incidents (2015, 2016, 2017, 2019) ..... 13

Figure 14 Locations of Existing and Proposed CCTV ..... 17

Figure 15 Locations of Existing CMS ..... 18

Figure 17 Concept Rendering at BWMT ..... 20

Figure 18 US 460 Detour Route CCTV Locations..... 22

Figure 19 US 19 Detour Route CCTV Locations..... 23

## Tables

---

Table 1 Average Daily Vehicle Hours of Delay by Day of Weekday .....	7
Table 2 Highlights of Programmed Capital Improvements with an impact on operations .....	9
Table 3 Average Response Time in Minutes by Service (2019) .....	13
Table 4 Benefits of Recommended Freeway Operations Improvements.....	14
Table 5 Counties/Localities Requiring PSAP Integration.....	15
Table 6 Recommended Camera Expansion .....	17
Table 7 Truck Climbing Lane Project - I-77NB.....	21
Table 8 Locations of Proposed CCTV on Detour Routes .....	22
Table 9 Summary of Recommended Projects for Detour Routes and Parallel Facilities .....	23
Table 10 Summary of Projects for Consideration for Detour Routes and Parallel Facilities .....	23
Table 11 Summary of Proposed Improvements .....	24
Table 12 Summary of Improvements Recommended for Consideration .....	24
Table 13 Freeway Operations Improvements Return on Investment .....	25

## Introduction

Interstate 77 (I-77) is a major north-south interstate highway in the eastern United States. The highway provides a direct corridor from the southeastern states to Ohio and the Great Lakes area. I-77 is a National Freight Corridor and a key route of the freight network by providing a corridor through the Appalachian Mountains to the Midwestern cities and the distribution/warehouse sites located on or nearby the highway. A large industrial park known as Progress Park is located north of the I-77/I-81 Overlap and includes multiple industries. Progress Park has room to expand and will increase freight activity along I-77.



The corridor is unique as there are two mountain tunnels on the northern half from West Virginia to Wytheville. The corridor has an 8-mile overlap with Interstate 81 near Wytheville. From North Carolina to Wytheville, the corridor crosses over Fancy Gap Mountain, which experiences significant weather and wind shear events. This section of highway contains several miles of continuous 4% to 5% upgrade in the northbound lanes. The section of highway often experiences atypical congestion in the summer months, particularly in the northbound direction, due to heavy traffic from beach communities with truck traffic climbing the inclines.

Given the mountainous terrain, Interstate 77 has limited parallel arterial highways. While US 52 does parallel most of I-77, the highway crosses several mountains with sharp turns that not all commercial vehicles traffic can use. The incident management plans must consider lengthy detours requiring communications, often with adjacent state Department of Transportation.

## Study Purpose

The purpose of this study is to identify a package of targeted operational improvements that are expected to deliver faster, safer, and more reliable travel on I-77 in Virginia.

This study is meant to complement the existing projects completed on I-77 to improve traffic safety, including the installation of Fancy Gap communication fiber, Fancy Gap Variable Speed Limit system, and highway widening efforts.

In 2019, the Virginia General Assembly passed House Bill 2718 and Senate Bill 1716 which provides revenues for improvements based on truck miles traveled on Virginia's interstate highways. While Interstates 81, 95, and 64 have higher volumes and allocations, 19.4% of the funding is to be assigned for other improvements to Interstate highway corridors. Such improvements include, but are not limited to operational strategies. The projected revenues, which are subject to change, were originally:

Corridor	FY20	FY21	FY22	FY23	FY24	FY25
<b>Other Improvements to Interstates</b>	\$19.6M	\$29.2M	\$42.9M	\$42.9M	\$42.9M	\$42.9M

The improvements identified in this report are eligible to use this funding.

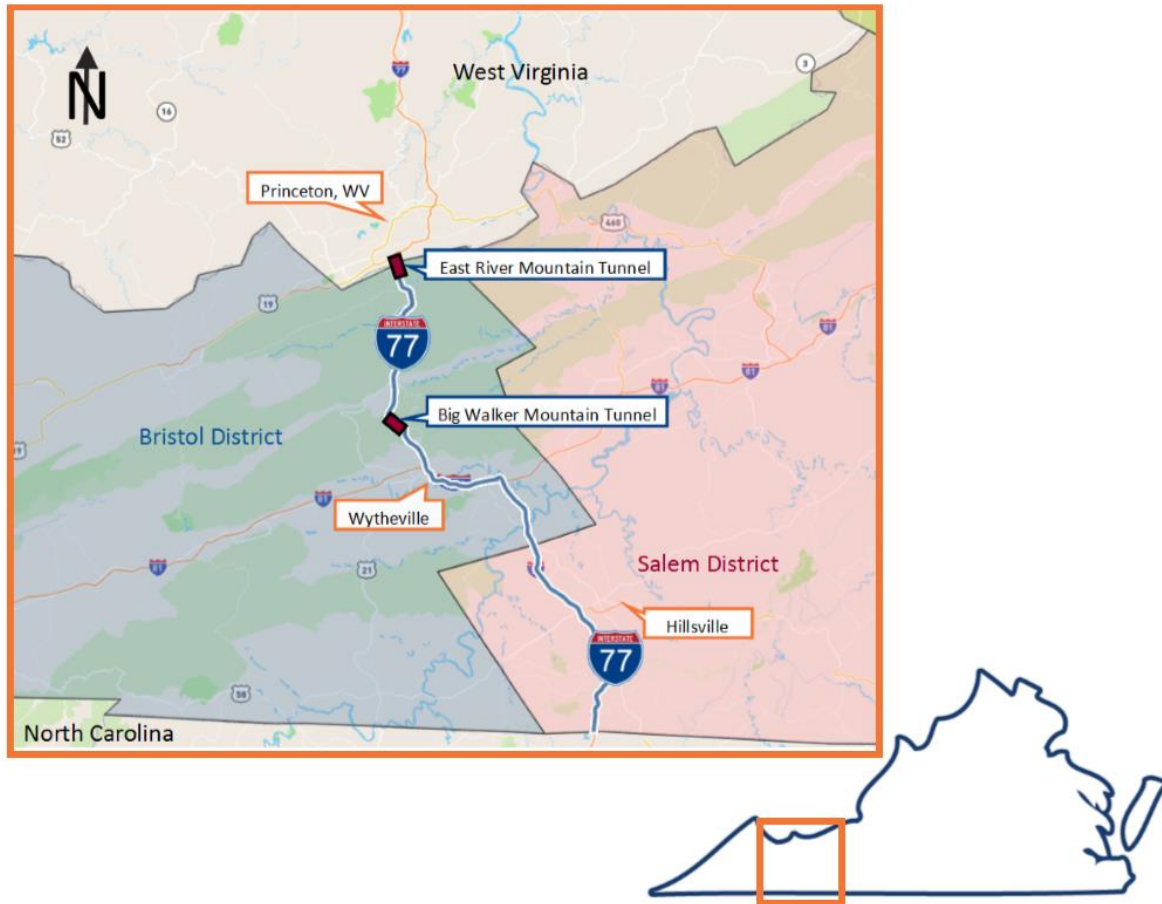


FIGURE 1 STUDY AREA

In 2020, the Virginia General Assembly passed House Bill 1414 which includes a new section of the Code of Virginia, 33.2-372, *Interstate Operations and Enhancement Plan*. This fund shall be used to improve the safety, reliability, and travel flow along interstate highway corridors in the Commonwealth. The Commonwealth Transportation Board (CTB) may use funds in the program to address needs in the Statewide Transportation Plan or an **interstate corridor plan** approved by the Board that incorporates operational and transportation demand strategies and other transportation improvements.

House Bill 1414 also included language for a new section of the Code of Virginia, 33.2-1532, *Special Structure Fund*. This fund shall be used to maintain, rehabilitate, and replaces tunnels and other special structures. On the I-77 Corridor, there are two tunnel facilities. This study includes recommendations that are specific to the *Interstate Operations and Enhancement Plan*. This study will identify projects and provide the estimated return on investment for consideration by the CTB when allocating the available funding.

## Multimodal Corridor Characteristics

The I-77 corridor is predominantly rural, with few multimodal opportunities. Mountain Lynx Transit provides bus services in Bland, Wythe, and Carroll Counties. This is an on-demand paratransit service with customers picked up at or near their homes. This service is only available on specific days of the



week. Amtrak service is not available along the corridor. The corridor has two park-and-ride lot facilities - one at Exit 19 and one on the I-81/I-77 overlap.

## Challenges in the Corridor

The I-77 Corridor has several significant challenges to safety and the efficient movement of people and goods. Weather and topography can be a significant challenge, particularly on the southern end of the corridor. The southern section of I-77 traverses Fancy Gap Mountain. Due to the topography, unique fog and wind shear events have



occurred. This section of I-77 has been extensively studied and recent improvements have been implemented. A variable speed limit system which lowers the posted speed limit when low visibility conditions are present was activated in 2016. Fiber optic lines with additional traffic surveillance and message equipment has also been installed.



Detour routes are limited and constrained. US 52 parallels I-77; however, the highway crosses over several mountain ranges. US 52 has sharp turns and grade changes which may limit its use particularly for commercial vehicles. Past detours have therefore considered a larger broader footprint such as:

- US 460 / I-81 via Christiansburg
- US 19 / I-81 via Abingdon
- I-64 / I-81 via Beckley, West Virginia

Likewise, when other adjacent states interstate highways have long-term shut downs, such as the rockslide on Interstate 40, traffic on I-77 may increase as motorists consider other alternate interstate routes to cross the Appalachian Mountain ranges.

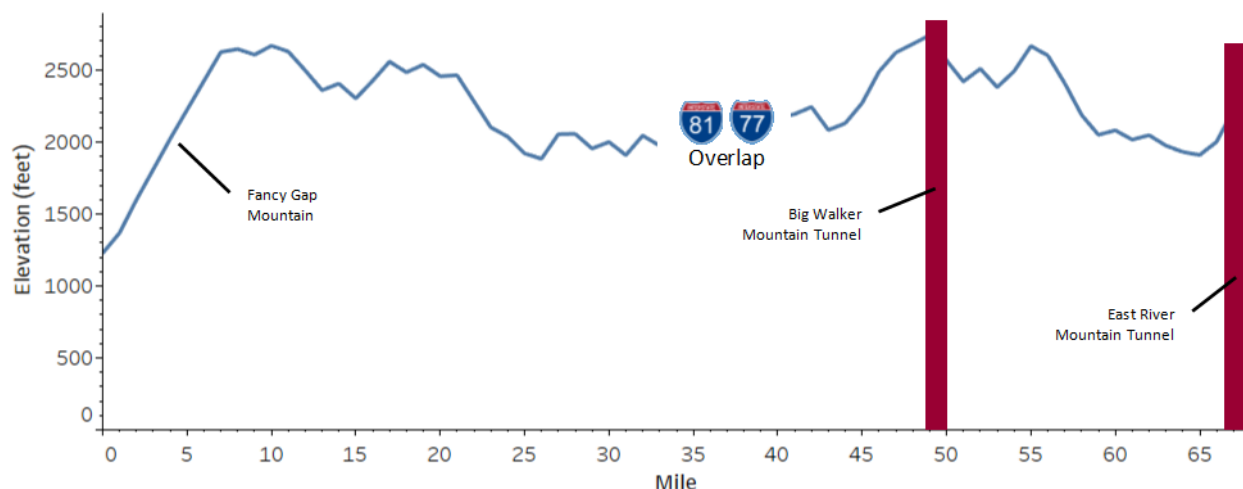


FIGURE 2 GRADE PROFILE

I-77 experiences atypical congestion compared to other interstates due to its location. There is significant grade change between the North Carolina state line and mile post 8 which can cause a speed differential between trucks and passenger cars (Figure 2). Due to the grade and weather, complex

incidents are not uncommon on the corridor. Quick and efficient incident clearance time is a priority for operations to limit the impact of these incidents on the travelling public. The northern part of corridor has two mountain tunnels. When an incident occurs in one of the tunnels, significant traffic queues can form, as there are limited alternative routes in the region. Figure 3 compares the causes of congestion along I-77 against all Virginia interstates.

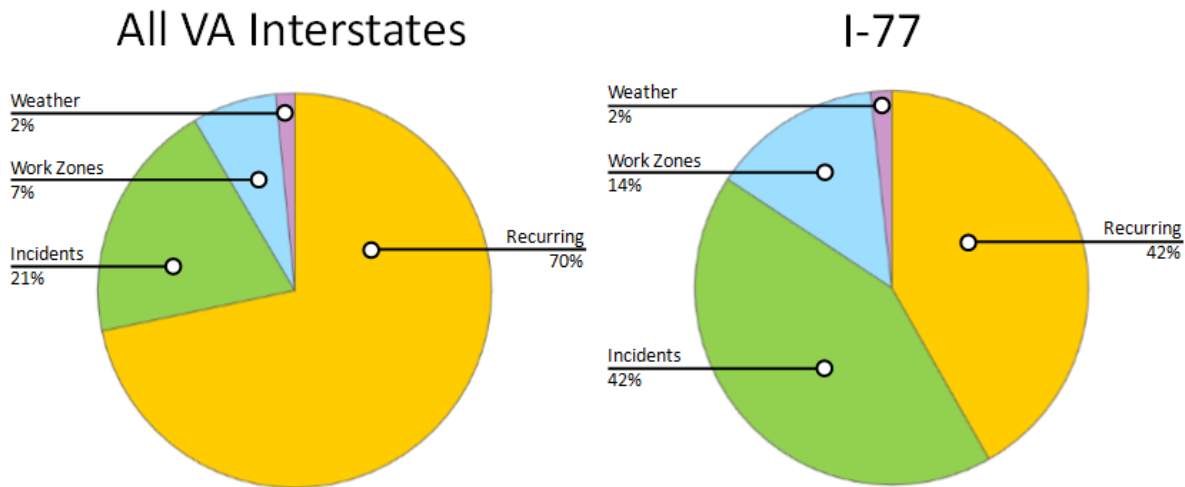


FIGURE 3 CAUSES OF CONGESTION ALONG THE CORRIDOR (2016, 2017)

On I-77, traffic congestion varies significantly by day of the week, with Saturday traffic consisting of more recurring congestion issues than the other days of the week (Figure 4). Between the hours of 12:00 PM and 7:00 PM, speeds can drop below 15 miles per hour, leading to a significant increase in delay (Table 1).

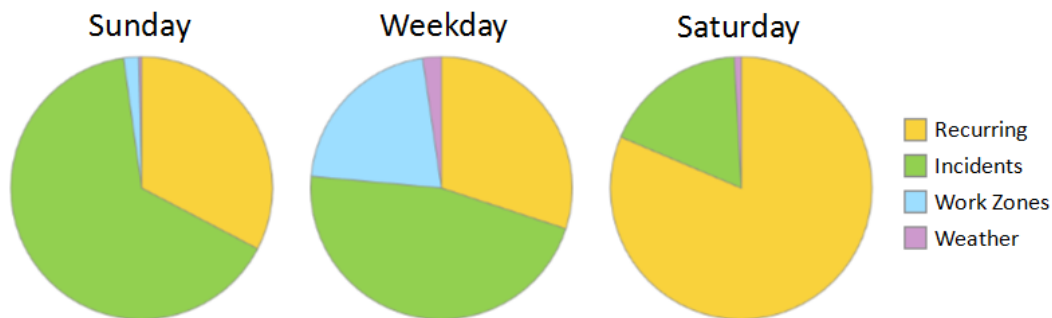


FIGURE 4 ESTIMATED CAUSES OF CONGESTION BY DAY OF WEEK (2016, 2017)

TABLE 1 AVERAGE DAILY VEHICLE HOURS OF DELAY BY DAY OF WEEKDAY

Sunday	Weekday	Saturday
560	510	940

The following figures highlight the average speeds along I-77 by all days of the week northbound (Figure 5), all days of the week southbound (Figure 6), and northbound during Saturdays in the summer (Figure 7). The greatest potential for significant speed variations is shown in Figure 7, which represents the busiest travel period during the year.



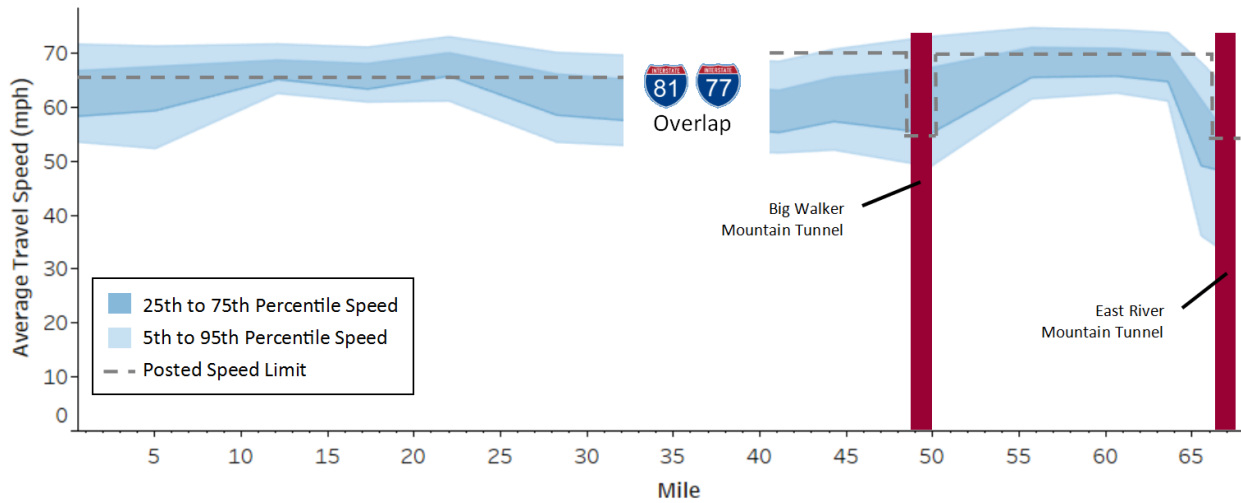


FIGURE 5 AVERAGE SPEEDS ON NORTHBOUND I-77 ALL DAYS OF THE WEEK (2019)

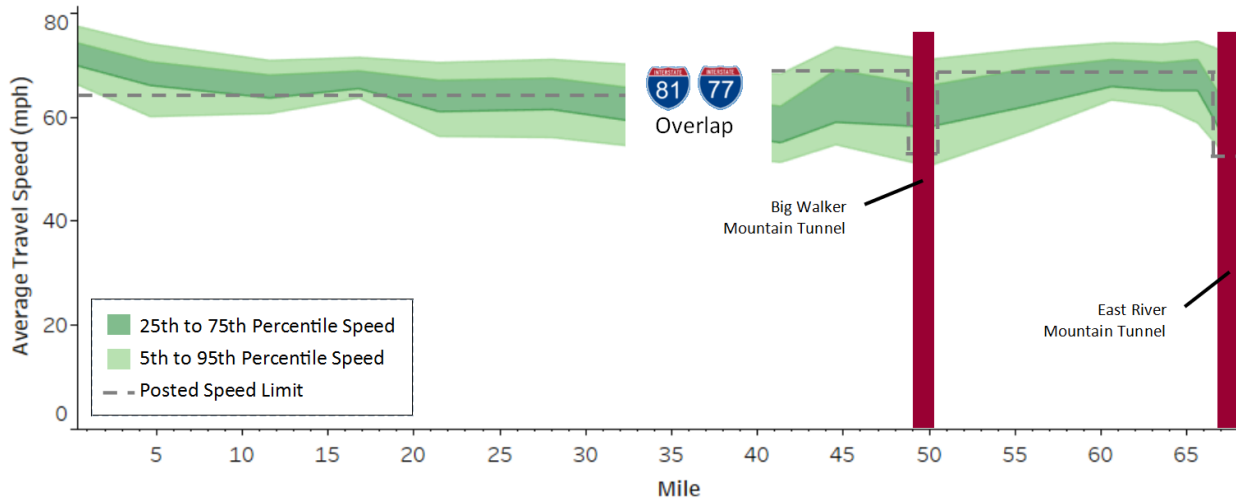


FIGURE 6 AVERAGE SPEEDS ON SOUTHBOUND I-77 ALL DAYS OF THE WEEK (2019)

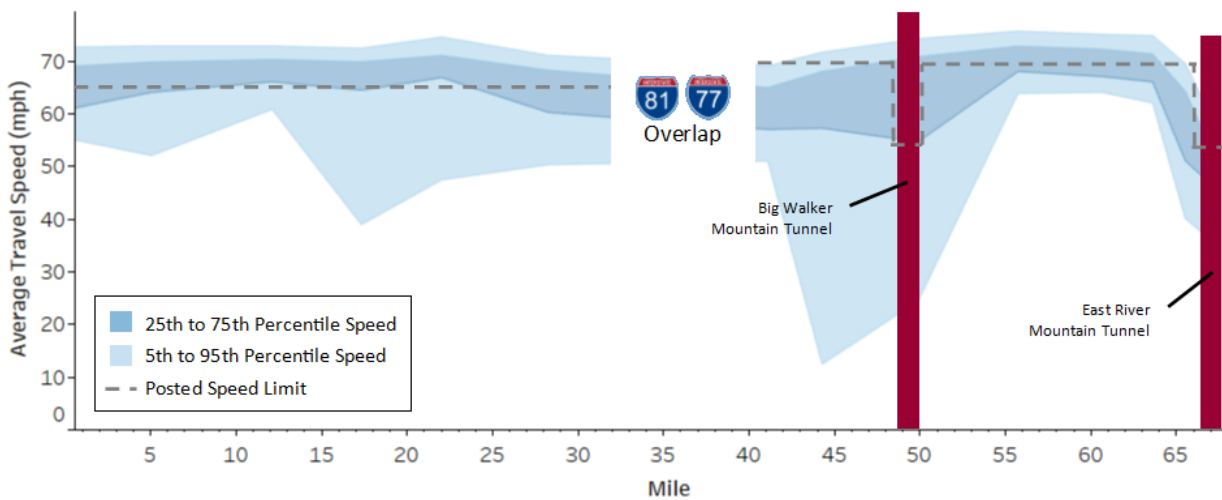


FIGURE 7 AVERAGE SPEEDS I-77 NORTHBOUND SATURDAY DURING JUNE, JULY, AUGUST (2019)

Along the northern half of I-77 there are two one-mile long tunnels. The Big Walker Mountain Tunnel is a 4,229 foot tunnel located near the Bland/Wythe County line. The East River Mountain Tunnel is a 5,412 foot tunnel located on the Virginia/West Virginia state line. Tunnel facilities present unique challenges. While there are few commercial vehicle restrictions, traffic speeds drop as vehicles travel through the facilities due to driver behavior. Likewise, there are different incident management needs for tunnel facilities, particularly to manage tunnel fires. Tunnel fires are rare, but they do occur and cause significant damage and congestion. The most recent significant fire occurred in July 2014 in the East River Mountain Tunnel.

VDOT has established several tunnel programs to improve incident management during events including, but not limited to:

- Incident response plans
- Tunnel exercise programs
- Augmented fire program staff
- Continuous camera coverage
- Backup generators
- Plans for redundant SCADA capabilities

VDOT has already recommended an investment of an additional \$6.2M in freeway improvements for I-77 over the next six years by way of its six year improvement program (Table 2).

TABLE 2 HIGHLIGHTS OF PROGRAMMED CAPITAL IMPROVEMENTS WITH AN IMPACT ON OPERATIONS

Improvement	Jurisdiction	Description	Completion Date	Cost
Additional Merge Lane on I-77N at Exit 41	Wythe Co.	1.165 mi long additional merge lane to improve safety and congestion. Added merge distance which should help reduce the amount of queuing and reduce rear end crashes.	2020	\$6.2M

\*Bridge replacements were not included in Table 2.

# Existing Conditions

Data was collected from numerous sources to build a picture of current travel conditions on the corridor. This data included travel speeds; numbers and types of crashes; numbers, type, and durations of incidents; origins and destinations of passenger cars and trucks; numbers and types of traffic; multimodal service; and location, number of spaces, and utilization of park-and-ride lots. Data was analyzed by day of the week and time of day to better understand existing traffic patterns. Data from 2018 was not used for baseline analysis due to a work zone in West Virginia that had significant traffic impacts on I-77.

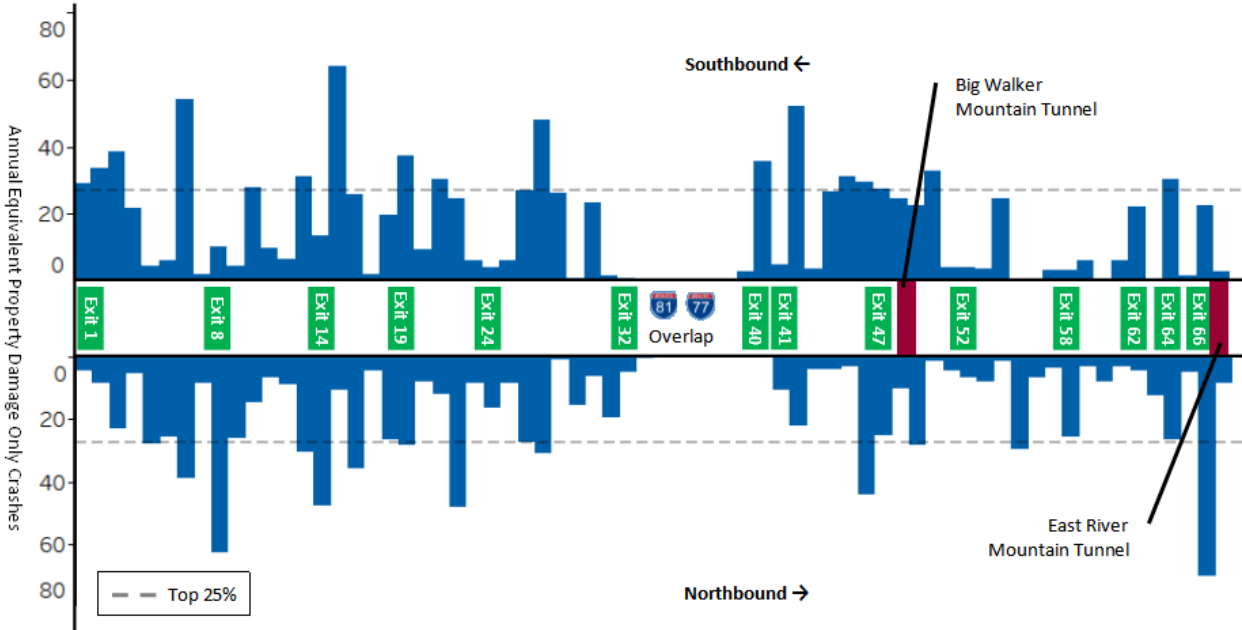


FIGURE 8 EQUIVALENT PROPERTY DAMAGE ONLY (EPDO) CRASHES (2015, 2016, 2017, 2019)

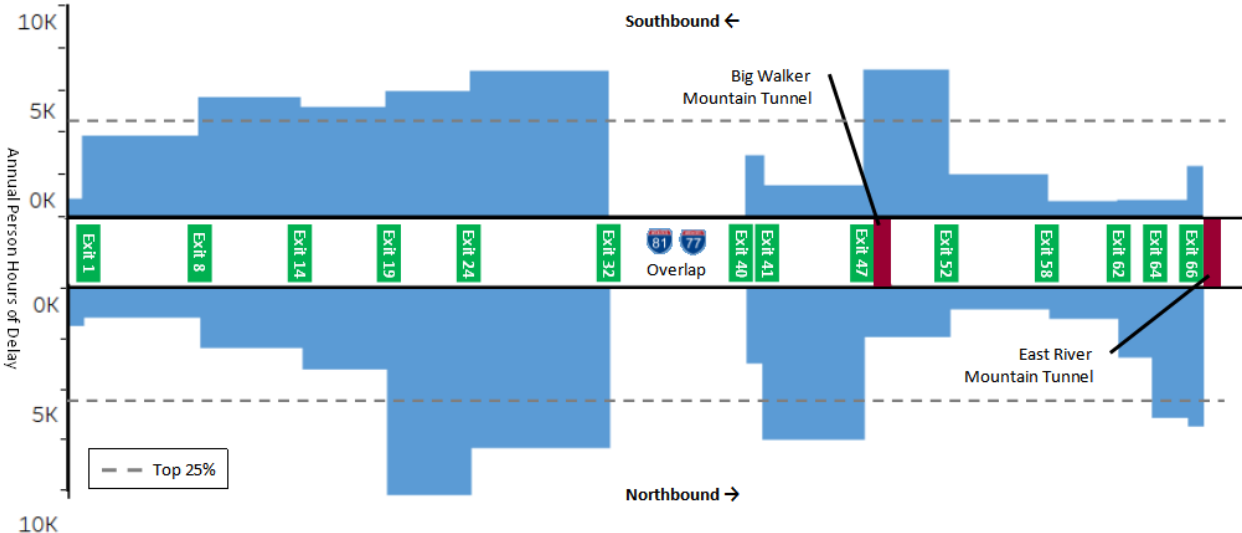


FIGURE 9 ANNUAL PERSON HOURS OF DELAY (2015, 2016, 2017, 2019)

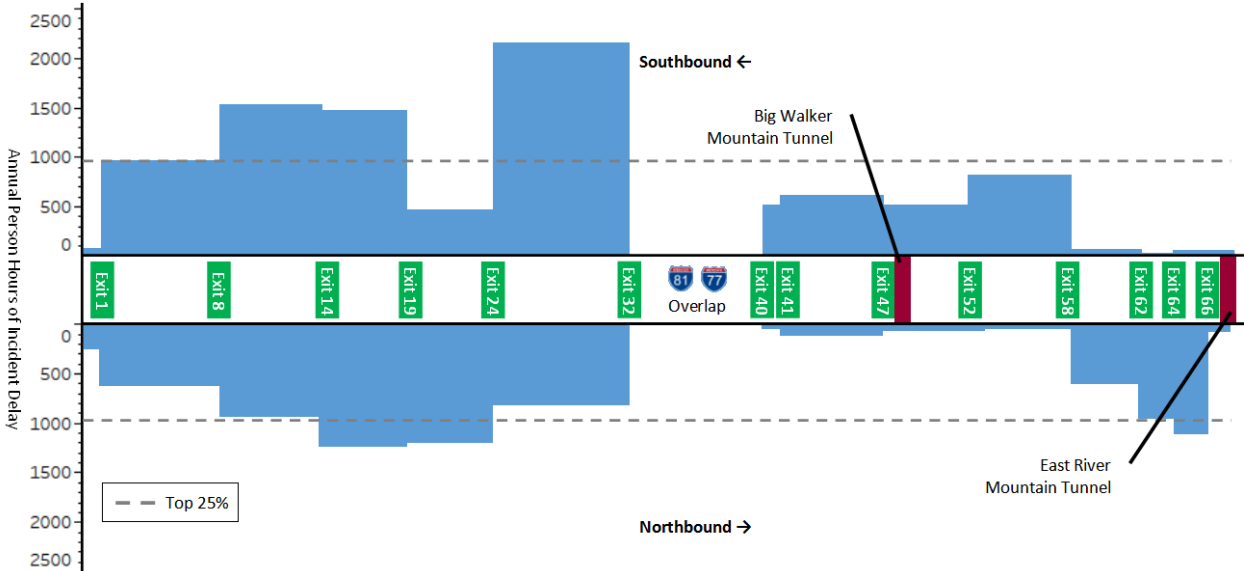


FIGURE 10 ANNUAL PERSON HOURS OF INCIDENT DELAY (2015, 2016, 2017, 2019)

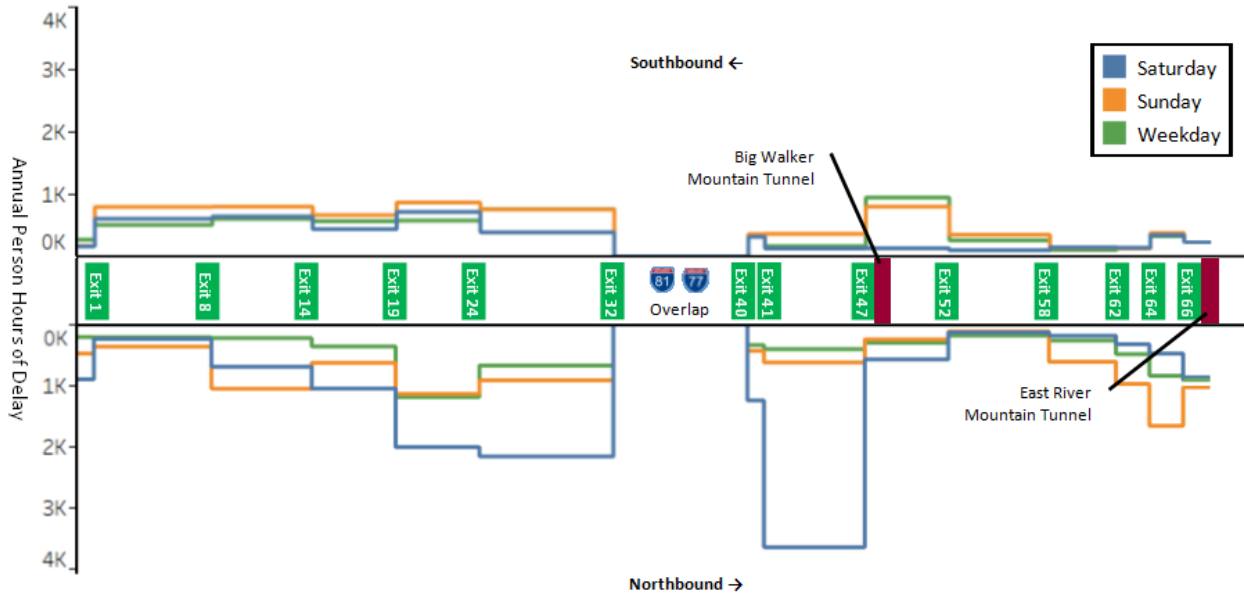


FIGURE 11 ANNUAL PERSON HOURS OF DELAY BY DAY OF WEEK (2015,2016,2017,2019)

### Performance Measures

Appropriate locations for foundational operations strategies were determined using a statewide screening based on the following performance datasets:

- **Traffic Volume:** The average annual daily traffic on a segment of interstate. Hourly profiles were used to estimate volume by hour and day of the week for some analyses. Source: VDOT Traffic Engineering Division.
- **Percentage of Traffic Volume that is Trucks:** Source: VDOT Traffic Engineering Division

- **Number of Incidents:** The total number of reported crash and disabled vehicle incidents on the mainline of the interstate. For some analyses, only lane-impacting incidents were considered. Source: VaTraffic.

To remain consistent with the evaluations done for I-81, I-95, and I-64, several other performance measures were used to justify targeted improvements for the foundational strategies as well as the innovative strategies, special facilities, detour, and capital projects. For each of these measures, the top 25 percent of 1-mile segments, regardless of direction, were identified and reviewed for potential improvements for the I-77 Corridor. These performance measures included:

- **Crash Frequency and Severity:** The total number of crashes, weighted by severity using the equivalent property damage only (EPDO) scale. Source: Police Reported Crash Database.
- **Total Delay:** The total person-hours of delay caused by all impacts of recurring congestion, incidents, weather events, and road work. Source: INRIX with VDOT Historical Volume Data.
- **Incident Delay:** The total person-hours of delay caused by incidents (crashes and disabled vehicles) that lead to at least one lane of the interstate to be closed for an hour or more. Source: INRIX with VDOT historical volume data and VaTraffic incident data.

## Supplementary Data

Additional data was collected and summarized to supplement the performance measures previously identified. The supplementary data includes the following:

- **Origin-Destination Data:** Summarization of the origin-destination patterns on I-77. Source: Streetlight. (Figure 12)
- **Incident Clearance Time:** The time to clear all travel lanes or scene. Source: VaTraffic. (Figure 13)
- **Incident Response Time:** The time for responders to arrive at incidents. Source: ATMS. (Table 3)

The travel patterns shown in Figure 12 indicate that a majority of traffic is using the I-77 Corridor from state line to state line, or as a means to get from the state line to I-81 in either direction. The analysis suggests a higher percentage of long-haul trips than local which presents different challenges when it comes to communications, given that many of the motorists are from out of town and may be unfamiliar with typical conditions on the corridor. More than 7,000 trips per day on average traverse the entire corridor.

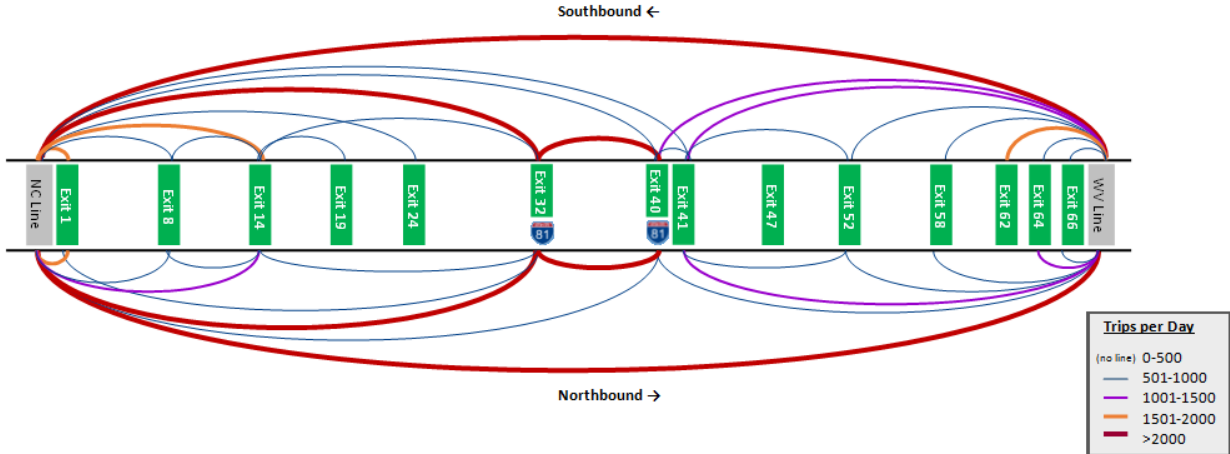


FIGURE 12 STATEWIDE ORIGIN-DESTINATION PATTERNS BY INTERCHANGE (2019)

Review of incident data on the I-77 corridor points to a hot spot between Exit 1 and Exit 8 which is a very mountainous stretch of highway (Figure 13). Significant incident activity in this area points to a need for detailed detour routing plans.

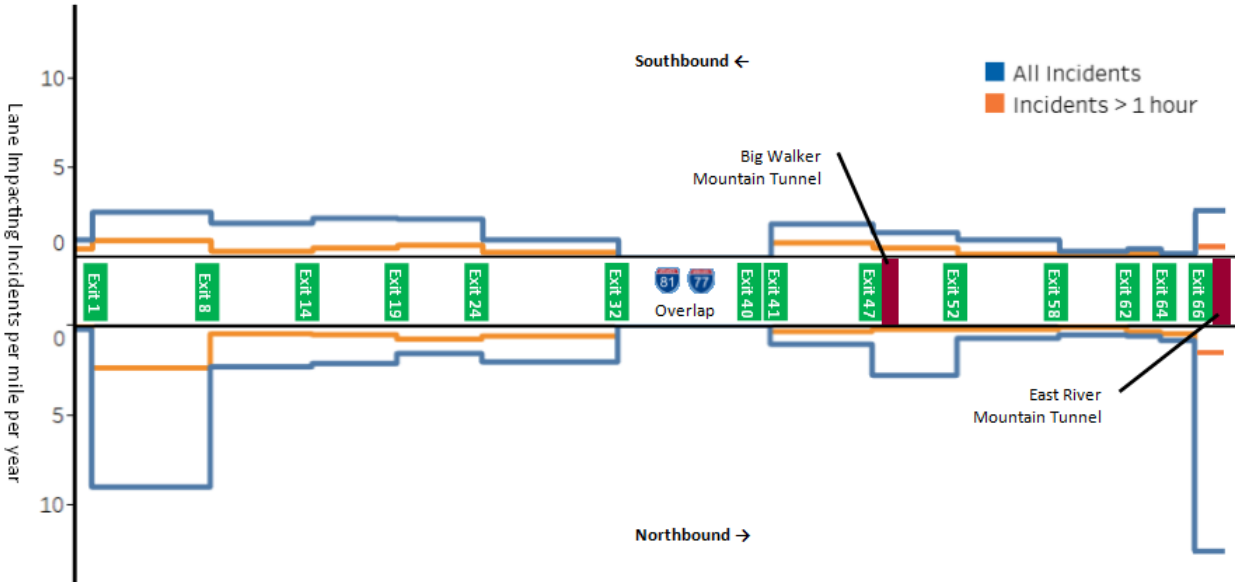


FIGURE 13 LANE IMPACTING INCIDENTS (2015, 2016, 2017, 2019)

The time that it takes various incident management services to get to the scene plays an important role in quick clearance goals. Incident Response Time is measured from the start of the incident to the time a party arrives on scene. Average Incident Response Times by clearance service is show in Table 3.

TABLE 3 AVERAGE RESPONSE TIME IN MINUTES BY SERVICE (2019)

Location	Wrecker Service	Fire/Rescue	VDOT IMC	SSP	HAZMAT Cleanup
I-77 MP 0-32 (Salem)	46	18	85	15	118
I-77 MP 40-67 (Bristol)	51	16	86	n/a	133
Other Interstates Statewide	49	13	55	13	97



## Operations Improvements Plan

VDOT cannot control all contributors to congestion; however, VDOT can mitigate its impact, particularly with incident management strategies. Because most of I-77's congestion outside of Saturdays during the summer is due to nonrecurring congestion, VDOT has an opportunity to improve mobility on this corridor.

Using the defined performance measures and analyses for I-77, the study team identified \$23M of improvements for freeway operations.

Parallel facility improvements were considered. However, due to the mountainous terrain, detour rerouting is challenging. For commercial vehicles, the available detour route increases the travel time significantly. The immediate parallel routes have turning radius or grades that may prohibit certain type of commercial vehicles. For this reason, there are more recommendations to improve freeway operations and incident events at the tunnel facilities which do not have simple detours.

For the I-77 Corridor, the Operations Improvement Plan strategies are classified into four groupings: Foundational Freeway Operations, Innovative Freeway Operations, Detour Routes & Improvement to Parallel Facilities, and Special Facilities Operations. Capital Improvements are also being evaluated and will be documented in a separate report. A high-level summary of the operations improvements is shown in Table 4.

TABLE 4 BENEFITS OF RECOMMENDED FREEWAY OPERATIONS IMPROVEMENTS

Proposed Improvements	Type	Move More People	Improve Safety	Reduce Non-Recurring Congestion	Reduce Recurring Congestion
CCTV Cameras	Freeway - Foundational		✓	✓	✓
Changeable Message Signs	Freeway - Foundational			✓	✓
Safety Service Patrols	Freeway - Foundational		✓	✓	
Towing Programs	Freeway - Foundational		✓	✓	
PSAP Integration	Freeway - Foundational			✓	
Road Weather Information Systems	Freeway - Foundational		✓	✓	
Geofenced Emergency Notifications	Freeway - Innovative			✓	✓
Advanced Work Zone Technologies	Freeway Innovative		✓	✓	
Wayfinding Signs	Detour Routes & Improvements to Parallel Facilities		✓	✓	
Tunnel Systems Improvements (SCADA, Traffic Management &, LRAD)	Special Facilities Operations	✓	✓	✓	✓

## Foundational Operations Strategies

Foundational operations strategies are used to address the impacts of non-recurring congestion such as vehicle crashes and weather events, and respond to those incidents as quickly as possible. Foundational strategies include the following types of improvements:

- Towing programs (towing recovery incentive program, incentive towing, and contracted towing)
- Safety service patrols
- Camera monitoring
- Message signs
- Freeway Incident Management Program Tools (miscellaneous low-cost operations improvements)
- Road Weather Information Systems

### Freeway Incident Management Program Tools

This program area includes a variety of sub-strategies with a combined purpose to provide better data tools and resources to access and respond to incident events properly. These tools enable the right resources to be brought to the scene which minimizes rework and delay. These sub-strategies include PSAP Integration, Residency IMCs, and developing Version 5 of the ATMS (included in the I-95 report).

#### *Public Safety Answering Point (PSAP) Integration*

While the Virginia State Police are often the first responder to incidents directly on I-77, localities can respond to and support I-77 incidents as well. Localities also respond to incidents along the parallel arterials. Information about the location and status of both interstate and arterial incidents is essential for effective incident management.

VDOT has developed a program to bring information about local incidents by way of Public Safety Answering Point (PSAP) integration. PSAP integration to bring information from local 911 call centers directly to its Traffic Operations Centers. At this time, none of the three counties on the I-77 Corridor have this integration.

TABLE 5 COUNTIES/LOCALITIES REQUIRING PSAP INTEGRATION

Corridor	Locations
77	<ul style="list-style-type: none"> <li>• Carroll, Wythe, Bland</li> </ul>

The cost of each integration is \$90,000. To complete the integration of the remaining 3 localities, the estimated cost is \$270,000.

#### *IMC Program*

A second component of the Freeway Incident Management Expansion is to hire additional Incident Management Coordinator (IMCs) to cover areas of significant innocent activity along the interstate highways. The IMC strategy exists within the Richmond District. Locations were determined following discussion with the Regional Operations Directors and reviewing incident data.

There is already sufficient IMC coverage for I-77 so no additional IMC are recommended at this time.

## Towing Programs

There are three towing programs, towing recovery incentive program (TRIP), instant dispatching, and contract towing.

### *Towing Recovery Incentive Program (TRIP)*

TRIP expansion and instant dispatching expansion is based on a risk assessment that compares the vulnerability of a highway segment to commercial vehicle incidents requiring heavy duty towing to the consequence of likely delay. Appendix A presents the methodology and analysis for TRIP expansion. The Statewide Freeway Operations Plan did not recommend TRIP expansion for I-77; however, the analysis only identified first opportunities for TRIP expansion and it does not preclude additional expansion. There is interest from the Southwest Region Operations Staff in expanding TRIP to include I-77 and it is included in the final recommendations in this report.

### *Instant Dispatch*

TRIP expansion and instant dispatching expansion is based on a risk assessment that compares the vulnerability of a highway segment to incidents requiring towing to the consequence of likely delay. Appendix B presents the methodology and analysis for instant dispatching expansion. Instant dispatching is not recommended for the I-77 corridor at this time because the vulnerability and consequence factors did not warrant the program.

### *Contract Towing*

Contract towing is recommended for corridors with hard shoulder running lanes and tunnels. These areas have no safe pull over areas and are vulnerable to creating secondary collisions. For the I-77 corridor this includes the Big Walker Mountain Tunnel and the East River Mountain Tunnel.

## Safety Service Patrols

Safety Service Patrol (SSP) expansion is based on the potential number of responses or customers. An upper control limit based on the hourly traffic volume was used to determine the SSP expansion locations. Appendix C presents the methodology and analysis for SSP expansion. Per this analysis new Safety Service Patrol expansion is not recommended at this time. However, there are some extenuating circumstances in Bland County that make it a candidate for interim or special event SSP coverage. When incidents occur in or approaching the mountain tunnels queues will form. The tunnel staff have assisted with traffic control and clearance in addition to their regular duties, particularly when traffic is significant during summer months. However, the resources, particularly labor, are limited, which can impact response or clearance times.

## CCTV Cameras

Camera expansions are based on three goals:

1. Have continuous camera coverage in the urban areas with populations exceeding 500,000. The three urban areas are Washington DC, Norfolk/Virginia Beach, and Richmond.
2. Have a camera at all interchanges to support detour management after incidents occur
3. Have cameras at locations at rural locations with incidents exceeding an upper control limit.

Appendix D presents the methodology and analysis for camera expansion. Table 6 presents the recommended expansions by corridor.

TABLE 6 RECOMMENDED CAMERA EXPANSION

Corridor	Camera Expansion Locations
77	<ul style="list-style-type: none"> <li>Exits: 19, 24</li> </ul>



FIGURE 14 LOCATIONS OF EXISTING AND PROPOSED CCTV

### Changeable Message Signs

Message signs communicate information to travelers. There is interest among practitioners on the value of future message signs because new tools, such as geofencing, travel apps, and connected vehicles, provide similar services.

Surveys with other states indicate message signs are often installed at key decision points on the mainline highway. Therefore, the proposed message signs are only being recommended for that purpose. New message signs at key decision points are not recommended for I-77 at this time within the Commonwealth.

A full matrix CMS is recommended at the approach to each of the mountain tunnels to communicate various traveler information to motorists. Full matrix CMS signs would be used to display non-standard

information to motorists approaching the tunnels. The CMS is incorporated in the tunnel recommendations discussed later in this report.

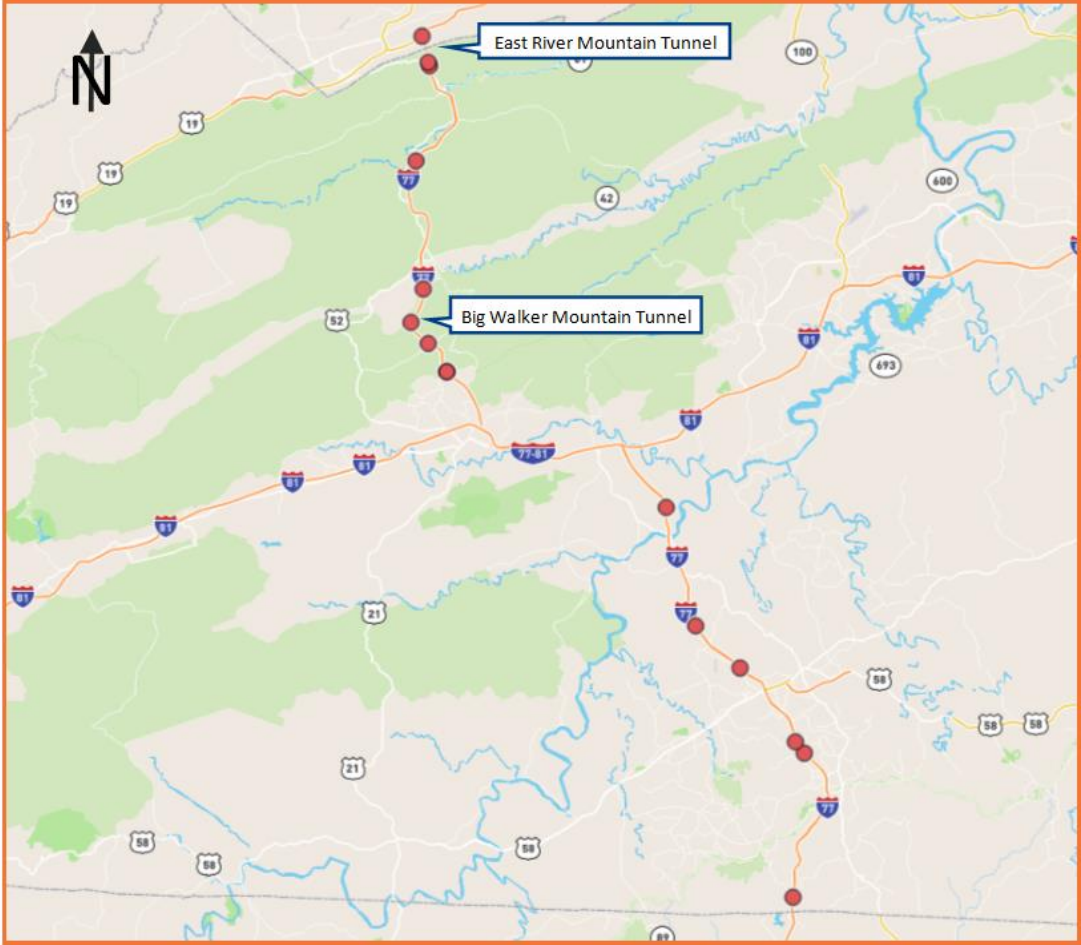


FIGURE 15 LOCATIONS OF EXISTING CMS

## Innovative Operations Strategies

The foundational strategies outlined previously will be implemented to address the various causes of non-recurring congestion. There are several additional strategies that can address both non-recurring congestion and recurring congestion resulting from travel demand exceeding capacity on a corridor.

These innovative strategies could include:

- Geofenced emergency notifications
- Advanced technologies for work zone management
- Ramp metering
- Variable speed limits (VSL)
- Regional Multimodal Mobility Program (RM3P)

This plan recommends including the statewide effort to develop a geofenced emergency notification and advanced technologies for work zone management. The remaining innovative operations strategies listed above not recommended. However, an investigation of the appropriateness of one or more of these strategies could be performed upon request.

### Variable Speed Limits

A variable speed limit system exists on I-77 between the NC State Line and Exit 14 to improve safety during low visibility conditions by reducing speeding and speed variability. Applications of the existing VSL system could be expanded to mitigate traffic beyond weather concerns. There is interest from SWRO in reviewing the feasibility of a VSL system approaching each of the mountain tunnels and having it programming into the tunnel SCADA. A formal VSL system is not included in the recommendations for I-77 at this time until a formal concept of operations and assessment is completed.

### Geofenced Emergency Notifications

The geofenced digital notification system is an ATMS tool that alerts drivers stuck in extended periods of congestion. When a large crash occurs and motorists become stranded, the geofenced digital notification system will send information to motorists' mobile phones directly through an alert system. Travelers can opt in to continued information by selecting a link included in the notification. The geofenced digital notification has been included in other Virginia corridor plans and should be considered for future implementation.

### Advanced Work Zone Technologies

Technologies are available to better inform motorists and traffic operations centers about the status of work zones. These technologies include smart cones, smart vests and other communication devices. A portable queue warning system for use at the tunnels is also included. The purpose of these technologies are to provide advanced notice of mobile or temporary work zones to the public or traffic operations centers. This information can be provided to motorist via 511, private sector information providers (i.e., WAZE), or VDOT's message signs. Advanced Work Zone Technologies have been included in other Virginia corridor plans and should be considered for future implementation.



## Truck Placard Detection

Upon conclusion of the VTTI study considerations should be made regarding the implementation of truck placard detection technologies. This is a helpful strategy to addressing incident management particularly with regard to vehicles carrying certain materials approaching the tunnels.

## Special Facilities Operations

All tunnel projects listed below will not be funded through the Corridor Improvement Plan but will be considered for other funding sources.

## SCADA System and Control Room Upgrades

The I-77 mountain tunnels are the only major tunnel facilities in Virginia that do not currently have a modern PC-based control system. This project will replace the original PLC and manual control system, reconfigure the tunnel control rooms, and implement a new Supervisory Control and Data Acquisition (SCADA) system at both tunnels. Connectivity and redundancy will be provided between both tunnels and the Salem Traffic Operations Center. The purpose of this project is to provide a long-term solution that will improve reliability, reduce risk or operator error, and can accommodate future improvement projects. The proposed SCADA system and control room improvements project is the top priority for the mountain tunnels. This project must be implemented before any of the other proposed system improvements can move forward.

## Tunnel Traffic Management System

This purpose of this project is to provide an automated traffic management system to quickly stop interstate traffic if there is an emergency or incident in the tunnel. The proposed upgrades include installation of additional overhead signs structures, Dynamic Message Signs (DMS), signals, and gates outside each portal that can be operated from the tunnel control room. This system aims to provide the ability to stop traffic safely and reliably, eliminate the need to tunnel staff to leave the control room and enter the roadway, and provide advanced warning to motorists during incidents or delays.



FIGURE 16 CONCEPT RENDERING AT BWMT

## Long Range Acoustic Devices

The purpose of long range acoustic devices (LRAD) is to direct audible messages to vehicle operators in the tunnel facilities during emergencies. VDOT and vendors have tested LRAD systems to facilitate communicating life safety emergency messages and information to motorists who may be stopped inside the tunnels due to a traffic incident. The desired LRAD system will have an effective range of at least 600 meters and emit a narrow sound wave cone. LRADs are desired at both tunnel facilities to promote incident and emergency management.

## Changeable Message Signs

At each tunnel approach, it is recommended that a new full color matrix (FCM) changeable message sign be installed on overhead gantries. These signs give the traffic operations center and tunnel control room the flexibility to provide motorists with various messages related to tunnel operations. These

signs are already in use on I-77 for the variable speed limit system. VDOT will work with West Virginia for installation of a gantry on the SB approach to ERMT.

## Capital Improvements

Capital Improvements for I-77 will be further documented in a separate report.

### Truck Climbing Lanes

The I-77 Corridor experiences congestion which is caused by heavy truck traffic in the northbound lanes that create congestion on the upgrades (4% to 5%). A 2018 analysis for a BUILD grant determined that three, one-mile truck climbing lanes could provide significant benefits including a 25% reduction in crashes and speed increases between 9 mph (weekday) to 14 mph (weekend).

TABLE 7 TRUCK CLIMBING LANE PROJECT - I-77NB

	Location
North Segment	MP 31-32
Middle Segment	MP 28-29
South Segment	MP 26.5-27.5

## Detour Routes and Improvements to Parallel Facilities

During traffic incidents or periods of congestion on the I-77 corridor, motorists may choose to use a parallel facility such as US 52 to avoid or minimize delays. A major incident on the interstate can cause a road closure of the impacted interstate segments and result in temporary routing of traffic onto a parallel facility. Natural disasters such as rockslides have occurred on interstates highways in North Carolina and Tennessee which significantly increases traffic on I-77 as there are few detours in the Appalachian area. Commercial vehicles are not able to use parts of US 52 as an alternate route due to road geometrics and weight. The suitable alternate route to West Virginia for commercial vehicles is I-81 and US 460 which is a significantly longer route.

Potential recommendations include:

- Arterial cameras and message signs along detour routes for the TOC to monitor
- Formal detour planning effort needs to be expanded
- Pre-staged resource caches (static signs) at local area headquarters
- Address manpower issues that are required to work major incidents

### CCTV Cameras

Major incidents in the tunnels can result in the need for long-term detours off of I-77. The western detour route follows I-81 in Abingdon to Bluefield at the West Virginia border on US 19 while the eastern route uses US 460 between I-81 in Christiansburg and the town of Glen Lyn at the West Virginia border. Added camera coverage on these routes will provide the Traffic Operations center with situational awareness to manage traffic flow during the detours. On average, all lanes of one of the tunnels are closed for more than two hours six times a year, necessitating directing travel on to one of the detour routes.

Locations for proposed CCTV on detour routes were determined by looking for signalized intersections and interchanges without existing CCTV in the vicinity (Figure 17 and Figure 18). At this time, eight (8) cameras should be considered as a potential future recommendation.

TABLE 8 LOCATIONS OF PROPOSED CCTV ON DETOUR ROUTES

Corridor	Camera Expansion Locations
US 460	<ul style="list-style-type: none"> <li>Route 61 Signalized Intersection in Narrows</li> <li>State Line in Glen Lyn</li> </ul>
US 19	<ul style="list-style-type: none"> <li>US 460 at Commerce Dr. Signalized Intersection</li> <li>US 460/US 19 at Signalized Intersection in Claypool Hill</li> <li>US 19 at Route 609 (Wardell Road) Signalized Intersection</li> <li>US 19 at VA 80 Signalized Intersection in Rosedale</li> <li>US 19 BUS at US 19 Signalized Intersection in Lebanon</li> <li>US 19 at US 58 ALT Signalized Intersection</li> </ul>

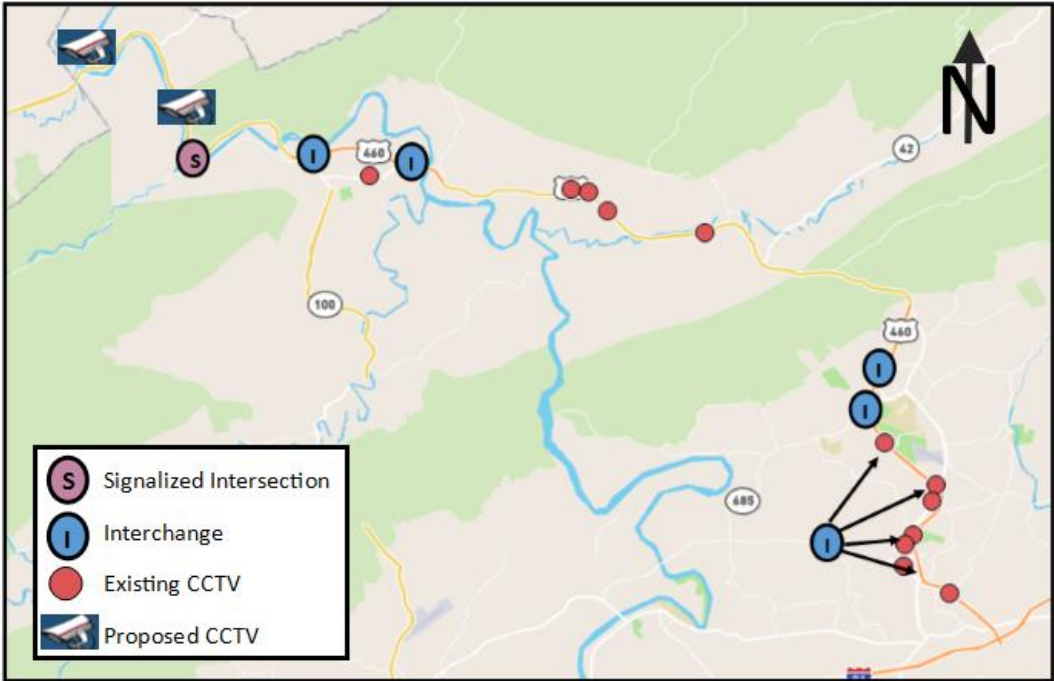


FIGURE 17 US 460 DETOUR ROUTE CCTV LOCATIONS



FIGURE 18 US 19 DETOUR ROUTE CCTV LOCATIONS

### Low Cost Detour Guidance

For additional guidance during significant congestion or incidents on I-77, it is recommended that portable message signs be staged at the Wytheville, Lebanon, and Christiansburg Residencies for quick deployment.

A summary of the proposed improvements for detour routes is show in Table 9.

TABLE 9 SUMMARY OF RECOMMENDED PROJECTS FOR DETOUR ROUTES AND PARALLEL FACILITIES

Proposed Improvement	Description	Quantity	Cost
Portable CMS	Pre-stage portable CMS at residencies for detour operations	6	\$210K

TABLE 10 SUMMARY OF PROJECTS FOR CONSIDERATION FOR DETOUR ROUTES AND PARALLEL FACILITIES

Proposed Improvement	Description	Quantity	Cost
CCTV	Camera coverage on major detour routes US 460 and US 19	8	\$535K
Updates & Expansion to Formal Detour Plans	Detour plans should be reviewed for updates due to changes in the system at regular intervals	n/a	\$30K
PSAP Integration	Giles, Russell, and Tazewell Counties	3	\$270K

## Summary of Proposed Improvements

Table 11 presents the recommend strategies to improve mobility and safety along the I-77 corridor.

TABLE 11 SUMMARY OF PROPOSED IMPROVEMENTS

Proposed Improvements	Location	Capital Cost/Year 1 Service	Annual O&M
CCTV on I-77	Exit 19	\$185,000	\$5,000
CCTV on I-77	Exit 24	\$185,000	\$5,000
TRIP	All I-77	\$150,000	\$270,000
PSAP Integration	Wythe County	\$90,000	\$0
PSAP Integration	Bland County	\$90,000	\$0
PSAP Integration	Carroll County	\$90,000	\$0
2 PCMS for Detour Use	Christiansburg Residency	\$70,000	\$2,000
2 PCMS for Detour Use	Lebanon Residency	\$70,000	\$2,000
2 PCMS for Detour Use	Wytheville Residency	\$70,000	\$2,000
SSP Hazard Devices	All SWRO SSP Vehicles	\$23,000	\$23,000
<b>Total</b>		<b>\$1,023,000</b>	<b>\$310,000</b>

Table 12 presents the list of projects which are recommended for further consideration.

TABLE 12 SUMMARY OF IMPROVEMENTS RECOMMENDED FOR CONSIDERATION

Proposed Improvements	Location	Capital Cost/Year 1 Service	Annual O&M
Detour Plan	All I-77	\$30,000	\$0
CCTV on US 460	US460 at Route 61 Signalized Intersection in Narrows	\$50,000	\$5,500
CCTV on US 460	US 460 at State Line in Glen Lynn	\$185,000	\$5,500
CCTV on US 19	US 460 at Commerce Dr Signalized Intersection near WV Line	\$50,000	\$5,500
CCTV on US 19	US 460/US 19 at Signalized Intersection in Claypool Hill	\$50,000	\$5,500
CCTV on US 19	US19 at Route 609 (Wardell Road) & US 19 Signalized Intersection	\$50,000	\$5,500
CCTV on US 19	US 19 at VA 80 in Rosedale signalized intersection	\$50,000	\$5,500
CCTV on US 19	US 19 BUS at US 19 Signalized Intersection in Lebanon	\$50,000	\$5,500
CCTV on US 19	US 19 at 58 ALT Signalized Intersection	\$50,000	\$5,500
PSAP Integration	Giles County	\$90,000	\$0
PSAP Integration	Russell County	\$90,000	\$0
PSAP Integration	Tazewell County	\$90,000	\$0
<b>Total</b>		<b>\$835,000</b>	<b>\$44,000</b>

## Return on Investment

ROI Analysis were conducted for each of the foundational operational improvement needs identified. Capital costs as well as the 10-year operations and maintenance (O&M) costs were calculated for each improvement and weighed against anticipated benefits.

TABLE 13 FREEWAY OPERATIONS IMPROVEMENTS RETURN ON INVESTMENT

Priority	Program		Benefit <sup>1</sup>	ROI
1	CCTV Cameras (mainline)	<ul style="list-style-type: none"> <li>Incident Detection and traffic monitoring</li> </ul>	<ul style="list-style-type: none"> <li>40% reduction in secondary crashes<sup>5</sup></li> <li>5% reduction in congestion caused by incidents<sup>6</sup></li> </ul>	5.5
3	TRIP	<ul style="list-style-type: none"> <li>Reduce incident duration &amp; prevent secondary crashes</li> </ul>	<ul style="list-style-type: none"> <li>TRIP – 50 minute reduction in incident duration for commercial vehicles<sup>4</sup></li> <li>40% reduction in secondary crashes<sup>5</sup></li> </ul>	5.1
4	CCTV Cameras (detour)	<ul style="list-style-type: none"> <li>Incident Detection and traffic monitoring</li> </ul>	<ul style="list-style-type: none"> <li>40% reduction in secondary crashes<sup>5</sup></li> <li>5% reduction in congestion caused by incidents<sup>6</sup></li> </ul>	4.9
5	PSAP Integration	<ul style="list-style-type: none"> <li>Increased accuracy of incident information to reduce incident duration</li> </ul>	<ul style="list-style-type: none"> <li>2% reduction in incident delay<sup>3</sup></li> </ul>	3.5
7	Low Cost Detour Guidance	<ul style="list-style-type: none"> <li>Provides guidance to detouring traffic</li> </ul>	<ul style="list-style-type: none"> <li>30 minutes saved per vehicle acting on information from detour guidance<sup>9</sup></li> </ul>	1.9

1. Only Mobility and Safety Benefits are listed; however, energy and environmental benefits were also incorporated into the ROI analysis
2. FHWA TOPS-BC tool
3. Assumption from consultant on I-95 ROI analysis
4. VTRC, TRIP Pilot Evaluation (2019)
5. USDOT, *Intelligent Transportation Systems for Traffic Incident Management* (2007)
6. RITA Database, Maryland CHART Program Performance (2002)
7. RITA Database, Assessment of Montana RWIS (2017)
8. AECOM, Benefit-Cost Analysis and Economic Impact of the I-77 Mountain Tunnels Project (2017)
9. Review of travel time & incident data during long-term detours by Operations Division
10. RITA Database, Minneapolis Queue Warning System, 2017



## Appendix A

### 2019 TRIP Expansion

#### Methodology

- Warranted TRIP expansion is based on risk. It considers the vulnerability of an area to truck incidents and consequence of significant congestion.
- The entire interstate system was segmented by county. Average hourly traffic volumes were then calculated.
- Average traffic volume by County-Interstate group was estimated using 2018 data calculated by VDOT's Traffic Engineering Division. Opposite directions were combined to get one volume for each County-Interstate. Truck percent includes all busses and 2+ axle trucks.
- Average traffic volume was normalized by the number of lanes and plotted against the truck percentage.

#### Data Findings

Formula Purpose	Control Limit	Analysis Findings for TRIP
<ul style="list-style-type: none"> <li>• Expand TRIP Coverage to area that is vulnerable to truck incidents and incidents have a significant impact to traffic flow</li> </ul>	<ul style="list-style-type: none"> <li>• 8% Heavy Vehicle Traffic</li> <li>• 12,000 Vehicles Per Day / # of Lanes</li> </ul>	<ul style="list-style-type: none"> <li>• Prince William County I-66</li> <li>• Augusta County I-81</li> <li>• Frederick County I-81</li> <li>• Montgomery County I-81</li> <li>• Roanoke County I-81</li> <li>• Rockingham County I-81</li> <li>• Caroline County I-95</li> <li>• Spotsylvania County I-95</li> <li>• Stafford County I-95</li> </ul>

#### Final Recommendations

- A first priority will be expansion on I-95 and I-81 beginning with the segments in the Proposed Expansion Region with the highest volume and truck percentage
- For the I-95 Corridor, begin TRIP expansion with coverage north to include Caroline County, Spotsylvania County, and Stafford County
- For the I-81 Corridor, begin TRIP expansion with coverage in Montgomery, Roanoke County, Augusta County, Rockingham County, Shenandoah County, and Frederick County
- Seasonal traffic trends, including beach traffic, could be used to further justify expansion to lower volume segments such as Greensville and Sussex counties on I-95
- Insufficient detour routes could be used to justify expansion to segments which have lower volumes but serve as a main thoroughfare in the region such as Botetourt and Rockbridge counties on I-81



Figure: Volume vs Truck % with identified expansion region

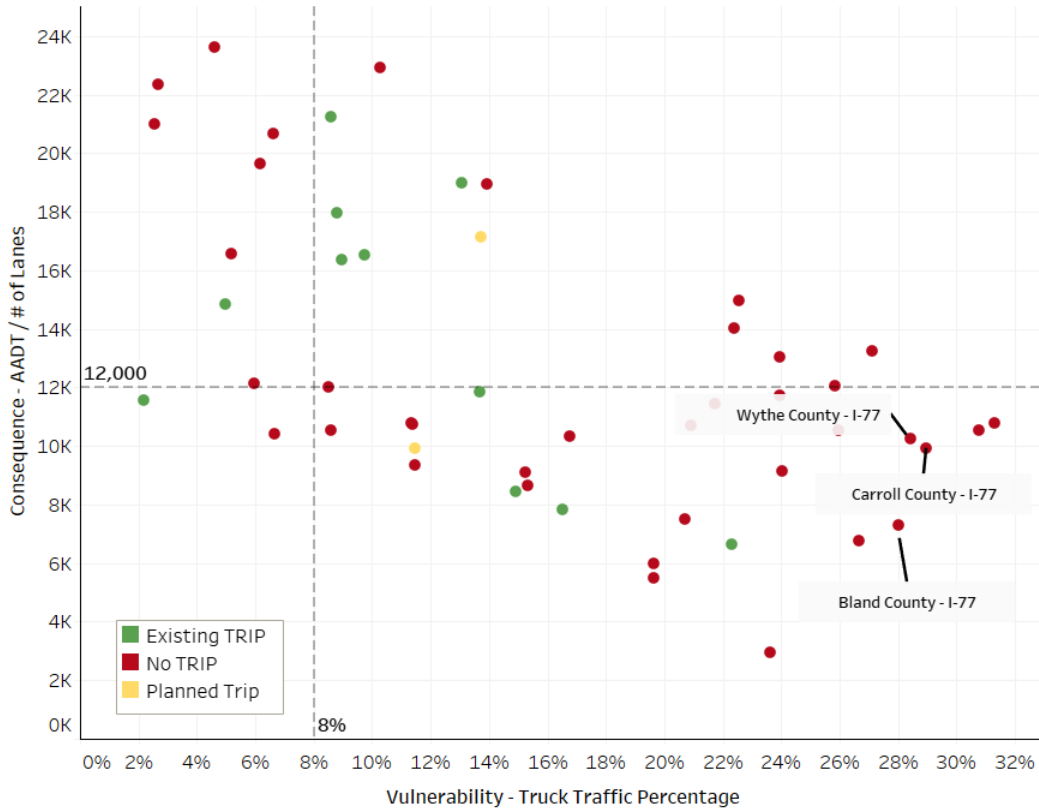


Figure: Volume vs Truck % highlighting the counties on I-77

## Appendix B

### 2019 Statewide Instant Dispatch Tow Program Expansion

#### Overview

This Appendix presents the recommended statewide Instant Tow Program expansion based on a data-driven analysis. A road segments vulnerability to incidents and queueing congestion is used to determine candidate locations for expansion.

#### Methodology

- Warranted Instant Tow Program expansion is based on risk. It considers the vulnerability of an area to incidents and the consequence of incidents on significant congestion.
- The entire interstate system was segmented by county. Average hourly traffic volumes were then calculated.
- Average traffic volume by County-Interstate group was estimated using 2018 data calculated by VDOT's Traffic Engineering Division. Opposite directions were combined to get one volume for each County-Interstate.
- Average traffic volume was normalized by the number of lanes and plotted against the number of lane impacting incidents per mile per year.
- Incident data by County-Interstate group over a three-year period was taken from VaTraffic and normalized by the length of the segment and the number of years to get an incident rate

#### Data Findings

Formula Purpose	Control Limit	Analysis Findings for Instant Tow	
<ul style="list-style-type: none"> <li>• Expand Instant Tow Program to area that is vulnerable to incidents and blocked lanes have a significant impact to traffic flow</li> </ul>	<ul style="list-style-type: none"> <li>• 100 incidents per mi per year</li> <li>• 12,000 Vehicles Per Day / # of Lanes</li> </ul>	<ul style="list-style-type: none"> <li>• Augusta County I-81</li> <li>• Chesterfield I-95</li> <li>• Fairfax I-66</li> <li>• Fairfax I-95</li> <li>• Arlington I-395</li> <li>• Va Beach/Norfolk I-64</li> <li>• Va Beach/Norfolk I-264</li> </ul>	<ul style="list-style-type: none"> <li>• Fairfax I-495</li> <li>• Stafford I-95</li> <li>• Henrico/Richmond I-64</li> <li>• Henrico/Richmond I-95</li> <li>• Prince William I-95</li> <li>• Suffolk/Chesapeake I-664</li> <li>• York/Hampton I-64</li> </ul>



Figure: Volume vs Incidents with identified expansion region and I-77 counties

## Appendix C

### 2019 Statewide SSP Coverage Expansion

#### Overview

This Appendix presents the recommended statewide safety service patrol route expansions based on a data-driven analysis. The feasibility of this analysis was verified as its results directly align with the qualitative recommendations offered by Regional Operations staff for expanded coverage along the I-95 corridor and I-295.

#### Methodology

- SSP expansion is based on the number of potential customers (average hourly traffic volumes).
- An upper control limit was selected using the Empirical Rule (68-95-99.7 Rule). This Rule uses the average hourly traffic volume and the standard deviation to set the upper control limit.
- The entire interstate system was segmented by county. Average hourly traffic volumes were then calculated.
- Average traffic volume by County-Interstate group was estimated using 2018 data calculated by VDOT's Traffic Engineering Division. Opposite directions were combined to get one volume for each County-Interstate. Hourly traffic volume factors were applied to average daily traffic to get typical hourly volumes by County-Interstate.
- Expanded SSP coverage is recommended for those segments exceeding the upper control limit.
- Existing SSP coverage (July 1, 2019) was reviewed to determine which hours in each County-Interstate group are currently served by SSP. Final route hours were developed using standard 8-hour shift requirements.

#### Data Findings

Item	Formula Purpose	Control Limit	Analysis Findings
<b>Formula 1:</b> Mean + 1/2 Standard Deviation	Expand coverage to hours or locations where service does not currently exist	2000 vehicles per hour	<ul style="list-style-type: none"> <li>• New morning (7AM-9AM) and evening peak (4PM-6PM) weekday coverage for I-295 between Exit 43 and Exit 53</li> <li>• Expand weekend coverage on Chesterfield I-95 Route (9AM-9PM)</li> <li>• Extend weekend hours on Caroline I-95 and Hanover I-95 routes to 10PM</li> <li>• Extend weekend hours on New Kent I-64 route to 8PM</li> <li>• New coverage on I-85 in Petersburg on Weekday evenings (4PM-6PM) and Weekends (3PM-5PM)</li> </ul>

<b>Formula 2:</b> Mean + 3 Standard Deviation	Recommend additional coverage where existing routes exist	5000 vehicles per hour	<ul style="list-style-type: none"> <li>Additional patroller for Fairfax I-95, I-66, I-495, I-395 routes</li> </ul>
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## Final Recommendations

- Expand weekend coverage for Chesterfield I-95 Route to 5AM-9PM
- Split the Chesterfield I-95 Route into two routes at Exit 61 and expand southern route to include I-85 from I-95 to Exit 61
- Add weekday coverage on I-295 between Exit 43 and Exit 53 from 5AM-9PM
- Expand weekend coverage for New Kent I-64 Route to 5AM-9PM
- Add additional patroller to Springfield Interchange

## Appendix D

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### Camera Analysis

#### Overview

An analysis of existing incident history was used to determine the appropriate location of new cameras to aid in incident detection and management.

#### Methodology

A survey was conducted with other states on CCTV/CMS/Towing operations, which revealed that the heavy urban areas all utilize full continuous camera coverage. The various heavy urban states surveyed included Georgia, Illinois, Maryland, New York, and Texas. Rural areas were covered mostly on the large interchanges in lower populated towns and cities.

Following the survey it was determined that all interstate corridors would be separated into Urban and Rural sections. For urban segments it was decided that a camera every mile would provide full continuous camera coverage.

To determine appropriate camera placement on the rural sections the Empirical Rule (68-95-99.7 Rule) was utilized with a sigma of 1.5. The rural interstates were divided into 1 mile segments by direction the number of incidents were put into corresponding bins. The standard deviation and average of the incidents by segment were used to find an upper control limit. If the number of incidents in a given segment exceeds the upper control limit, then it is deemed that a camera is necessary.