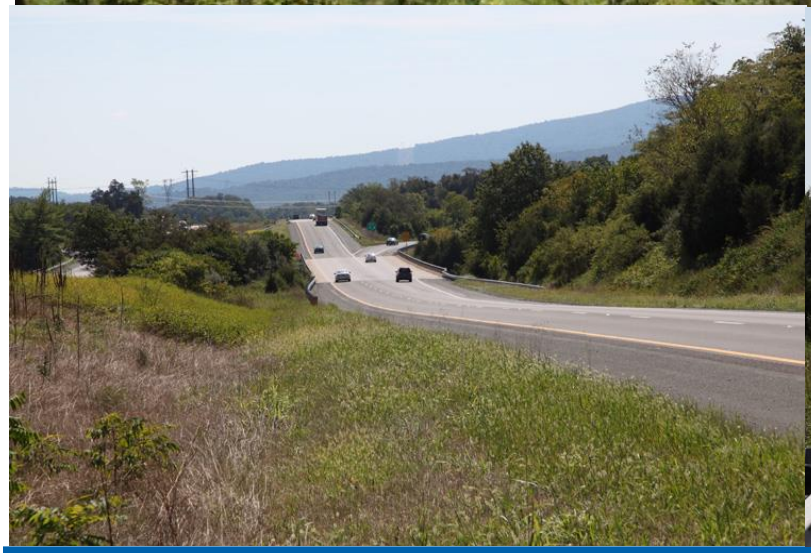

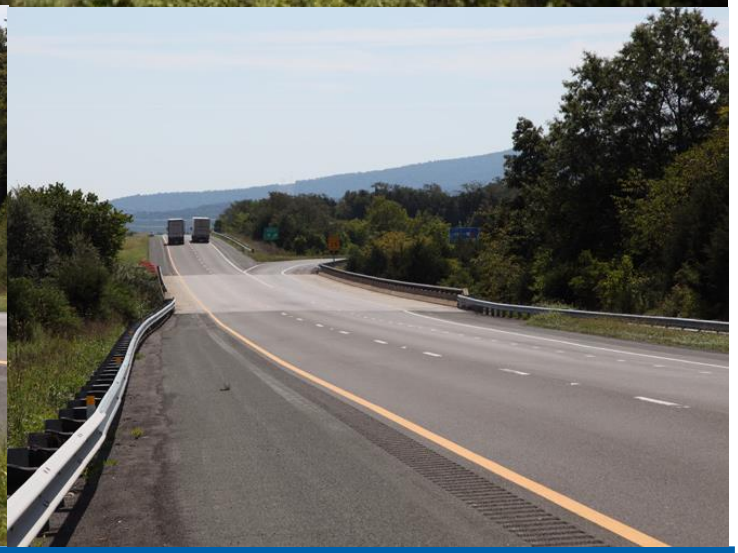

Interstate 66 (I-81 to Exit 40)

Corridor Improvement Plan

VDOT

March 2021

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Introduction

Interstate 66 (I-66) is an interstate highway in the Southeastern United States. It connects I-81 to Washington DC. The entire corridor is 75 miles long; however, major improvements are underway in the eastern portion of the corridor so this document will focus on the western half between I-81 and Exit 40.

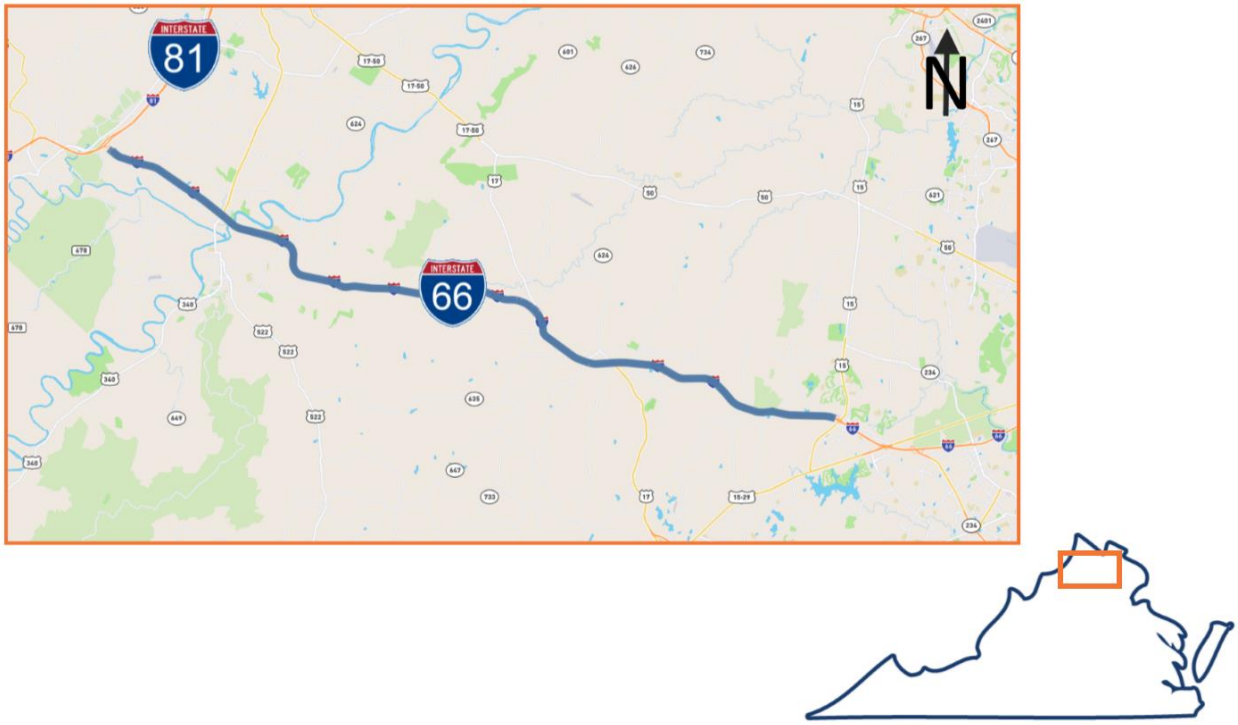

FIGURE 1 STUDY AREA

Study Purpose

The purpose of this project is to identify a package of target operational improvements that are expected to deliver faster, safer, and more reliable travel on the western portion of I-66 in Virginia.

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
Other Improvements to Interstates	$19.6M	$29.2M	$42.9M	$42.9M	$42.9M	$42.9M

The improvements identified in this report were eligible to use this fund.

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 Board may use funs in the program to address needs in the Statewide Transportation Plan or an* ***interstate corridor plan*** *approved by the Board through operational and transportation demand strategies and other transportation improvements.*

This study will identify projects and provide the estimated return on investment for management team to consider when allocating the available funding.

Multimodal Corridor Characteristics

This section of I-66 is predominately rural with limited multimodal opportunities. There are existing park & ride lots along I-66 at Exit 6, Exit 13, Exit 18, Exit 23, Exit 31, and Exit 40. There is no Amtrak service in the area and the nearest Metro Station is at Exit 62.

Challenges in the Corridor

This section of the I-66 Corridor has unique challenges to safety and reliability. Specifically, the congestion profiles for this part of I-66 vary significantly from the statewide model. The main cause of congestion is incidents. Work zones and weather both contribute to a greater portion of delay on the corridor and less congestion is due to bottlenecks and capacity issues (Figure 2).

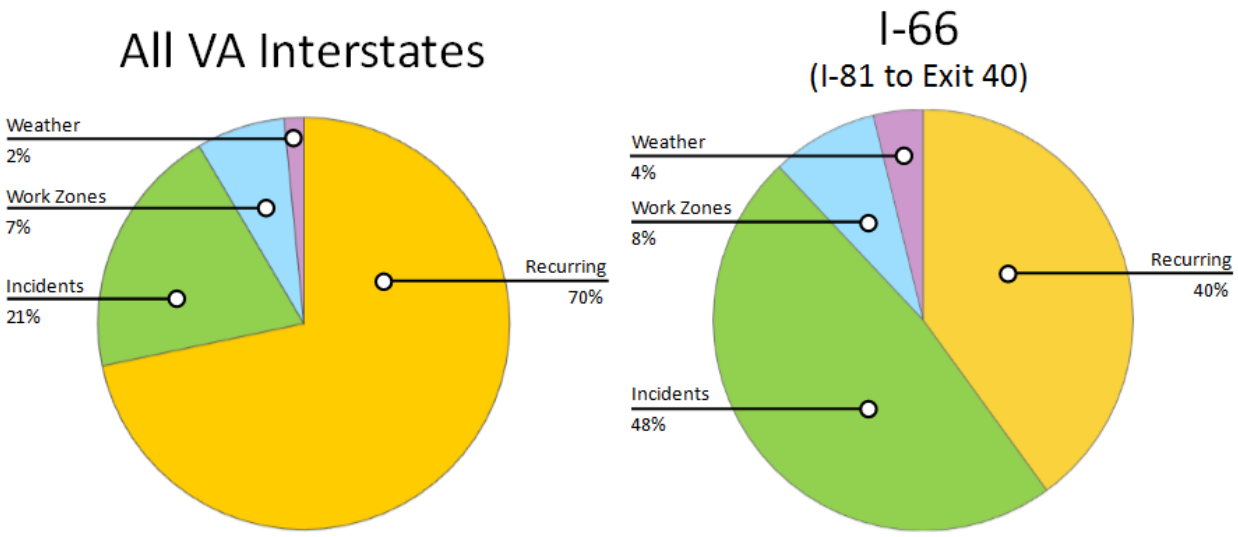

FIGURE 2 CAUSES OF CONGESTION ALONG THE CORRIDOR

There are limited resources to identify and clear incidents. A review of the sources of incident detection reveals that statewide, cameras are responsible for detecting 6% of crash and disabled vehicle incidents (**Error! Reference source not found.**). On this section of I-66, only 1% of incidents are detected by CCTV suggesting that some incidents are going undetected and could serve as an even larger source of operational issues on the corridor.

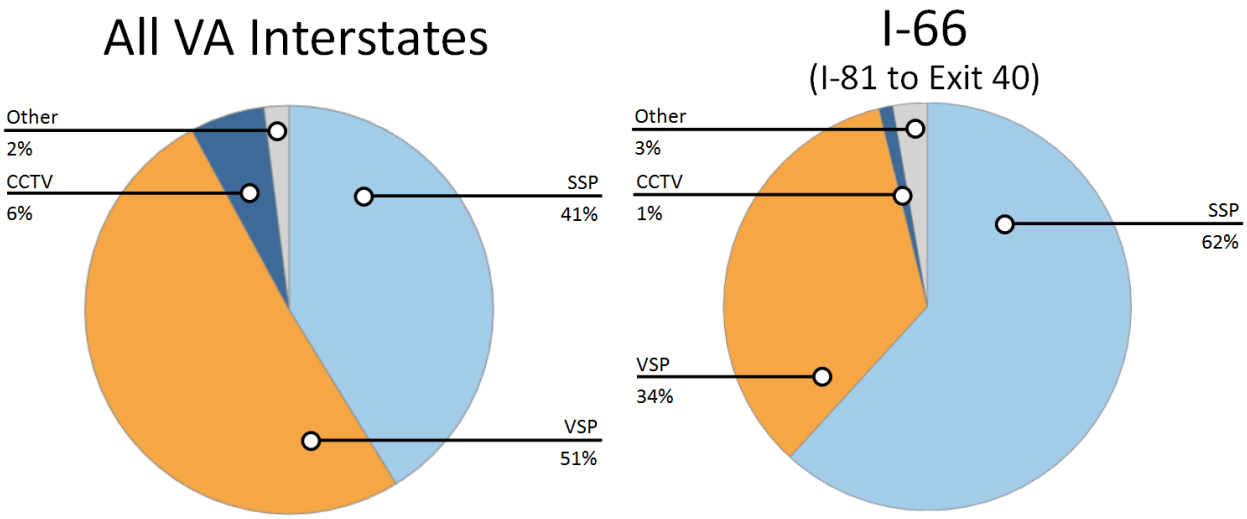

FIGURE 3 DETECTION SOURCE OF INCIDENTS

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 data of the week and time of day to better understand existing traffic patterns.

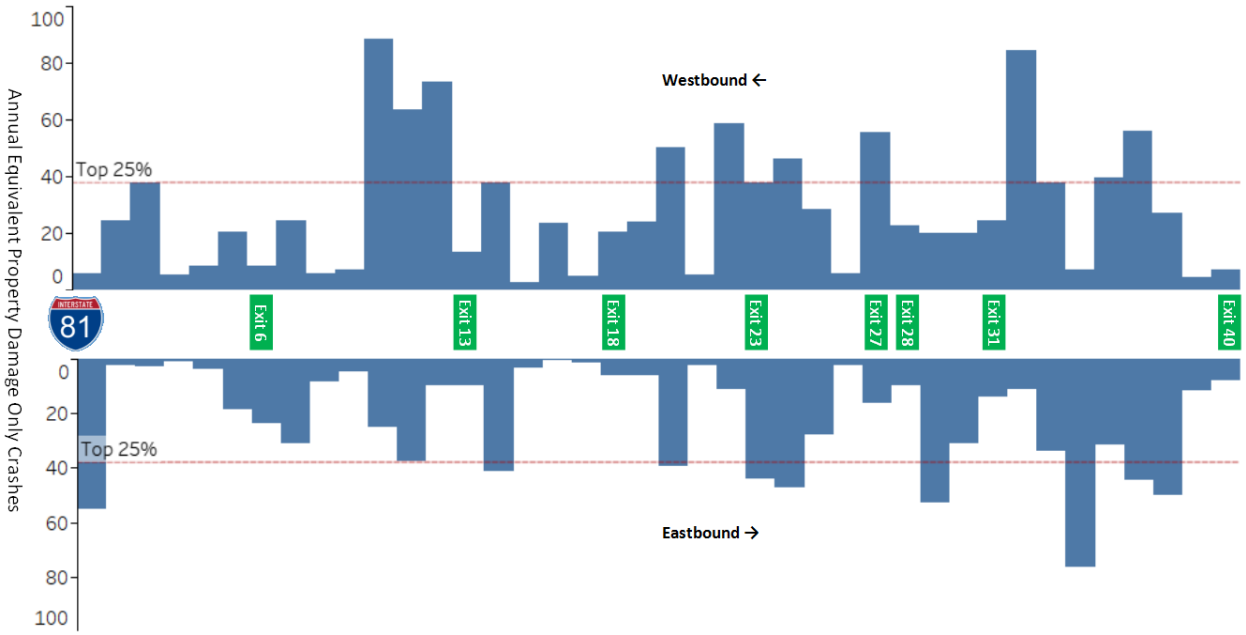

FIGURE 4 EQUIVALENT PROPERTY DAMAGE ONLY (EPDO) CRASHES (2015-2019)

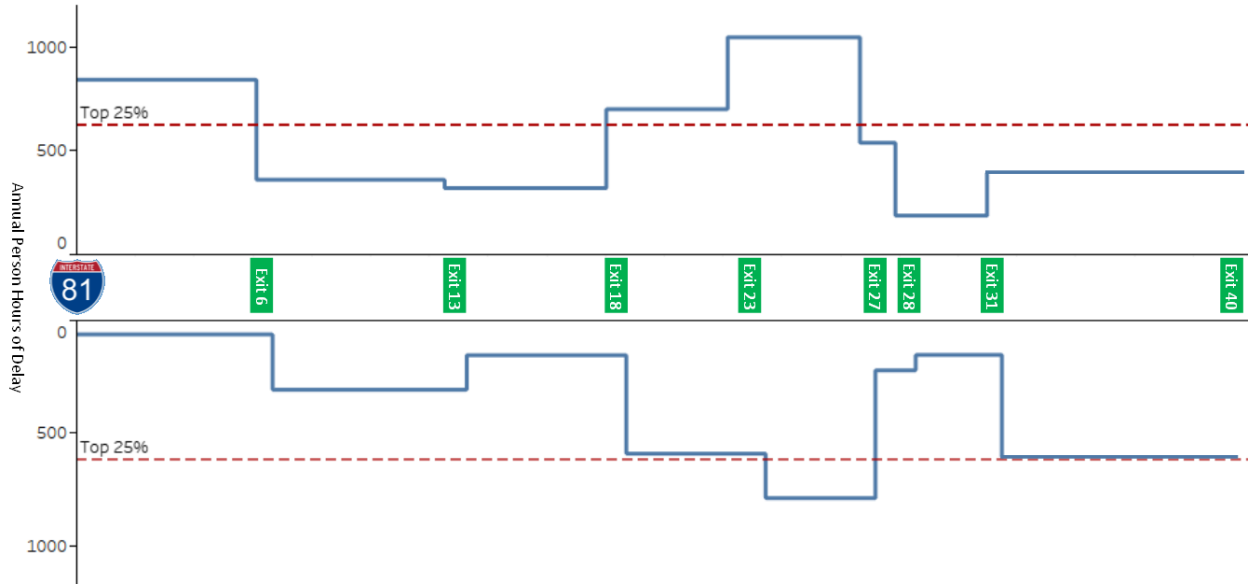

FIGURE 5 ANNUAL PERSON HOURS OF DELAY (2015-2019)

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. 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.

Operations Improvements Plan

VDOT cannot control all contributors to congestion. However, VDOT can mitigate its impact, particularly with incident management strategies. Most of I-66's unreliable or congestion is due to non-recurring congestion which includes incident clearance and work zone management. Therefore, VDOT has an opportunity to improve mobility on this corridor as these causes can be directly influenced by VDOT.

Using the defined performance measures and analyses for I-66 between I-81 and Exit 40, the study team identified $0.625M of improvements for freeway operations.

For the I-66 Corridor, the Operations Improvement Plan strategies are classified into three groupings: Freeway Operations, both Foundational Operations and Innovative Operations, and Capital Roadway Improvements. A high level summary of the Improvements is shown in Table 1.

TABLE 1 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		✓	✓	
Freeway Incident Management Program Tools	Freeway - Foundational	✓	✓	✓	✓
Curve Warning	Freeway - Foundational		✓		
Speed Enforcement	Freeway - Foundational		✓	✓	
Interstate Reference Locations Signs	Freeway - Foundational			✓	
Geofenced Emergency Notifications	Innovative			✓	✓
Advanced Work Zone Technologies	Innovative		✓	✓	
High Wind Notification System	Innovative		✓	✓	

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)
- Interstate reference signs
- Curve warning signs

Freeway Incident Management Program Tools

This program area includes a variety of sub-strategies with a combined purpose to provide better tools to access and respond to events properly. These tools enable the right resources to be brought to the scene which minimize rework and delay. These sub-strategies include PSAP Integration, Residency IMCs, and developing Version 5 of the ATMS (included in the I-95 report). Analysis performed for the I-95 Corridor Project revealed that this collection of strategies had the best return on investment.

Public Safety Answering Point (PSAP) Integration

While the Virginia State Police are often the first responder to incidents directly on I-66, localities can respond to and support I-66 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.

TABLE 2 COUNTIES/LOCALITIES REQUIRING PSAP INTEGRATION

Corridor	# Outstanding Entities	Locations
66	1	• Warren

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. TRIP is not recommended for I-66 between I-81 and Exit 40 at this time.

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-66 between I-81 and Exit 40.

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. Contract Towing is not recommend for the I-66 between I-81 and Exit 40.

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. I-66 is served by existing SSP coverage between I-81 and mile 31 and no further expansion is recommended at this time.

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 key 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 3 presents the recommended camera expansion locations. Due to obstructions, visibility in both directions may not be possible at every location so field review is needed to see if multiple cameras are needed at a given location.

TABLE 3 RECOMMENDED CAMERA EXPANSION

Sites	Camera Expansion Locations
Interchanges	• Exits 23

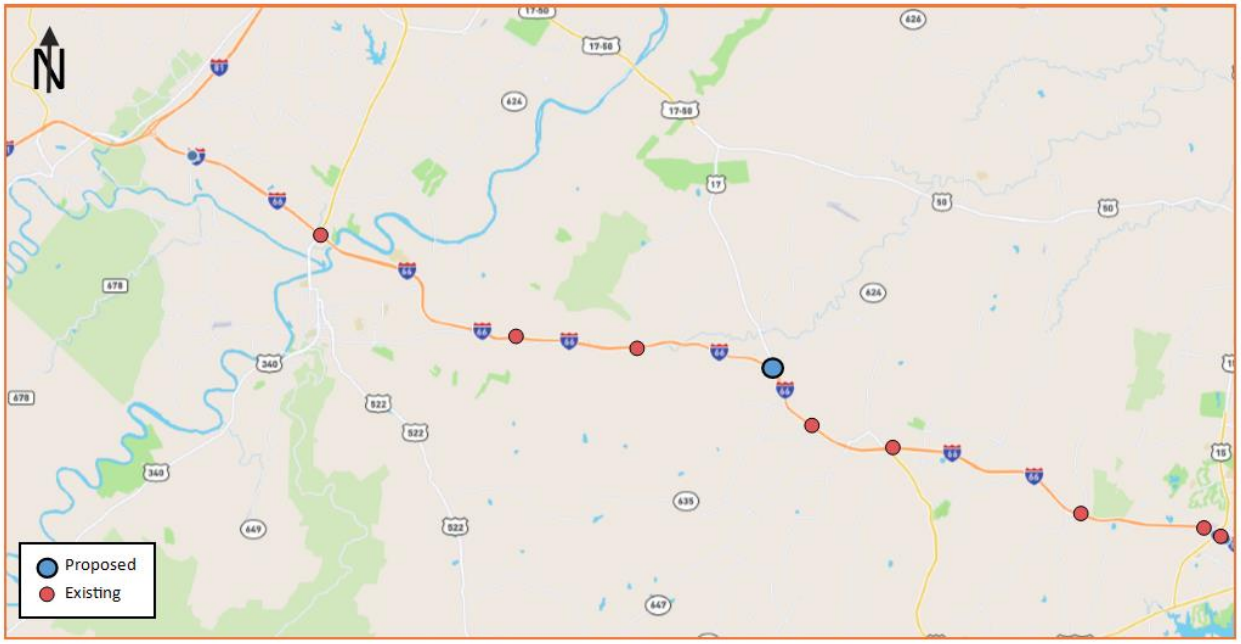

FIGURE 6 LOCATIONS OF EXISTING AND PROPOSED CCTV

Changeable Message Signs

Message signs communicate information to travelers. There is debate 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 being recommended for that purpose.

TABLE 4 RECOMMENDED MESSAGE SIGN EXPANSION

	Message Sign Expansion Locations
Install New	• WB approaching Exit 28 (US 17)

FIGURE 7 LOCATIONS OF EXISTING AND PROPOSED CMS

Innovative Operations Strategies

The foundational strategies outlines 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.

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. The purpose of these technologies are to provide advance 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.

Summary of Proposed Improvements

Table 5 presents the recommend strategies to improve mobility and safety along the I-66 corridor.

TABLE 5 PROPOSED IMPROVEMENTS

Proposed Improvements	Location	Capital Cost/Year 1 Service	Annual O&M
CCTV	Exit 23	$185,000	$5,500
Message Sign	Approaching Exit 28 WB (US 17)	$350,000	$25,000
PSAP Integration	Warren County	$90,000	$0
	Total	**$625,000**	**$30,500**

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
• Expand TRIP Coverage to area that is vulnerable to truck incidents and incidents have a significant impact to traffic flow	• 8% Heavy Vehicle Traffic • 12,000 Vehicles Per Day / # of Lanes	• Prince William County I-66 • Augusta County I-81 • Frederick County I-81 • Montgomery County I-81 • Roanoke County I-81 • Rockingham County I-81 • Caroline County I-95 • Spotsylvania County I-95 • Stafford County I-95

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

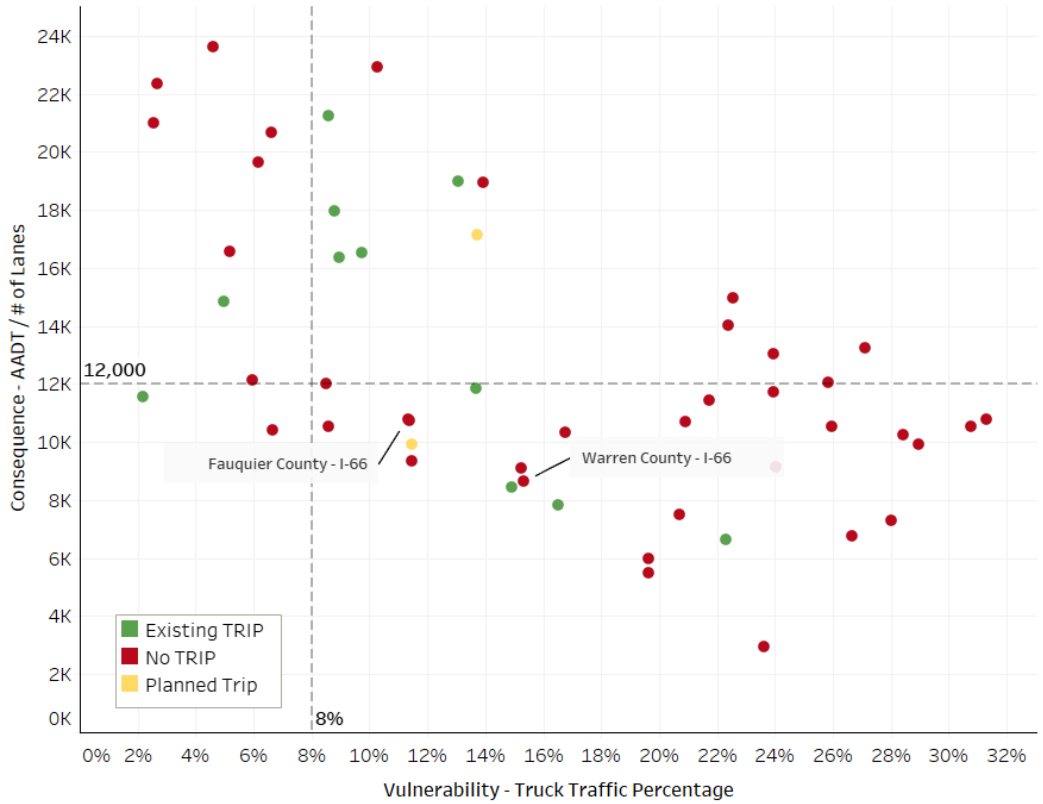

Figure: Volume vs Truck % highlighting the top candidates for expansion

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	
• Expand Instant Tow Program to area that is vulnerable to incidents and blocked lanes have a significant impact to traffic flow	• 100 incidents per mi per year • 12,000 Vehicles Per Day / # of Lanes	• Augusta County I-81 • Chesterfield I-95 • Fairfax I-66 • Fairfax I-95 • Arlington I-395 • Va Beach/Norfolk I-64 • Va Beach/Norfolk I-264	• Fairfax I-495 • Stafford I-95 • Henrico/Richmond I-64 • Henrico/Richmond I-95 • Prince William I-95 • Suffolk/Chesapeake I-664 • York/Hampton I-64

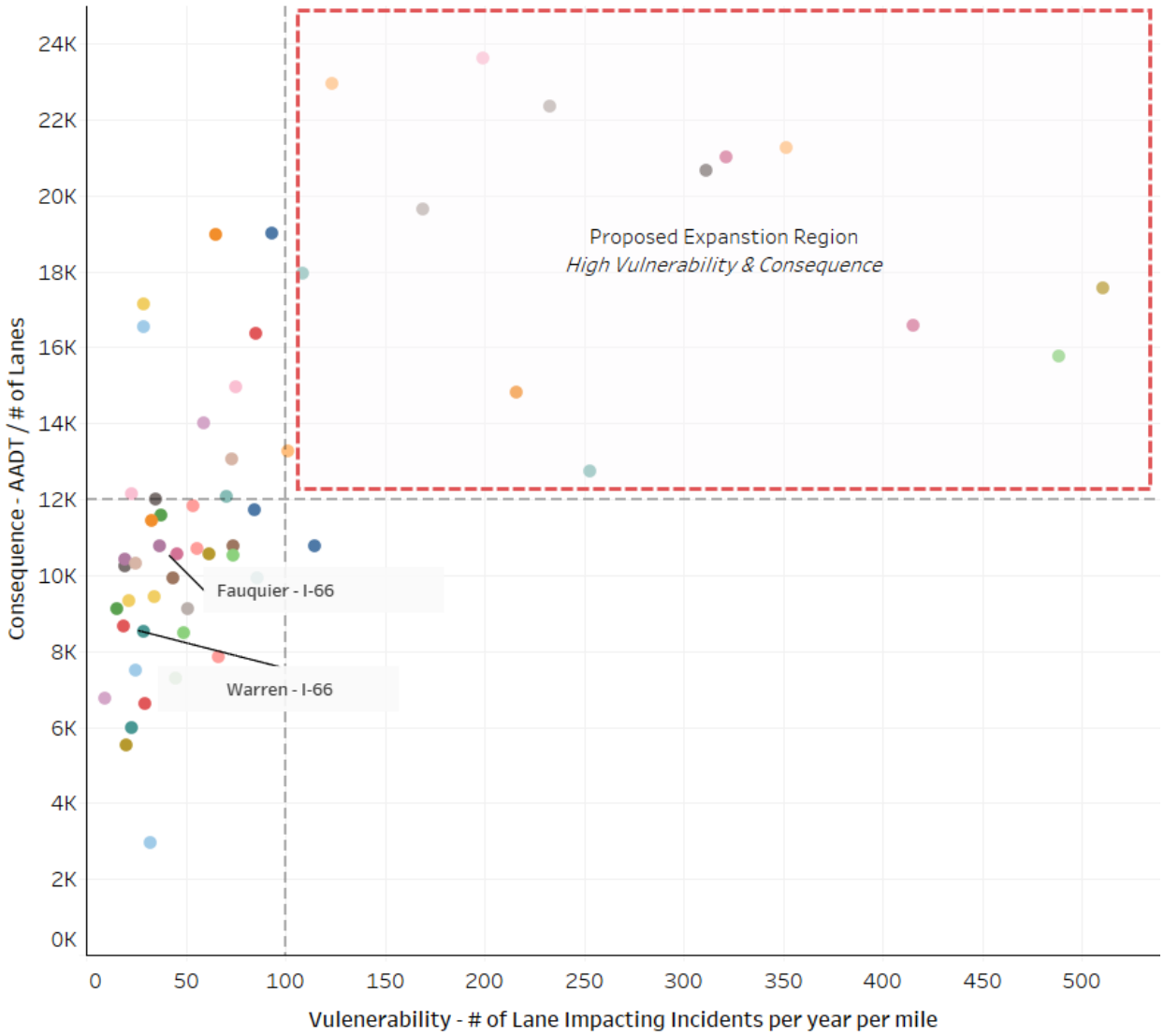

Figure: Volume vs Incidents with identified expansion region

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
Formula 1: Mean + 1/2 Standard Deviation	Expand coverage to hours or locations where service does not currently exist	2000 vehicles per hour	• New morning (7AM-9AM) and evening peak (4PM-6PM) weekday coverage for I-295 between Exit 43 and Exit 53 • Expand weekend coverage on Chesterfield I-95 Route (9AM-9PM) • Extend weekend hours on Caroline I-95 and Hanover I-95 routes to 10PM • Extend weekend hours on New Kent I-64 route to 8PM • New coverage on I-85 in Petersburg on Weekday evenings (4PM-6PM) and Weekends (3PM-5PM)

Formula 2: Mean + 3 Standard Deviation	Recommend additional coverage where existing routes exist	5000 vehicles per hour	• Additional patroller for Fairfax I-95, I-66, I-495, I-395 routes

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

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 number of incidents in a given segment exceeds the upper control limit, then it is deemed that a camera is necessary.