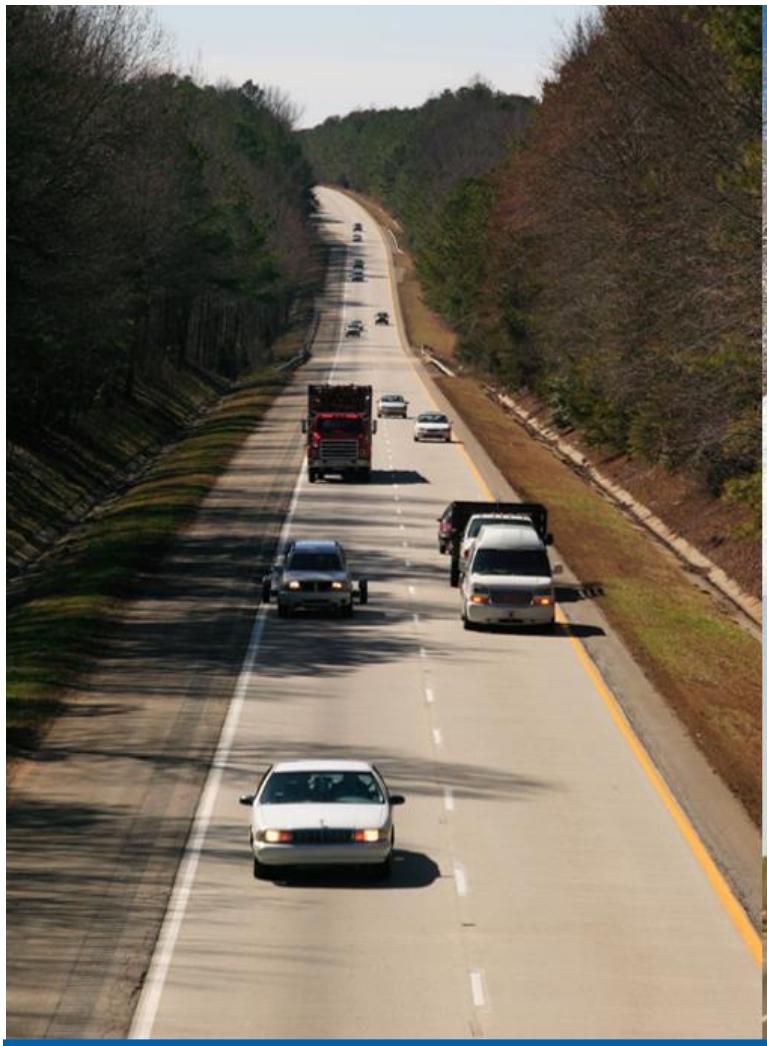

Interstate 85

Corridor Improvement Plan

VDOT

March 2021

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Introduction

Interstate 85 (I-85) is a major interstate highway in the Southeastern United States. It connects multiple metropolitan areas, including Atlanta, Charlotte, and Raleigh/Durham to the I-95 corridor and Northeastern cities. In Virginia, I-85 is a 69 mile long northeast-southwest corridor in the south central part of Virginia connecting North Carolina near South Hill with the I-95 Corridor in Petersburg. US 460 briefly overlaps the highway a few miles west of Petersburg to the complex I-95 interchange. The corridor provides an alternate route from I-95 to access the south east for people, goods, and freight.

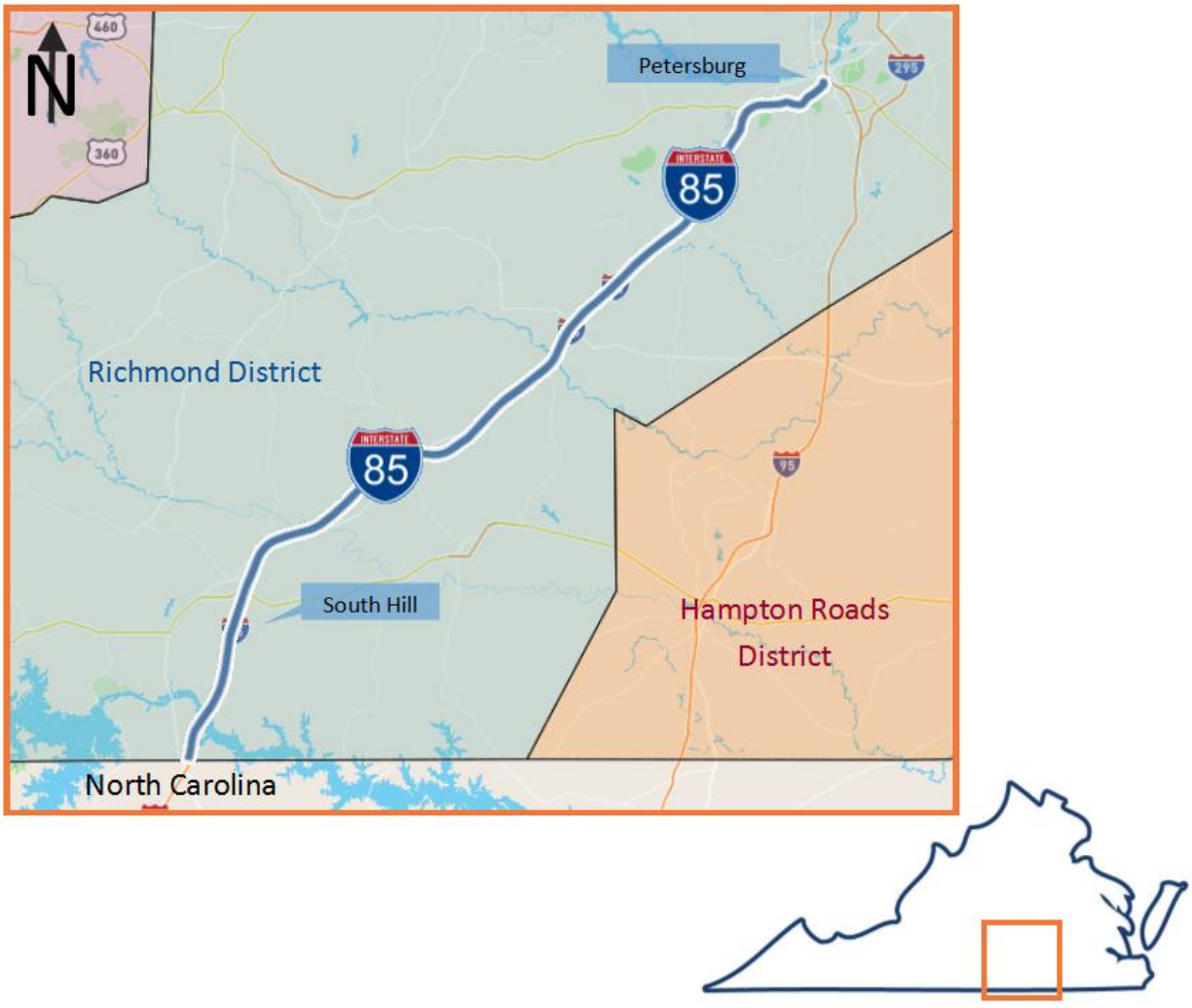

FIGURE 1 STUDY AREA

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 I-85 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

The I-85 corridor is predominately rural, with limited multimodal opportunities. The Petersburg Area Transit operates fourteen, daily short distance bus routes from 5:45 am to 7:00 pm. There is a commuter route to downtown Richmond. The Blackstone Area Bus System operates the Dinwiddie Express, a weekday route that parallels I-85 from McKenney to Petersburg. The Lake Area Bus serves portions of Mecklenburg County with on-call bus service. Greyhound buses provide service in South Hill and Petersburg. Amtrak does not have service that parallels the I-85 Corridor in

Virginia. Train service is available in Petersburg only for points north and south. There are also no park & ride facilities along the corridor.

Challenges in the Corridor

The I-85 Corridor has unique challenges to safety and reliability. The terrain is predominately rural without significant elevation changes. However, the rural characteristics of the route can contribute to mobility issues. Specifically, the congestion profiles for I-85 vary significantly from the statewide model. Incidents, work zones, and weather all contribute to a greater portion of delay on the corridor and less congestion is due to bottlenecks and capacity issues (Figure 2).

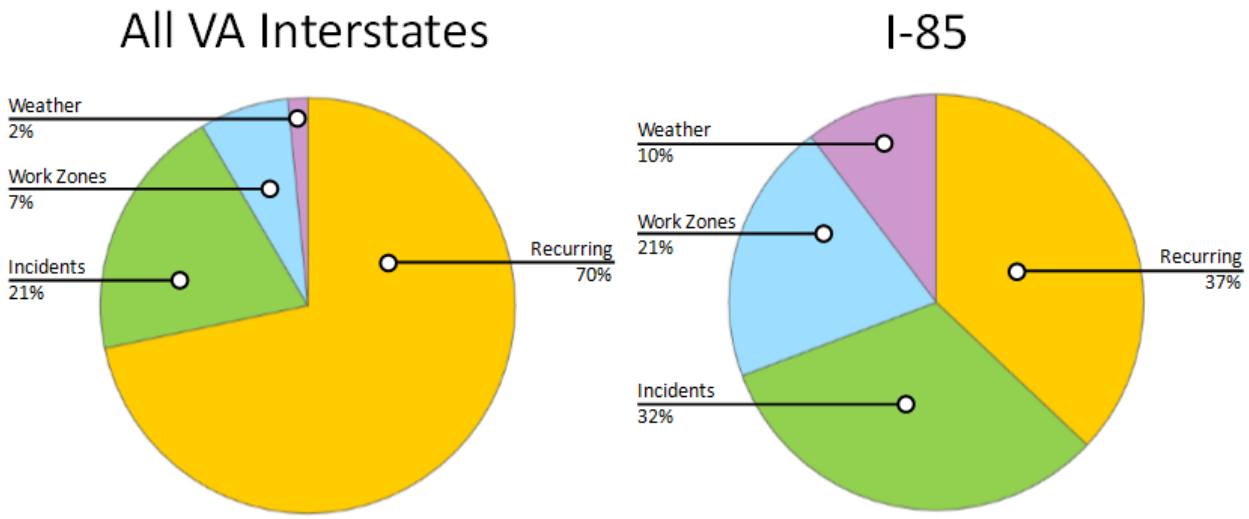

FIGURE 2 CAUSES OF CONGESTION ALONG THE CORRIDOR

There are limited resources to identify and clear incidents. There are no safety service patrol routes and minimal camera surveillance. Nearly every incident currently being identified by the State Police (99%) compared to 51% detected by VSP Statewide (Figure 3). This suggests that many incidents are going undetected and could serve as an even larger source of operational issues on the corridor.

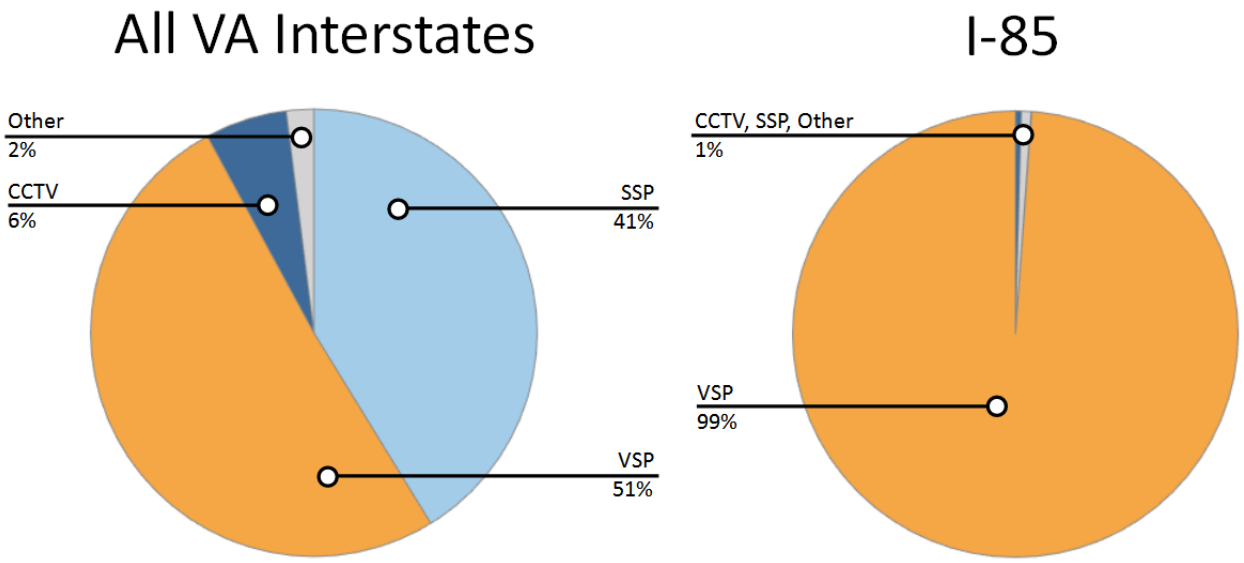

FIGURE 3 DETECTION SOURCE OF INCIDENTS

The recurring congestion is located primarily in the Petersburg area. A contributor of the delay in this area may also be due to having four interchanges in 7 miles which contributes to merging and weaving incidents.

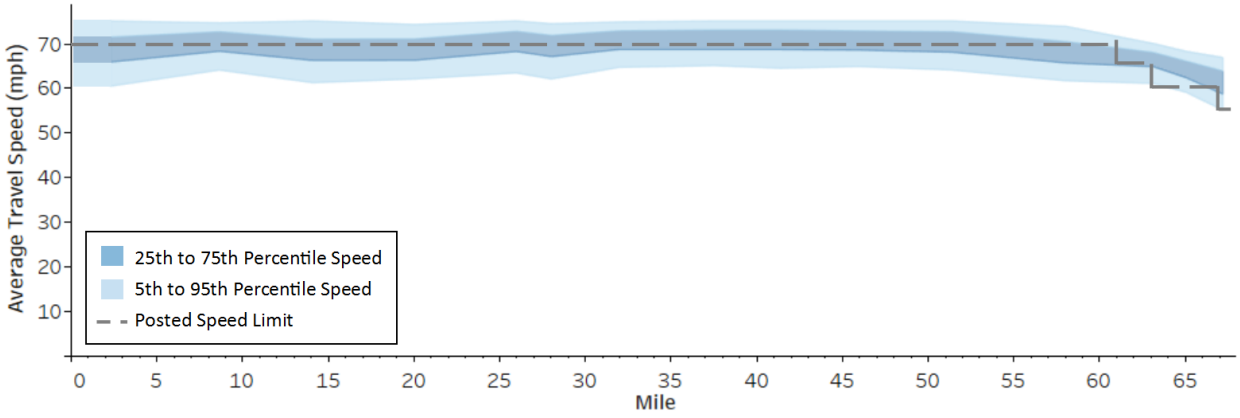

FIGURE 4 AVERAGE SPEED ON I-85 NORTHBOUND (2019)

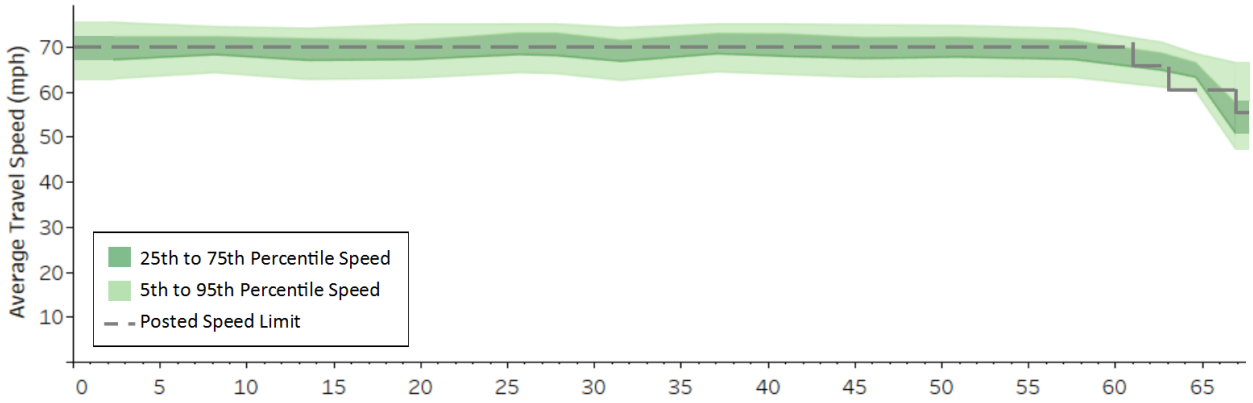

FIGURE 5 AVERAGE SPEED ON I-85 SOUTHBOUND (2019)

VDOT has already recommended an investment of an additional $8.2M in freeway improvements for I-85 over the next six years by way of its six year improvement program. As shown in Table 1, the project scopes vary. Also as shown in Table 1, the focus of many projects on I-85 is to prevent or mitigate incidents which are a key cause of congestion on this corridor.

TABLE 1 HIGHLIGHTS OF PROGRAMMED CAPITAL IMPROVEMENTS WITH AN IMPACT ON OPERATIONS

Improvement	Jurisdiction	Description	Completion Date	Cost
Low Bridge Warning System	Petersburg	Install low bridge warning system on I-85NB near I-95 (UPC 112646)	9/2021	$170K
Pavement	Various	Pavement project (UPC 116526)	12/20	$8,049K

*Bridge replacements were not included in Table 1.

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.

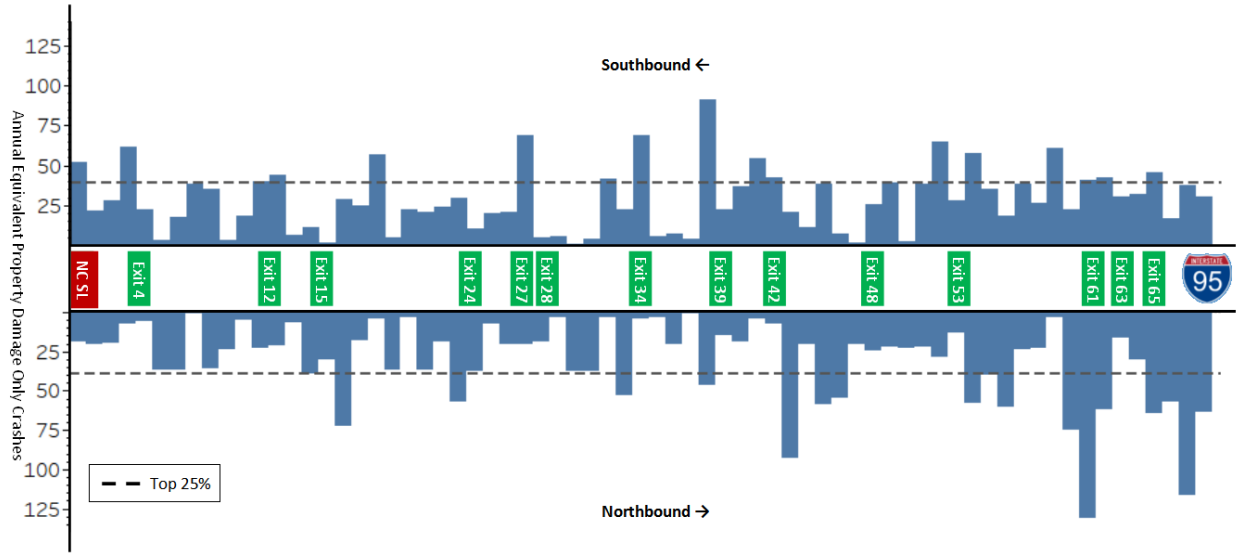

FIGURE 6 EQUIVALENT PROPERTY DAMAGE ONLY (EPDO) CRASHES (2015-2019)

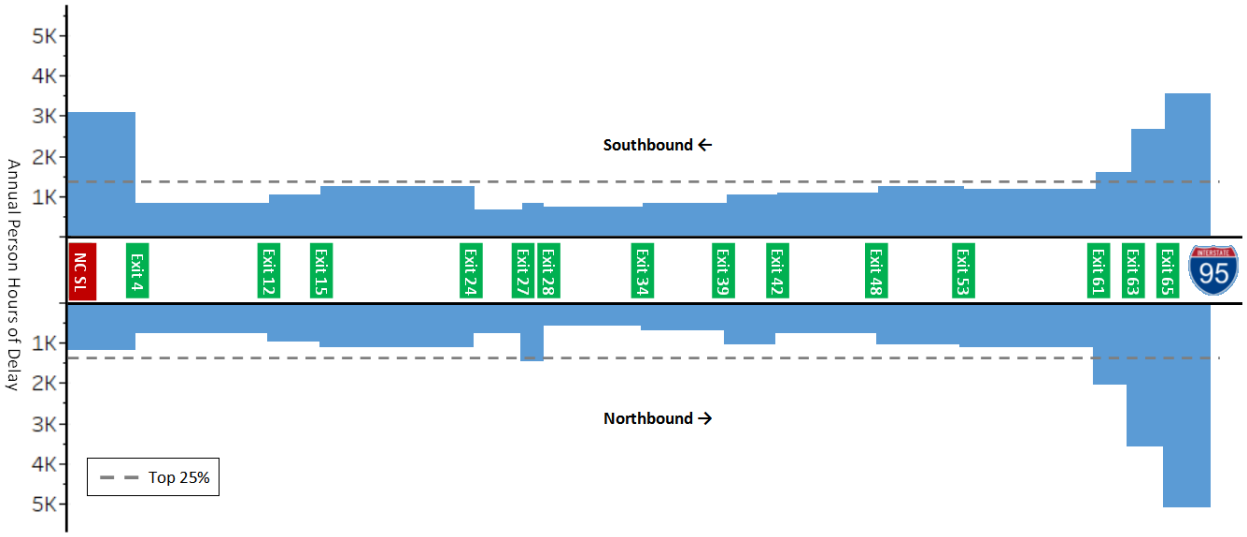

FIGURE 7 ANNUAL PERSON HOURS OF DELAY (2015-2019)

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.

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-85. Source: Streetlight.
- ***Incident Clearance Time:*** The time to clear all travel lands or scene. Source: VaTraffic.

The travel patterns show in Figure 8 indicate that a majority of the trips on the corridor are local trips in the Petersburg area. There are also a significant number of long haul trips from one end of the corridor to the other and between the North Carolina state line and US 58.

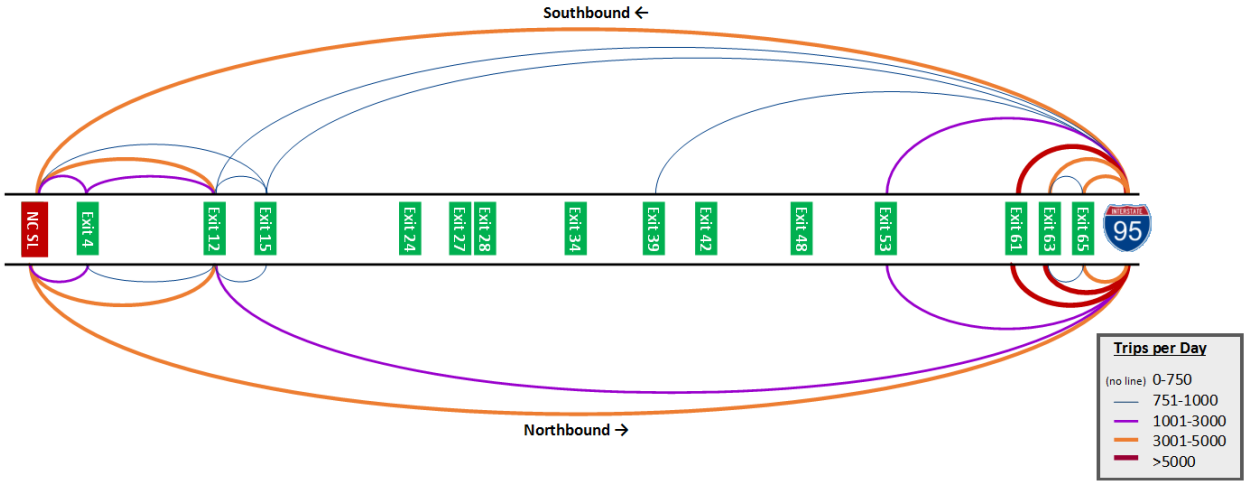

FIGURE 8 STATEWIDE ORIGIN-DESTINATION PATTERNS BY INTERCHANGE

Incident data shows the most activity at the northern end of the corridor in the Petersburg area.

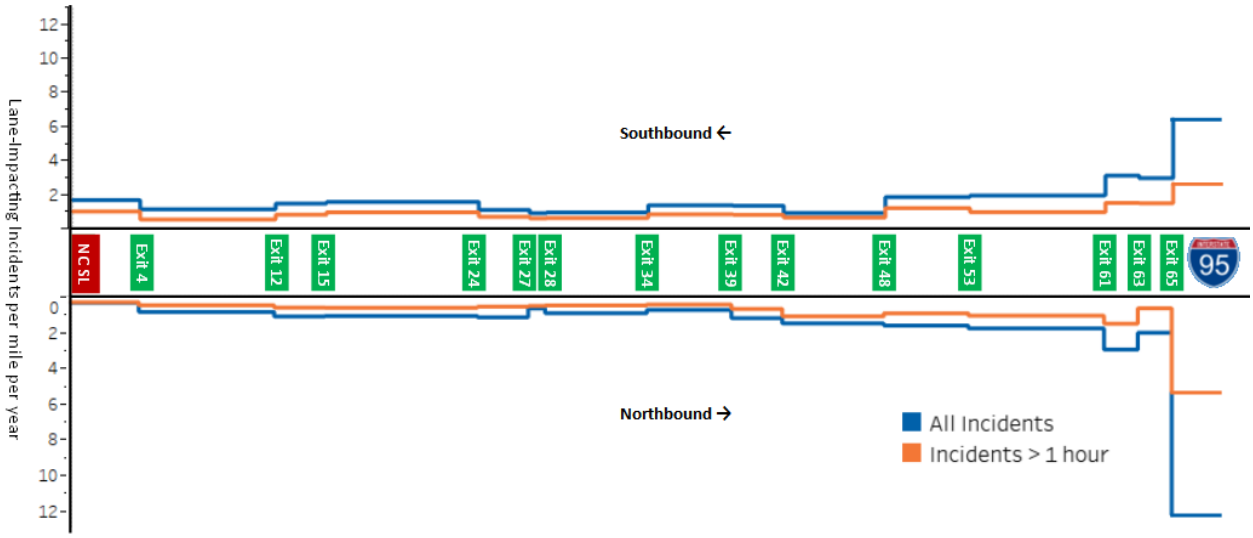

FIGURE 9 LANE IMPACTING INCIDENTS (2015-2019)

Operations Improvements Plan

VDOT cannot control all contributors to congestion. However, VDOT can mitigate its impact, particularly with incident clearance strategies. Most of I-85'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-85, the study team identified $2.295M of improvements for freeway operations.

Parallel facility improvements were considered. Route 1 parallels the entire length of I-85 in many locations as a four lane highway. This route offers additional capacity for the corridor.

For the I-85 Corridor, the Operations Improvement Plan strategies are classified into four groupings: Freeway Operations, both Foundational Operations and Innovative Operations; Arterial Operations; and Capital Roadway Improvements. A high level summary of the Improvements is shown in Table 2.

TABLE 2 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		✓	✓	

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:

- Freeway Incident Management Program Tools (miscellaneous low-cost operations improvements)
- Towing programs (towing recovery incentive program, incentive towing, and contracted towing)
- Safety service patrols
- Camera monitoring
- Changeable message signs
- Curve warning systems

Camera monitoring and message signs can be combined into Active Traffic Management programs that include queue warning programs.

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 2020 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-85, localities can respond to and support I-85 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-85 Corridor have this integration.

TABLE 3 COUNTIES/LOCALITIES REQUIRING PSAP INTEGRATION

Corridor	# Outstanding Entities	Locations
85	4	• Brunswick, Mecklenburg, Dinwiddie, Petersburg*

**Petersburg PSAP integration costs will be covered in the I-95 Corridor Improvement effort.*

The cost of each integration is $90,000. To complete the integration of the remaining 3 localities, the estimated cost is $280,000.

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 and there are currently IMCs at the South Hill and Petersburg Residencies.

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. I-85 is already served by TRIP between mile marker 42 and I-95. While this is not a new program for I-85, it requires significant annual funding which will be considered for this study. Annual operating costs for TRIP on I-85 is estimated at $55,000.

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-85 corridor at this time.

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-85.

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.

The analysis reveal the need for SSP coverage in the Petersburg Area (Exit 61 to I-95) on weekday evening and weekends during the day.

Estimated annual operating costs for a new SSP route which operates 7 days a week from 5 AM to 9 PM is $360,000. Exact extents of the new routes should be at the region's discretion as it make sense to alter adjacent routes to optimize SSP coverage.

FIGURE 10 LOCATIONS OF PROPOSED SSP COVERAGE

Camera Monitoring

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 4 presents the recommended expansions by corridor.

TABLE 4 RECOMMENDED CAMERA EXPANSION

Sites	Camera Expansion Locations
Interchanges	• Exits: 12, 28, 34, 42, 61
High Incidents Locations	• Mile Marker 67 Northbound

FIGURE 11 LOCATIONS OF EXISTING AND PROPOSED CCTV

Dense vegetation dictate the need for multiple cameras for complete coverage at an interchange. Field review will be done to determine the final number of new 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 only being recommended for that purpose.

TABLE 5 RECOMMENDED MESSAGE SIGN EXPANSION

	Message Sign Expansion Locations
Install New	• SB before US 460 interchange

FIGURE 12 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. 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.

Detour Routes and Improvements to Parallel Facilities

During traffic incidents or periods of congestion on the I-85 corridor, motorists may choose to use a parallel facility such as US 1 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. Detailed detour route plans have not been completed for I-85.

Low Cost Detour Guidance

For additional guidance during significant congestion or incidents on I-85, it is recommended that portable message signs be staged at the Hillsville and Petersburg Residencies for quick deployment.

Signs & Markings

Updated signs and markings are recommended for US 1 to improve operations and safety during detours due to congestion or incidents on I-85.

TABLE 6 PROJECTS ON ARTERIAL ROUTES

Project	Cost
Formal Detour Plan for I-85	$60,000
Signs & Markings	$250,000

Summary of Proposed Improvements

Table 7 presents the recommend strategies to improve mobility and safety along the I-85 corridor.

TABLE 7 SUMMARY OF PROPOSED IMPROVEMENTS

Proposed Improvements	Location	Capital Cost/Year 1 Service	Annual O&M
CCTV	Exit12	$185,000	$5,500
CCTV	Exit 28	$185,000	$5,500
CCTV	Exit 34	$185,000	$5,500
CCTV	Exit 42	$185,000	$5,500
CCTV	Exit 61	$185,000	$5,500
CMS (new)	SB before US 460 Interchange (Exit 61)	$350,000	$25,000
SSP	Exit 61 to I-95 5AM-9PM 7 days/week	$0	$360,000
PSAP Integration	Mecklenburg County	$90,000	$0
PSAP Integration	Brunswick County	$90,000	$0
PSAP Integration	Dinwiddie County	$90,000	$0
Portable DMS (2)	Petersburg Residency	$70,000	$2,000
Portable DMS (2)	Hillsville Residency	$70,000	$2,000
Signs & Markings	US 1	$250,000	$0
	Total	**$2,295,000**	**$416,500**

Table 8 presents the list of projects which are recommended for further consideration

TABLE 8 SUMMARY OF IMPROVEMENTS RECOMMENDED FOR CONSIDERATION

Proposed Improvements	Location	Capital Cost/Year 1 Service	Annual O&M
Detour Plan	I-85	$200,000	$0
	Total	**$200,000**	**$0**

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 weighted against anticipated benefits.

TABLE 9 FREEWAY OPERATIONS IMPROVEMENTS RETURN ON INVESTMENT

Priority	Program	Benefit[1]		ROI
1	**TRIP**	• Reduce incident duration & prevent secondary crashes	• TRIP – 50 minute reduction in incident duration for commercial vehicles[4] • 40% reduction in secondary crashes[5]	7.8
2	**CCTV Cameras**	• Incident Detection and traffic monitoring	• 40% reduction in secondary crashes[5] • 5% reduction in congestion caused by incidents[6]	6.7
3	**CMS**	• Part of ATM Communications Tool	• 3 minutes/vehicle time savings[Error! Reference source not found.]	6.5
6	**SSP**	• Reduced congestion by clearing incidents faster and opening lanes to traffic • Reduces secondary crashes	• 17% reduction in scene clearance time[8]	2.7
9	**PSAP**	• Increased accuracy of incident information to reduce incident duration	• 8% reduction in incident delay[3]	2.2

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. VTRC Final Report 07-R33 (2007)
9. Review of travel time & incident data during long-term detours by Operations Division
10. Assumption from VDOT Operations

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

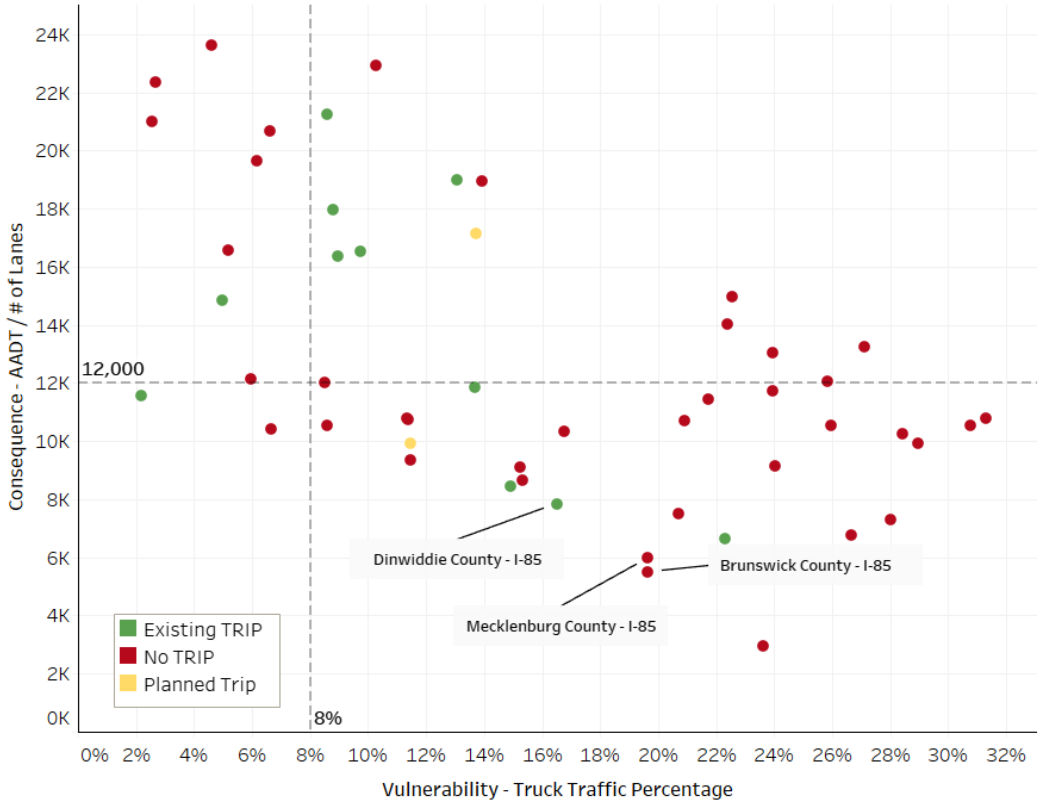

Figure: Volume vs Truck % highlighting the top candidates for expansion

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

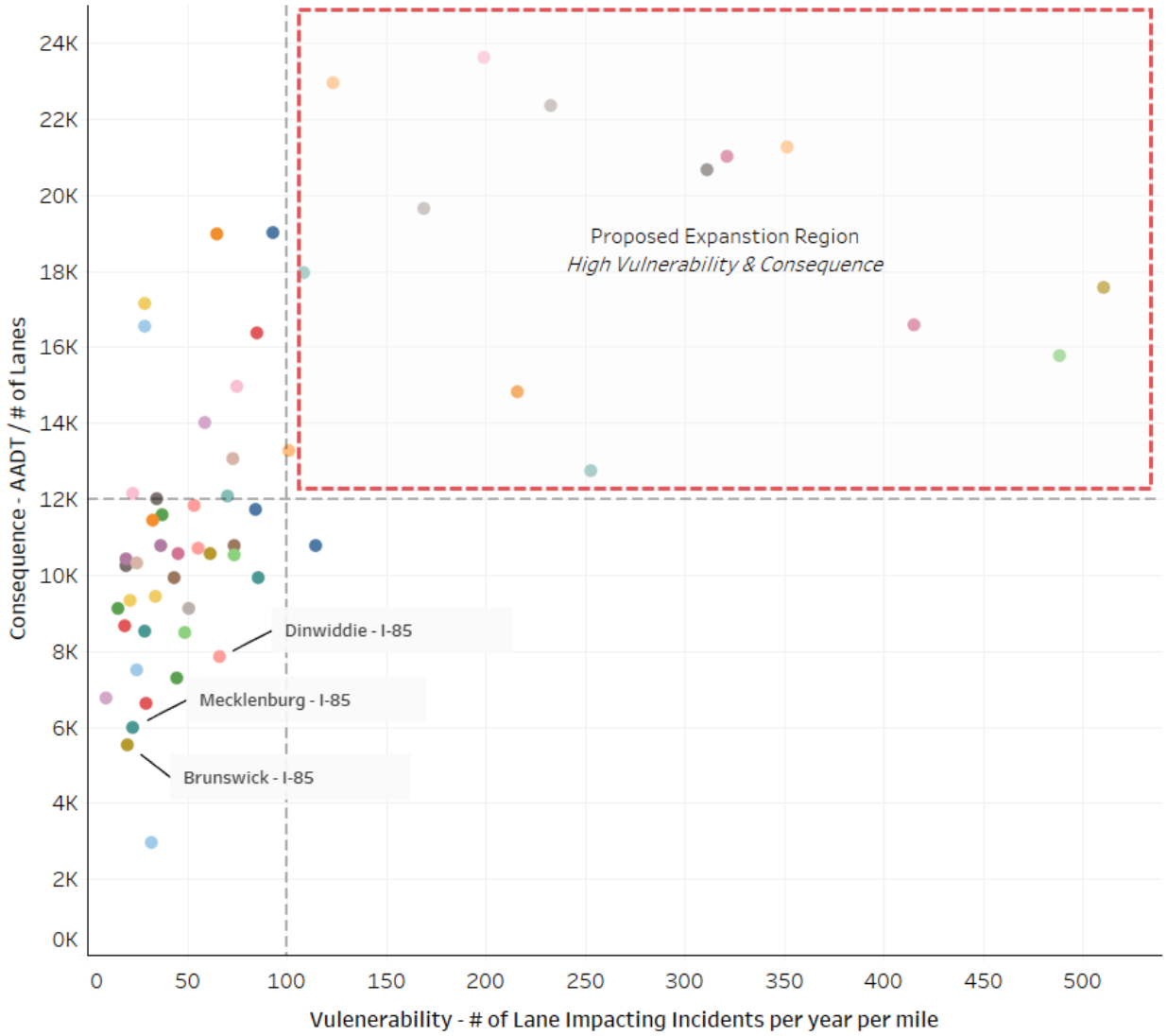

Figure: Volume vs Incidents with identified expansion region

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.