COMMONWEALTH of VIRGINIA

DEPARTMENT OF TRANSPORTATION
1401 EAST BROAD STREET
RICHMOND, VIRGINIA 23219 2000

Charles A. Kilpatrick, P.E.
Commissioner

June 28, 2016

The Honorable Governor Terry McAuliffe
Members of the Virginia General Assembly

Dear Ladies and Gentlemen:

I am pleased to present the Virginia Transportation Technology Plan developed pursuant to House Joint Resolution 122. House Joint Resolution 122, as agreed to during the 2014 General Assembly Session, directed the Secretary of Transportation and the Department of Transportation "to create and implement statewide technology goals and a five-year plan of action. Such goals and plan shall be directed to the efficiency, safety, and convenience of all modes of transportation throughout the Commonwealth".

The attached Technology Plan was developed in coordination with the Secretary of Transportation. If you have any questions or need additional information, please feel free to contact me.

Sincerely,

Charles A. Kilpatrick, P.E.
Commissioner of Highways

Cc: The Honorable Aubrey L. Layne
Mr. Garrett Moore, P.E.

VDOT Virginia Department of Transportation

Virginia Transportation Technology Plan

House Joint Resolution 122

Report to the General Assembly

Virginia Department of Transportation
1401 East Broad Street
Richmond, Virginia 23219

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EXECUTIVE SUMMARY

House Joint Resolution 122 (HJR122), as adopted during the 2014 General Assembly Session (Appendix A), required the Secretary of Transportation and the Department of Transportation (VDOT) to "create and implement statewide transportation technology goals and a five-year plan of action. Such goals and plan shall be directed to the efficiency, safety, and convenience of all modes of transportation throughout the Commonwealth." Representatives from VDOT and the Department of Rail and Public Transportation (DRPT), with additional information provided by the Department of Motor Vehicles (DMV), collaborated in the development of this report.

This Transportation Technology Plan (TTP or Plan), set forth in Appendix C, builds on Virginia's long-term efforts to promote "efficiency, safety, and convenience of all modes of transportation throughout the Commonwealth." It considers existing documents including the *VTRANS 2040 Vision Plan*, Office of Intermodal Planning and Investment *Corridors of Statewide Significance Needs Assessments* from the VTRANS Multimodal Transportation Plan, VDOT's *FY16 Business Plan*, and DRPT's *Strategic Plan.* The plan also takes account the upcoming impact of House Bill 2, *Statewide Prioritization Process for Project Selection*, to ensure that the defined projects were selected by a rational, repeatable, quantitative process.

Development of Virginia's Transportation Technology Program Goals

Technology is a primary tool for transportation operations programs. Therefore, the Transportation Technology Plan focuses on using technologies to meet the intent of House Joint Resolution 122 and moving people, goods, and services as efficiently, safely, and conveniently as possible. The three selected goals for the Transportation Technology Plan are derived from the most relevant goals of the FY16 *VDOT Business Plan* (Table 1).

Table 1: Transportation Technology Plan – Mission, Goals and Objectives

Mission: Keep Virginia Moving (Using Technology)	
Goals	**Objectives**
OPERATE	
Ensure efficient use of the existing transportation system and services to meet customer demand and expectations of a system that is safe and reliable, and enable the easy movement of goods and people across all modes.	1. Increase mobility by improving access to multimodal travel options 2. Improve transportation system efficiency by reducing the growth of vehicle hours of delay. 3. Improve transportation system efficiency by reducing the reliability buffer time index. 4. Reduce median duration of incidents.
OPTIMIZE	
Use a systematic, needs-based process to effectively manage our assets, preserve and maintain the condition of the transportation system, and safely ***optimize existing resources***.	5. Optimize existing system throughput by improving freeway, arterial and transit operations, encouraging mode and route switch, and providing better information to travelers.

SUPPORT	
Efficiently and effectively provide the appropriate tools, guidance, and processes that enable core programs and services to meet their objectives.	6. Accelerate deployment of projects with near-term benefits

In addition to the broad goals and objectives identified in HJR 122, this Plan was developed to support the *VTRANS 2040* Guiding Principles for Transportation Investments in Virginia, specifically #7:

1. Optimize return on investment
2. Ensure safety, security and resiliency
3. Deliver programs efficiently
4. Provide transparency and accountability through performance management
5. Improve coordination between transportation and land use
6. Ensure efficient intermodal connections
7. Consider operational improvements and demand management first

    - Maximize capacity of the transportation network through increased use of technology and operational improvements as well as managing demand for the system before investing in major capacity expansions

    - Focusing on enhancing system performance through technology and user information is a prudent way to increase the efficiency of our current system in light of future constraints and uncertainties

This focus will require close coordination with multiple external partners, including:

- DRPT
- DMV
- Localities
- Transit service providers
- Transportation Management Agencies
- Metropolitan Planning Organizations
- Non-motorized transport advocates

Identifying Programs and Projects to Support Transportation Technology Plan Objectives

Projects identified for inclusion in the plan were developed by VDOT, DRPT and DMV staff to support the goals of HJR 122, agency business plan goals, and specific needs identified in the *Corridors of Statewide Significance Needs Assessments* prepared by the Office of Intermodal Planning and Investment.

Based on the requirements of HJR 122, staff reviewed each of the twelve (12) *Corridors of Statewide Significance Needs Assessments* to identify transportation technology projects to support the identified corridor needs. This review produced projects focused on specific needs of Corridors of Statewide Significance as well as a set of Statewide Programs that will support needs across multiple Corridors.

To develop specific projects for the Transportation Technology Plan, each of the twelve (12) *Corridors of Statewide Significance Needs Assessments* were evaluated to identify potential technology solutions to identified corridor needs. In addition, specific data on each corridor segment was used to support project identification. Data included:

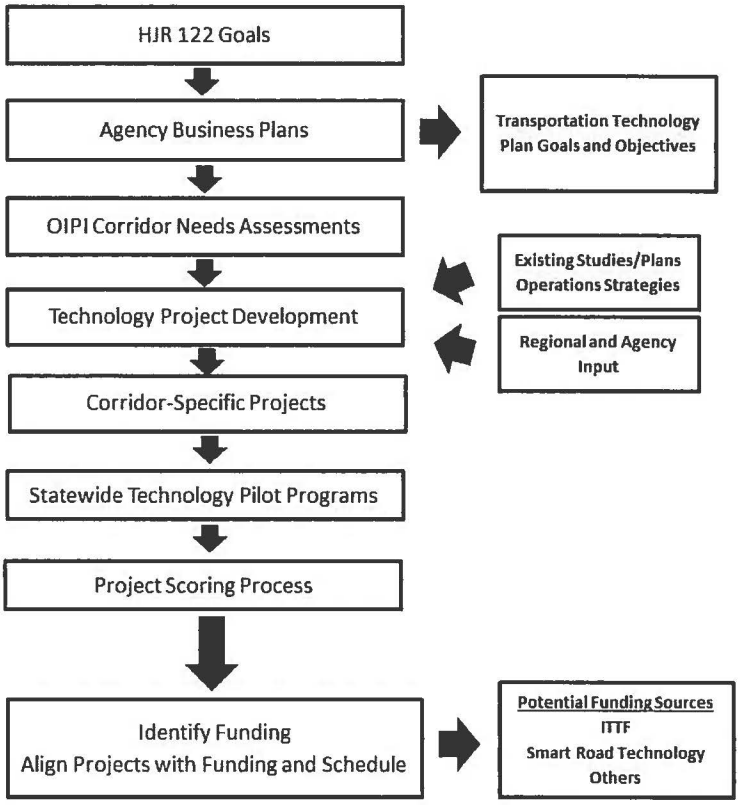
- Availability of modal options
- Availability of redundant facilities
- Safety
- Person hours of delay
- Freight-ton hours of delay
- Weekday peak period reliability

VDOT identified eight (8) potential operations strategies to apply toward resolving critical statewide and corridor needs. These eight (8) operations strategies are used to categorize and summarize the current and upcoming transportation technologies that will be used to achieve the above goals. The eight strategies are:

1. Enhance operations traffic management
2. Strengthen incident and emergency response
3. Support multimodal travel
4. Manage arterials
5. Furnish traveler information
6. Support commercial vehicle/freight activity
7. Conduct emerging technology research
8. Enhance enabling technology infrastructure

Using the data reported on these measures and the corridor needs identified in the Corridor Needs Assessments, staff identified specific technology projects to improve reliability, safety and throughput on 31 of 39 corridor segments. Technology solutions were not applicable for eight (8) corridor segments. In addition, several statewide technology programs have been identified to meet broad TTP goals and objectives across multiple corridors. The statewide technology programs focus on high-priority agency initiatives and key multimodal technology pilot programs.

Figure 1: Project Development and Scoring Process



Implementing the Transportation Technology Plan

VDOT developed a project scoring process based on the goals and objectives of the Transportation Technology Plan in order to develop a rank ordered list of project priorities. Project scoring criteria included:

- Support for multimodal travel
- Support for incident management
- Reduction in vehicle hours of delay
- Reduction in buffer time index [1]
- Optimization of corridor throughput
- Project readiness

Using this process, all corridor-specific projects were scored and then ranked in descending order to obtain a rank ordered list of priority projects. Table 2 illustrates the top ten ranked projects. A detailed description of the project scoring criteria is included in Appendix D to this document. Statewide programs were not included in the project ranking process due to the critical need for their implementation and their

[1] The Buffer Time Index is a ratio defining the amount of extra time needed to ensure on-time arrival with 95% confidence.

broad application to multiple corridors statewide. While safety was not an explicit criterion for scoring projects, safety data was considered when selecting corridor segments for technology applications and in the selection of the type of strategy to improve travel on that corridor segment.

Table 2: Top Ten Ranked Corridor-Specific Projects

VTrans2040 Corridor/Segment	Route	District*	Segment End Points	Selected Strategy	Selected Project	Project Description	Estimated Project Budget	Final Score	Funding Source **
Washington to NC Segment 3	I-95	NOVA/FR	Caroline / Spotsylvania CL Maryland Border	Multimodal	I-95/I-395 ICM Program: Multimodal Traveler Information	Electronic signage displaying roadway, transit and parking information to allow travelers to more easily change mode and route of travel	$ 5,700,000	10	ITTF
East-West Segment 5	I-64	HR	York / James City CL to I-264	Commercial Vehicle Operations	I-64 Integrated Overheight Detection Systems	Deployment of technology to detect and divert overheight vehicles in advance of HRBT	$ 900,000	10	ITTF
East-West Segment 5	I-64	HR	York / James City CL to I-264	Arterial Operations	US60/US17/Rt. 143/199 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,560,000	10	ITTF
East-West Segment 5	I-64	HR	York / James City CL to I-264	Operations Traffic Management	HRBT Tunnel Traffic & Safety Improvements	Upgrade of existing lane control and tunnel traffic safety systems	$ 5,445,371	9	SRT
East-West Segment 5	I-64	HR	York / James City CL to I-264	Operations Traffic Management	I-64 Hampton Roads Active Traffic Management System: Phase 1 Westbound	Deployment of camera, sensor, lane control and variable speed limit technologies to actively manage westbound traffic approaching HRBT	$ 14,500,000	9	ITTF
Northern Virginia Segment 2	I-66	NOVA	Prince William / Fauquier CL to District of Columbia	Operations Traffic Management	Rosslyn Tunnel Traffic & Safety Improvements	Upgrade of existing lane control and tunnel traffic safety systems	$ 3,500,000	9	SRT
East-West Segment 5	I-64	HR	York / James City CL to I-264	Operations Traffic Management	MMMBT Tunnel Traffic & Safety Improvements	Upgrade of existing lane control and tunnel traffic safety systems	$ 7,000,000	9	ITTF
Washington to NC Segment 3	I-95	NOVA/FR	Caroline / Spotsylvania CL Maryland Border	Operations Traffic Management	I-95/I-395 ICM Program: Dynamic Ramp Metering	Upgrade of existing ramp metering system	$ 3,500,000	8	SRT
Washington to NC Segment 2	I-95	RIC/FR	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	Commercial Vehicle Operations	I-95 Integrated Overheight Detection Systems	Deployment of over-height vehicle detection technology to catch and divert overheight vehicles in advance of I-95 overpasses	$ 900,000	8	ITTF
Washington to NC Segment 2	I-95	RIC/FR	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	Operations Traffic Management	I-95 Richmond Active Traffic Management System	Deployment of dynamic lane control and ramp metering technologies	$ 6,035,000	8	ITTF

Implementation of the plan, then, is dependent on the availability of financial resources. There are several potential funding sources for the TTP including, but not limited to:

- Innovation Technology Transportation Fund
- Smart Road Technology Fund
- Future High Priority Project Applications
- Future Federal Grants

VDOT will seek to implement top ranking corridor-specific projects in conjunction with the statewide programs through all available funding sources.

Table 3 summarizes the 5-year TTP program cost by program area.

Table 3: 5-Year Program Cost by Program Area

Operations Strategy	5-Year Cost	Percent of Total Cost
Corridor-Specific Projects	$116,630,212	79%
Statewide Programs and Pilots	$31,501,000	21%
TOTAL:	**$148,131,212**	**100%**

Table 4 summarizes the 5-year TTP program cost by operations strategy.

Table 4: 5-Year Program Cost by Operations Strategy Area

Operations Strategy	5-Year Cost	Percent of Total Cost
Operations Traffic Management	$59,020,371	40%
Incident Management	$9,000,000	6%
Multimodal	$17,800,000	12%
Arterial Management	$45,936,841	31%
Traveler Information	$6,700,000	5%
Enabling Technologies	$4,874,000	3%
Commercial Vehicle Operations	$4,800,000	3%
TOTAL:	**$148,131,212**	**100%**

Table 5 summarizes the 5-year TTP program cost by Corridor of Statewide Significance.

Table 5: 5-Year Program Cost by Corridor of Statewide Significance

COSS	5-Year Cost	Percent of Corridor Cost
Coastal	$4,220,000	4%
Crescent	$15,692,000	13%
East-West*	$40,183,371	34%
Eastern Shore	$570,000	1%
Heartland	$2,079,000	2%
North Carolina to West Virginia	$800,000	1%
North-South	$1,360,000	1%
Northern Virginia*	$7,534,020	6%
Seminole	$1,414,998	1%
Southside	$2,090,000	2%
Washington to North Carolina	$40,686,823	35%
Western Mountain*	$0	0%
TOTAL:	**$116,630,212**	**100%**

* Corridors with recent active traffic management system deployments

A comprehensive listing of all projects is included in Appendix C to this document. The final scoring and ranking of projects is included in Appendix D.

Benefits of a Comprehensive Transportation Technology Plan

Virginia has applied technology solutions to improving mobility and achieved several successes. Four (4) notable achievements include:

- **Reducing the median duration of incident from 52 minutes to 48 minutes**. This reduction was largely achieved by expanding safety service patrols while expanding camera coverage and message signs to monitor and manage events. Reducing the length of incident can also reduce congestion when travel lanes open sooner and improve safety.
- **Reducing the vehicle hours of delay on I-95 in Prince William and Fairfax counties** in fiscal year 2015 by using technologies with the I-95 HOT lanes. Over 400,000 hours or $9.2M was saved in FY15.
- **Increasing use of 511 traveler information website by 30% in past 3 years.** Travelers are more aware of traffic conditions and can adjust their travel accordingly.
- **Improving arterial travel time by 10% to 25%.** Deployment of Adaptive Signal Control Technology (ASCT) on 13 corridors across Virginia in the past five (5) years also improved reliability by nine (9) percent and reduced total crashes by 17 percent on average on these key arterial corridors.

Recent studies posted in the United States Department of Transportation Intelligent Transportation Systems Joint Programs Office Cost/Benefits Database state:

- Adaptive signal control systems installed on two corridors in Colorado improved weekday travel times 6 to 9 percent (2012).
- A Bay Area Rapid Transit (BART) smart parking system encourage 30 percent of surveyed travelers to use transit instead of driving alone to their place of work (2008).
- Connected vehicle technologies can improve roadway capacity by 20 percent (2011).

Direct quantification of all technologies benefits is challenging. As road conditions improve, travelers adjust their commutes to use the most efficient route possible. Also, additional data sources are just becoming available to analyze events and programs. However, as shown with the three above examples, technology has a positive impact on improving mobility. For this reason, while HJR122 requests a five year plan, this report includes actions and activities beyond the five year planning period.

Strengths of the Transportation Technology Plan

In response to HJR 122, VDOT and its agency partners developed a Transportation Technology Plan that meets the goals and objectives of the Commonwealth. This plan:

1. Supports *VTRANS 2040*
2. Takes a corridor-based approach, focusing on Corridors of Statewide Significance
3. Supports multimodal travel
4. Considers both rural and urban needs

In addition, the new projects in the Transportation Technology Plan fit into an on-going, multi-agency transportation technology program. Currently, VDOT, DRPT and DMV have more than $45,000,000 in active transportation technology projects. The Transportation Technology Plan, then, represents the future of the transportation technology program in the Commonwealth of Virginia.

TRANSPORTATION TECHNOLOGY PLAN GOALS

Transportation technology is referred to as Smart Roadway Technology or High Tech Infrastructure Improvements. Per the *Code of Virginia*, High Tech Infrastructure Improvements, sometimes referred to as Smart Roadway Technology, means those projects or programs that reduce congestion, improve mobility, improve safety, provide up-to-date travel data, or improve emergency response. These technologies are often developed, deployed and used by transportation operations programs. The development of these statewide transportation technology goals and their plan of action considered the role of transportation operations, the importance of multi-modalism, and need for geographic parity.

Transportation Operations in Virginia

Operations pertain to actively managing the Commonwealth's roadways. They involve monitoring conditions on highways and arterials, and employing a host of strategies and technologies to improve safety, enhance mobility, and respond promptly to incidents. Operations involve transportation stakeholders and jurisdictions working collaboratively to optimize roadway performance. They also focus on furnishing timely, reliable information to travelers so that they, too, can be part of the solution. As the operations program matures, the emphasis is, increasingly, on managing interrelated traffic "corridors," rather than individual roadways.

The Virginia Department of Transportation (VDOT) has an established operations program. In carrying out its operations activities, VDOT routinely employs advanced and often innovative technologies. Five VDOT operations regions manage and deliver the statewide transportation operations program. Each region maintains a transportation operations center (TOC) and uses technology to (1) monitor regional traffic and travel conditions, (2) facilitate incident and weather event management, (3) operate and coordinate traffic signals, and (4) disseminate information to travelers.

The Research Council, a partnership between VDOT and the University of Virginia, is responsible for researching emerging transportation technologies. The Virginia Tech Transportation Institute (VTTI) also contributes significantly to the emerging technologies effort, particularly in the area of "connected vehicles."

DRPT focuses on rail and public transportation operations and commuter services; it encourages local and regional transit agencies to make ongoing use of innovative technologies. DMV oversees much of the commercial vehicle safety activity across the State, including the weighing and inspection of large trucks.

Multi-Modalism

The capacity of the Virginia transportation network to move people and goods encompasses all modes of transportation, including highways, transit, bicycles, and pedestrian travel. Consequently, this Plan takes account of technologies that facilitate integrated, multi-modal transportation system management and operations.

Transportation Technology Goals

Transportation technologies are tools for operations programs. The premise for the Transportation Technology Plan goals is to use the appropriate technologies to achieve on-going operations goals. Several key documents contributed to the development of this Plan and its goals, including the Office of the Secretary of Transportation's *VTRANS 2040 Vision* and Office of Intermodal Planning and Investment *Corridors of Statewide Significance Needs Assessments*, *VDOT's FY16 Business Plan*, and *DRPT's Strategic Plan*. Additionally, House Bill 2 (HB2), *Statewide Prioritization Process for Project Selection,* was considered for the purposes of defining projects to support the goals which will be consistent with the selection process specified in HB2, and evaluating projects in relation to their impacts on safety and congestion.

Three technology goals (and their source document) are:

- **Operate:** (VDOT FY16 Business Plan) Ensure efficient use of the existing transportation system and services to meet customer demand and expectations of a system that is safe and reliable, and enable the easy movement of goods and people across all modes. Per the VDOT FY16 Business Plan, the goal includes integrated corridor management, integration of system performance and safety data, intelligent transportation systems (ITS), park and ride intermodal facilities, tunnel and moveable bridges management, traveler information and support systems, and incident management.
- **Optimize:** (VDOT FY16 Business Plan) Use a systematic, needs-based process to effectively manage our assets, preserve and maintain the condition of the transportation system, and safely optimize existing resources.
- **Support:** (VDOT FY16 Business Plan) Efficiently and effectively provide the appropriate tools, guidance, and processes that enable core programs and services to meet their objectives. Per the FY16 Business Plan, this goal includes areas such as information technology, research, tolling, safety, and business transformation.

The objectives associated with each of the three TTP goals are identified in Table 1.

Table 1: Transportation Technology Plan – Mission, Goals and Objectives

Mission: Keep Virginia Moving (Using Technology)	
Goals	**Objectives**
OPERATE	
Ensure efficient use of the existing transportation system and services to meet customer demand and expectations of a system that is safe and reliable, and enable the easy movement of goods and people across all modes.	1. Increase mobility by improving access to multimodal travel options 2. Improve transportation system efficiency by reducing the growth of vehicle hours of delay. 3. Improve transportation system efficiency by reducing the reliability buffer time index. 4. Reduce median duration of incidents.
OPTIMIZE	
Use a systematic, needs-based process to effectively manage our assets, preserve and maintain the condition of the transportation system, and safely ***optimize existing resources***.	5. Optimize existing system throughput by improving arterial operations, encouraging mode switch and providing better information to travelers.
SUPPORT	
Efficiently and effectively provide the appropriate tools, guidance, and processes that enable core programs and services to meet their objectives.	6. Accelerate deployment of projects with near-term benefits

Technology is a primary tool for transportation operations programs. Therefore, the Transportation Technology Plan focuses on using technologies to meet the intent of House Joint Resolution 122 and moving people, goods, and services as efficiently, safely, and conveniently as possible. The three selected goals for the Transportation Technology Plan are derived from the most relevant goals of the FY16 *VDOT Business Plan*.

DEVELOPMENT OF VIRGINIA'S TRANSPORTATION TECHNOLOGY PLAN

Virginia's Transportation Technology Plan was developed by the Virginia Department of Transportation (VDOT) in cooperation with the Department of Rail and Public Transportation (DRPT) and the Department of Motor Vehicles (DMV) in response to HJR 122.

Development of Virginia's Transportation Technology Program

In addition to the broad program goals and objectives identified in HR 122, this Plan was developed to support the *VTRANS 2040* Guiding Principles for Transportation Investments in Virginia, specifically #4:

1. Optimize return on investment
2. Ensure safety, security and resiliency
3. Efficiently Deliver Programs
4. Consider operational improvements and demand management first
5. Ensure transparency and accountability and promote performance management
6. Improve coordination between transportation and land use
7. Ensure efficient intermodal connections

    - Guiding Principle 4 further seeks to maximize capacity of the transportation network through increased use of technology and operational improvements as well as managing demand for the system before investing in major capacity expansions. Focusing on enhancing system performance through technology and user information is a prudent way to increase the efficiency of our current system in light of future constraints and uncertainties

This focus will require close coordination with multiple external partners, including:

- DRPT
- DMV
- Localities
- Transit service providers
- Transportation Management Agencies
- Metropolitan Planning Organizations
- Non-motorized transport advocates

Past and Future Transportation Technology Program Successes

Virginia has achieved a number of successes in the past few years utilizing technology to improve transportation system operations. Recent successes include:

- Coordinated operations between VDOT's Northern Region TOC and the I-95 HOT lanes traffic operations center which contributed to the seamless start-up operation of those facilities; decreasing Vehicle Hours of Delay in the region by 400,000 hours in a single year and saving $9,276,000 per year.

- Integration with the Virginia State Police computer aided dispatch system. This integration, combined with expanded CCTV and Safety Service Patrol coverage, contributed to a decrease in incident clearance time from 52 minutes to 48 minutes over four (4) years
- Strong public support for the Reach the Beach travel time sign program, and its expansion to other destinations in the I-64 corridor; currently 13 signs, soon to be 20
- Annual increases in 511 usage by the public to obtain real-time information on road conditions; greater than 50% increase in web and mobile usage over the past three (3) years
- Expansion of 511 to include streaming video, multimodal travel options and point-to-point travel time comparisons; nearly 1,000 streaming traffic cameras now on-line
- Deployment and testing of adaptive signal control technology at more than 100 intersections on key arterials statewide to improve traffic flow; improving mobility in several small to medium size communities such as Winchester and Lynchburg
- The addition of more than 3,000 miles of fiber optic cable to the VDOT network via shared resource agreements with the private sector; valued at approximately $400,000,000
- The deployment of approximately 50 roadside detectors in support of connected vehicle testing and evaluation; VDOT is the lead agency in the national Connected Vehicle Pooled Fund Study

Current transportation technology program activities include:

- Implementation of the I-66 Active Traffic Management (ATM) project; providing dynamic lane assignment and other technologies to improve facility safety, reliability and throughput
- Implementation of the I-64 ATM project; improving safety on Afton Mountain
- Implementation of the I-77 ATM project; improving safety at Fancy Gap
- Continue deployment of adaptive signal control technology on key arterials
- Deployment and testing of automated signal performance metrics in Salem and Culpeper Districts
- Deployment and testing of advanced transportation controllers in Northern and Southwest Operations Regions
- Electronic credentialing and weigh-in-motion system deployment by DMV
- Transit signal priority system for the Richmond bus rapid transit project by DRPT

Moving forward under this proposed Transportation Technology Plan, Virginia will see:

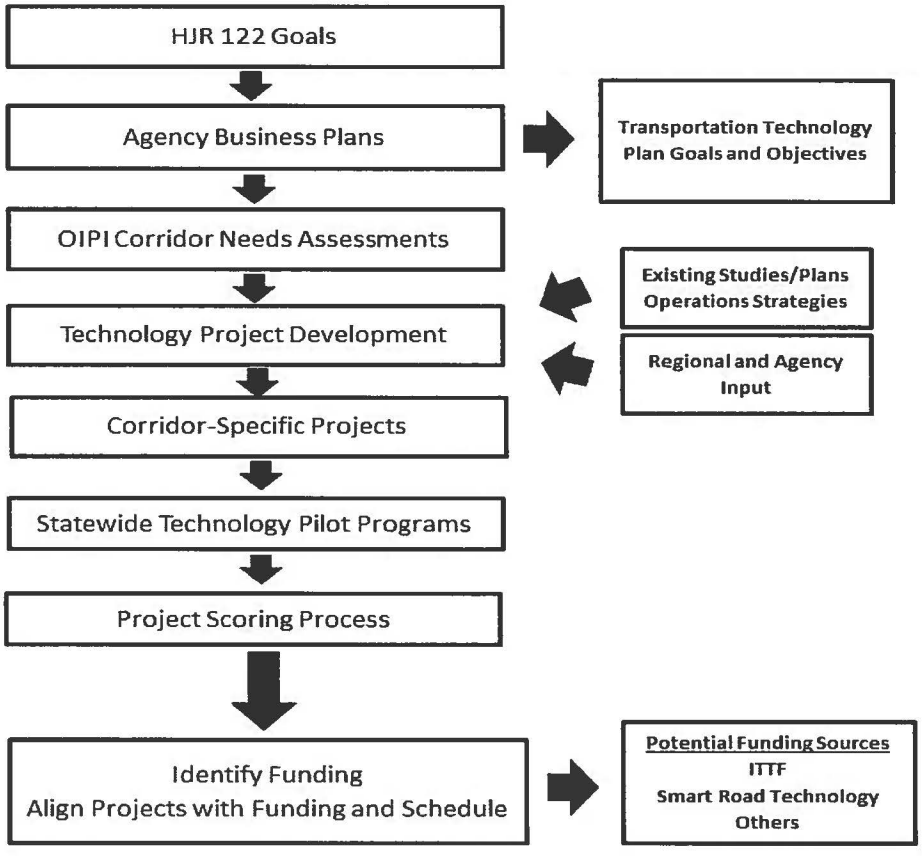
- Implementation of key elements of the I-95/I-395 Integrated Corridor Management Program; bringing together multiple technologies and services in a corridor-wide, multimodal approach to improve travel times, modal choice and facility throughput
- Development of a Northern Region East-West Corridor (I-66) Integrated Corridor Management Program by adding improved arterial operations on parallel facilities, support for improved transit operations and integration with localities for improved operations
- Deployment of smarter signal control technology on more than 2,000 miles of major arterial routes statewide, increasing their throughput and attractiveness as non-Interstate travel options
- Deployment of technologies to improve the safety and efficiency of bus, bicycle and pedestrian travel in urban areas; facilitating mode switch away from single-occupancy vehicles

- Implementation of dynamic parking signage; to provide motorists with real-time information on parking availability at VDOT Park & Ride lots and Washington Metropolitan Area Transit Authority (WMATA) rail stations
- Expansion of the travel time destination signage program; offering this popular service to motorists in major metro areas statewide
- Continued preparations for future mobility solutions such as connected and autonomous vehicles; ensuring Virginia stays at the forefront of these revolutionary technologies.

Identifying Programs and Projects to Support Transportation Technology Plan Objectives

Projects identified for inclusion in the plan were developed by VDOT, DRPT and DMV staff to support the goals of HJR 122, agency business plan goals, and specific needs identified in the *Corridors of Statewide Significance Needs Assessments* prepared by the Office of Intermodal Planning and Investment. Figure 1 illustrates the high-level project selection process.

Figure 1: Project Development and Scoring Process



Based on the requirements of HJR 122, staff reviewed each of the twelve (12) *Corridors of Statewide Significance Needs Assessments* to identify transportation technology projects to support the identified corridor needs. This review produced projects focused on specific needs of Corridors of Statewide Significance as well as set of Statewide Programs that will support needs across multiple Corridors (see Appendix C).

Using Corridors of Statewide Significance Needs Assessment Data to Support Project Development

To develop specific projects for the Transportation Technology Plan, each of the twelve (12) *Corridors of Statewide Significance Needs Assessment* were evaluated to identify potential technology solutions to identified corridor needs. In addition, specific data on each corridor segment was used to support project identification. Data included

- Availability of modal options
- Availability of redundant facilities
- Safety
- Person hours of delay
- Freight-ton hours of delay
- Weekday peak period reliability

VDOT has identified eight (8) potential operations strategies to apply toward resolving critical statewide and corridor needs. These eight (8) operations strategies are used to categorize and summarize the current and upcoming transportation technologies that will be used to achieve the above goals. The eight strategies are:

1. Enhance operations traffic management
2. Strengthen incident and emergency response
3. Support multimodal travel
4. Manage arterials
5. Furnish traveler information
6. Support commercial vehicle/freight activity
7. Conduct emerging technology research
8. Enhance enabling technology infrastructure

These operations strategies are summarized using the following parameters:

- *Description.* Defines the operations strategy, including specification of the subsets of technology under each strategy.

- *Applicable Technologies.* Examples of technologies associated with the strategy are indicated.

- *Existing Practice.* Highlights key trends and activities in the Commonwealth, under each strategy, that have occurred to date.

- *Desired Five-Year Level of Capability.* Broadly describes what VDOT and its partners anticipate achieving, under each strategy, over the next five years.

- *Actions.* Identifies the key five-year actions needed to move from "existing practice" to "desired five-year level of capability." Some actions may be subject to the availability of funding.

- *Expected Outcomes.* Summarizes the general impacts anticipated once the specified actions are completed.

- *Expected Benefits.* Summarizes the benefits anticipated once the specified actions are completed.

- *Costs.* Estimated costs to implement key elements of each strategy are identified.

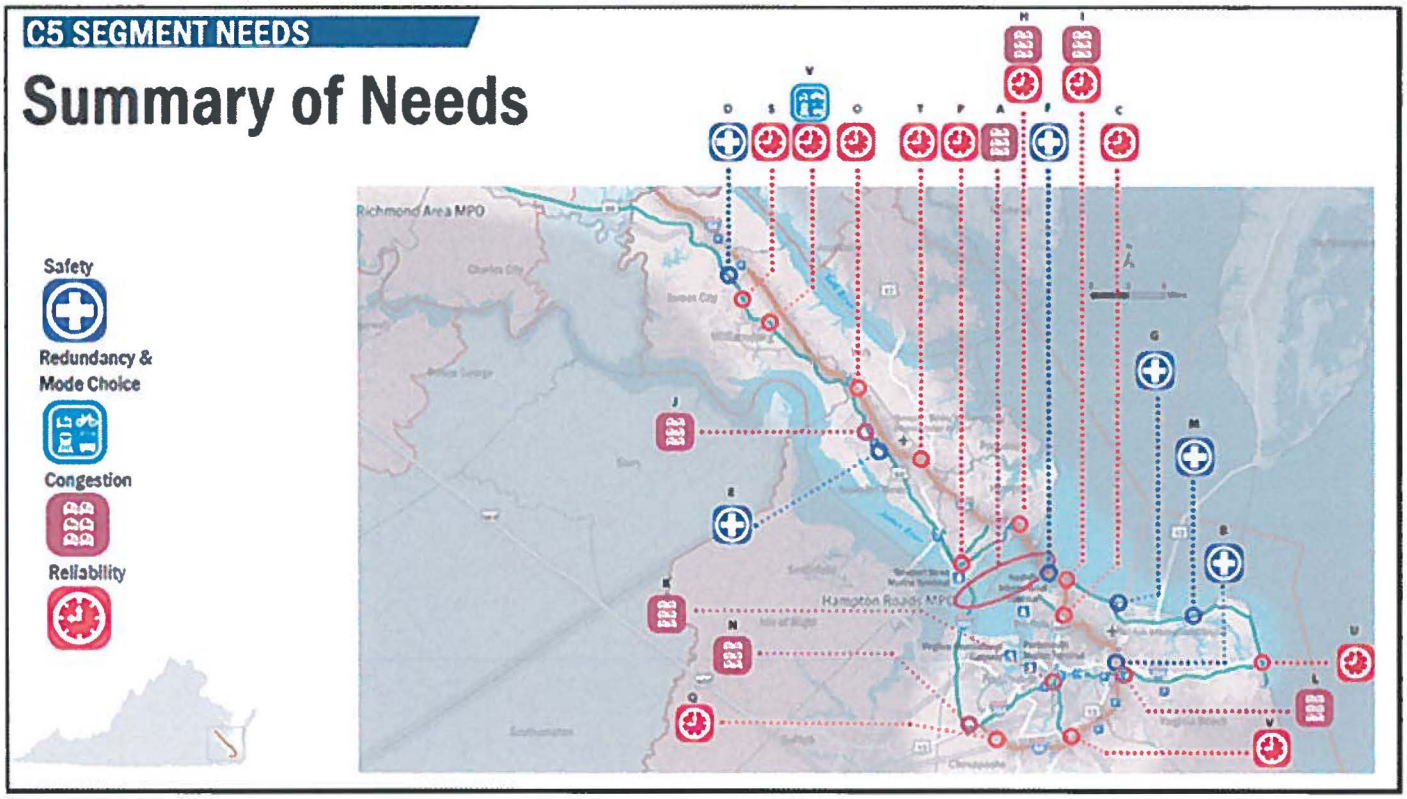
Using the data reported on these measures and the corridor needs identified in the Corridor Needs Assessments, staff identified specific technology projects to improve reliability, safety and throughput on 31 of 39 corridor segments (See Figure 2 below for example of correlating Corridor Needs into specific technology projects). Technology solutions were not applicable for eight (8) corridor segments. In addition, several statewide technology programs and pilot efforts have identified to meet broad TTP goals and objectives across multiple corridors. The statewide technology programs focus on high-priority agency initiatives and key multimodal technology pilot programs.

In order to develop a rank ordered list of project priorities, VDOT developed a project scoring process based on the goals and objectives of the Transportation Technology Plan. Project scoring criteria included:

- Support for multimodal travel
- Support for incident management
- Reduction in vehicle hours of delay
- Reduction in buffer time index
- Optimization of corridor throughput
- Project readiness

While safety was not an explicit criterion for scoring projects, safety data was considered when selecting corridor segments for technology applications and in the selection of the type of strategy to improve travel on that corridor segment.

Figure 2:
Example: East-West Corridor Segment 5 Summary of Needs



Corridor Needs

Item	Need
A	Congestion between I-64 Hampton & Norfolk
D	US60 between Lightfoot Rd & Rt 612 - crashes
F	Severe crashes – south end of HRBT
I	I-64 HRBT to I-564 significant delay
P	Delay near I-64 MMMBT

Project Identification

Technology Project	Addressed Need
I-64 Active Traffic Management	A, I
US60 Arterial Oper	A, D
HRBT Tunnel Traffic & Safety System	F
I-64 HRBT Over-height Detectors	I
MMMBT Tunnel Traffic & Safety System	P

Using this process, all corridor-specific projects were scored and then ranked in descending order to obtain a rank ordered list of priority projects. Table 2 illustrates the top ten (10) ranked projects. A detailed description of the project scoring criteria is included in Appendix D to this document. Statewide programs were not included in the project ranking process due to the critical need for their implementation and their broad application to multiple corridors statewide.

Table 2: Top Ten Ranked Corridor-Specific Projects

VTrans2040 Corridor/Segment	Route	District*	Segment End Points	Selected Strategy	Selected Project	Project Description	Estimated Project Budget	Final Score	Funding Source **
Washington to NC Segment 3	I-95	NOVA/FR	Caroline / Spotsylvania CL Maryland Border	Multimodal	I-95/I-395 ICM Program: Multimodal Traveler Information	Electronic signage displaying roadway, transit and parking information to allow travelers to more easily change mode and route of travel	$ 5,700,000	10	ITTF
East-West Segment 5	I-64	HR	York / James City CL to I-264	Commercial Vehicle Operations	I-64 Integrated Overheight Detection Systems	Deployment of technology to detect and divert overheight vehicles in advance of HRBT	$ 900,000	10	ITTF
East-West Segment 5	I-64	HR	York / James City CL to I-264	Arterial Operations	US60/US17/Rt. 143/199 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,560,000	10	ITTF
East-West Segment 5	I-64	HR	York / James City CL to I-264	Operations Traffic Management	HRBT Tunnel Traffic & Safety Improvements	Upgrade of existing lane control and tunnel traffic safety systems	$ 5,445,371	9	SRT
East-West Segment 5	I-64	HR	York / James City CL to I-264	Operations Traffic Management	I-64 Hampton Roads Active Traffic Management System: Phase 1 Westbound	Deployment of camera, sensor, lane control and variable speed limit technologies to actively manage westbound traffic approaching HRBT	$ 14,500,000	9	ITTF
Northern Virginia Segment 2	I-66	NOVA	Prince William / Fauquier CL to District of Columbia	Operations Traffic Management	Rosslyn Tunnel Traffic & Safety Improvements	Upgrade of existing lane control and tunnel traffic safety systems	$ 3,500,000	9	SRT
East-West Segment 5	I-64	HR	York / James City CL to I-264	Operations Traffic Management	MMMBT Tunnel Traffic & Safety Improvements	Upgrade of existing lane control and tunnel traffic safety systems	$ 7,000,000	9	ITTF
Washington to NC Segment 3	I-95	NOVA/FR	Caroline / Spotsylvania CL Maryland Border	Operations Traffic Management	I-95/I-395 ICM Program: Dynamic Ramp Metering	Upgrade of existing ramp metering system	$ 3,500,000	8	SRT
Washington to NC Segment 2	I-95	RIC/FR	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	Commercial Vehicle Operations	I-95 Integrated Overheight Detection Systems	Deployment of over-height vehicle detection technology to catch and divert overheight vehicles in advance of I-95 overpasses	$ 900,000	8	ITTF
Washington to NC Segment 2	I-95	RIC/FR	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	Operations Traffic Management	I-95 Richmond Active Traffic Management System	Deployment of dynamic lane control and ramp metering technologies	$ 6,035,000	8	ITTF

Implementation of the plan, then, is dependent on the availability of financial resources. There are several potential funding sources for the TTP including, but not limited to:

- Innovation Technology Transportation Fund (ITTF)
- Smart Road Technology Fund (Replaced by the ITTF as of 2014)
- Future High Priority Project Applications
- Future Federal Grants

VDOT will seek to implement top ranking corridor-specific projects in conjunction with the statewide programs through all available funding sources.

Table 3 summarizes the 5-year TTP program cost by program area.

Table 3: 5-Year Program Cost by Program Area

Operations Strategy	5-Year Cost	Percent of Total Cost
Corridor-Specific Projects	$116,630,212	79%
Statewide Programs and Pilots	$31,501,000	21%
TOTAL:	**$148,131,212**	**100%**

Table 4 summarizes the 5-year TTP program cost by operations strategy area.

Table 4: 5-Year Program Cost by Operations Strategy Area

Operations Strategy	5-Year Cost	Percent of Total Cost
Operations Traffic Management	$59,020,371	40%
Incident Management	$9,000,000	6%
Multimodal	$17,800,000	12%
Arterial Management	$45,936,841	31%
Traveler Information	$6,700,000	5%
Enabling Technologies	$4,874,000	3%
Commercial Vehicle Operations	$4,800,000	3%
Emerging Technology Research [2]	$0	0%
TOTAL:	**$148,131,212**	**100%**

[2] Emerging technology research not included as a funded TTP element as funding is focused on technology deployment and not research activities.

Table 5 summarizes the 5-year TTP program cost by Corridor of Statewide Significance.

Table 5: 5-Year Program Cost by Corridor of Statewide Significance

COSS	5-Year Cost	Percent of Corridor Cost
Coastal	$4,220,000	4%
Crescent	$15,692,000	13%
East-West*	$40,183,371	34%
Eastern Shore	$570,000	1%
Heartland	$2,079,000	2%
North Carolina to West Virginia	$800,000	1%
North-South	$1,360,000	1%
Northern Virginia*	$7,534,020	6%
Seminole	$1,414,998	1%
Southside	$2,090,000	2%
Washington to North Carolina	$40,686,823	35%
Western Mountain*	$0	0%
TOTAL:	**$116,630,212**	**100%**

* Corridors with recent active traffic management system deployments

A comprehensive listing of all projects is included in Appendix C to this document. The final scoring and ranking of projects is included in Appendix D.

Benefits of a Comprehensive Transportation Technology Plan

Virginia has applied technology solutions to improving mobility and achieved several successes. Four notable achievements include:

- **Reducing the median duration of incident from 52 minutes to 48 minutes**. This reduction was largely achieved by expanding safety service patrols while expanding camera coverage and message signs to monitor and manage events. Reducing the length of incident can also reduce congestion when travel lanes open sooner and improve safety.
- **Reducing the vehicle hours of delay on I-95 in Prince William and Fairfax counties** in fiscal year 2015 by using technologies with the I-95 HOT lanes. Over 400,000 hours or $9.2M was saved in FY15.
- **Increasing use of 511 traveler information website by 30% in past 3 years.** Travelers are more aware of traffic conditions and can adjust their travel accordingly.
- **Improving arterial travel time by 10% to 25%.** Deployment of Adaptive Signal Control Technology (ASCT) on 13 corridors across Virginia in the past five (5) years also improved reliability by nine (9) percent and reduced total crashes by 17 percent on average on these key arterial corridors.

Recent studies posted in the United States Department of Transportation Intelligent Transportation Systems state:

- Adaptive signal control systems installed on two corridors in Colorado improved weekday travel times 6 to 9 percent (2012).
- A Bay Area Rapid Transit (BART) smart parking system encourage 30 percent of surveyed travelers to use transit instead of driving alone to their place of work (2008).
- Connected vehicle technologies can improve roadway capacity by 20 percent (2011).

Direct quantification of all technologies benefits is challenging. As road conditions improve, travelers adjust their commutes to use the most efficient route possible. Also, additional data sources are just becoming available to analyze events and programs. However, as shown with the three above examples, technology has a positive impact on improving mobility. For this reason, while HJR122 requests a five year plan, this report includes actions and activities beyond the five year planning period.

Strengths of the Transportation Technology Plan

In response to HJR 122, VDOT and its agency partners developed a Transportation Technology Plan that meets the goals and objectives of the Commonwealth. This plan:

1. Supports *VTRANS 2040*
2. Takes a corridor-based approach, focusing on Corridors of Statewide Significance
3. Supports multimodal travel
4. Considers both rural and urban needs

In addition, the new projects in the Transportation Technology Plan fit into an on-going, multi-agency transportation technology program. Currently, VDOT, DRPT and DMV have more than $45,000,000 in active transportation technology projects. The Transportation Technology Plan, then, represents the future of the transportation technology program in the Commonwealth of Virginia.

TECHNOLOGY STRATEGIES

The goals and objectives in the Plan are addressed by the following eight sets of technology strategies:

1. Enhance operations traffic management
2. Strengthen incident and emergency response
3. Support multimodal travel
4. Manage arterials
5. Furnish traveler information
6. Support commercial vehicle/freight activity
7. Conduct emerging technology research
8. Enhance enabling technology infrastructure

The remainder of this section of the Plan summarizes the eight technology strategies using the following parameters:

1. *Description.* Defines the technology strategy.
2. *Applicable Technologies.* Lists examples of technologies associated with the strategy.
3. *Existing Practice.* Highlights activities in the Commonwealth, under each strategy, that have occurred to date.
4. *Desired Five-Year Level of Capability.* Broadly describes what VDOT and its partners anticipate achieving, under each strategy, over the next five years.
5. *Actions.* Identifies the key five-year actions needed to move from "existing practice" to "desired five-year level of capability." Some actions may be subject to the availability of funding.
6. *Expected Outcomes.* Summarizes the general impacts anticipated once the specified actions are completed.
7. *Expected Benefits.* Summarizes the benefits anticipated once the specified actions are completed.
8. *Costs.* Estimated costs to implement key elements of each strategy are identified.

Strategy 1: Enhance operations traffic management

DESCRIPTION

Operations traffic management is a group of technology-based initiatives to manage and redistribute traffic across multiple parallel freeways, arterials, and transit systems. The concept focuses on optimizing performance on existing transportation facilities, using technology to monitor and respond to changing traffic conditions, and to furnish real-time information and guidance to travelers. During peak travel periods, travelers may be encouraged to consider changing routes or modes such as traveling on a parallel highway when the interstates have incidents, or utilizing transit, ridesharing, or telecommuting. To succeed, operations traffic management must be reliable; the public expects that travel information and their experiences will be reasonably predictable and that they will arrive at their destinations on time.

Operations traffic management strategies support TTP program goals for improving system efficiency and increasing reliability.

Operations traffic management encompasses the following technology initiatives:

- *Integrated Corridor Management (ICM).* Utilizes a corridor-wide, multimodal approach to traffic demand management. Rather than focus on roadways individually, ICM seeks to operate and optimize the roads and transit systems in the region as an integrated corridor.
- *Active Traffic Management (ATM).* A key element of ICM that focuses on traffic and safety management on a key road, such as the interstate. ATM uses technology to monitor and manage lane-by-lane conditions and shares this information and options to travelers.
- *Managed Lanes/HOV Lanes/Hard-Shoulder Running and Ramp Metering.* A part of ATM that monitors traffic conditions on specific lanes to either provide additional, temporary capacity or manage traffic better.
- *Open-Road Tolling.* Supports the electronic collection of tolls using vehicle transponders. The technology enables tolls to be collected while vehicles are traveling through the toll "readers" at near highway speeds.
- *Arterial management*, which also supports operations traffic management, is a separate strategic category in this plan.

APPLICABLE TECHNOLOGIES

Key technologies that support operation traffic management include the following:

- *Traffic cameras*
- *Vehicle detectors*
- *Parking sensors*
- *HOV gates*
- *Electronic message signs*
- *Fog visibility sensors*
- *Fiber optic and wireless communications*
- *Toll-tag readers*
- *Tunnel traffic & operational systems*
- *Automatic vehicle identification systems*
- *Automated vehicle location systems*
- *Transportation management software*
- *Variable speed limit systems*
- *Dynamic ramp metering systems*
- *Queue warning systems*
- *Lane control signs*
- *Mobile applications*
- *Advanced traffic counters*

EXISTING PRACTICE

Intelligent Transportation System (ITS) technologies are located primarily on the interstates across the Commonwealth. These devices, including traffic cameras, vehicle detectors, weather stations, fog visibility sensors, signage, are routinely used to monitor roadway conditions, verify incidents, and provide information to travelers. Messages to travelers are shared on electronic message signs, 511 *Virginia*, and highway advisory radios. The messages include traffic conditions, severe weather warnings, special event notices, roadway closures, guidance on

alternative routes during incidents and heavy congestion, and estimated travel times.
Table 6 lists the current quantities of important ITS technology.

Table 6: 2014 Quantities of Intelligent Transportation System Devices

VDOT Region	Cameras	Message Signs	Vehicle Detectors	Road Weather Information Systems	Highway Advisory Radios
Central (Richmond)	54	34	0	0	6
Eastern (Hampton Roads)	290	214	226	6	23
Northern	289	216	299	20	16
Northwest	123	48	19	7	0
Southwest	197	93	0	27	18
Total	**953**	**605**	**544**	**60**	**63**

Figure 3 shows the location of cameras and message signs.

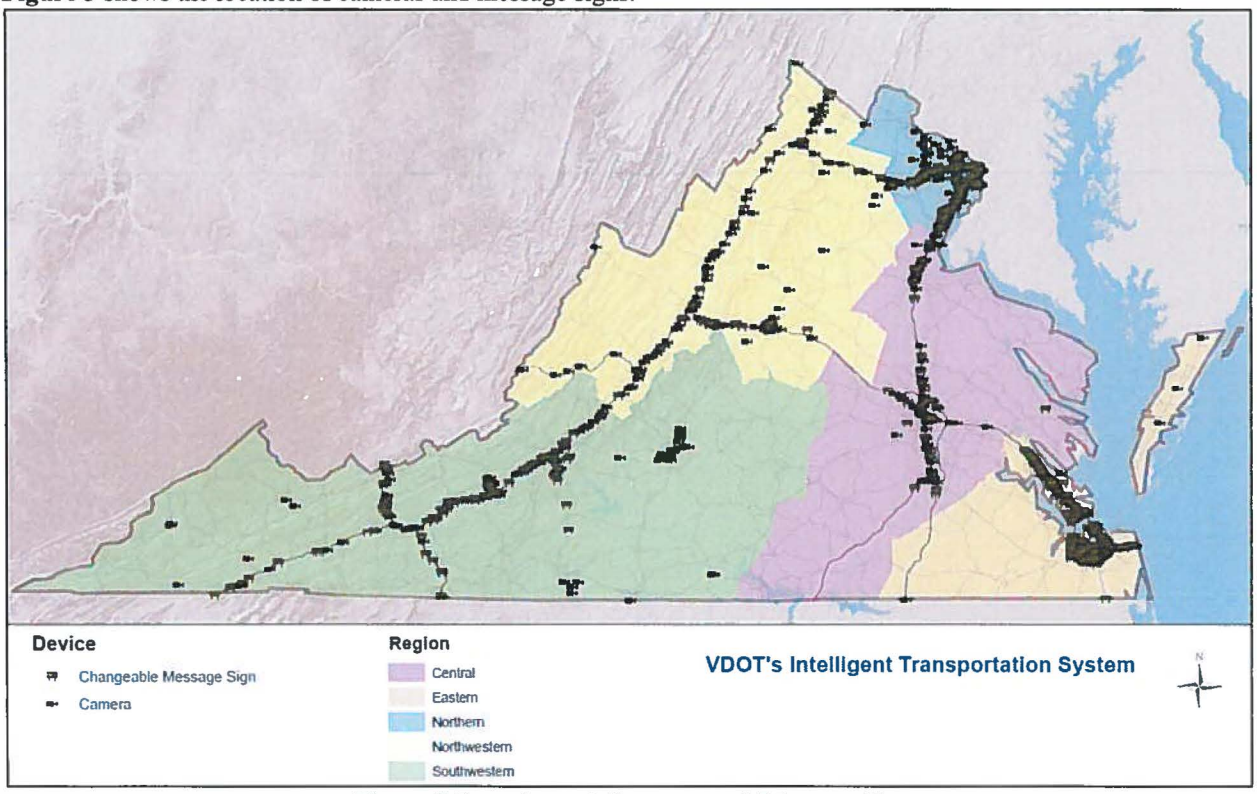


Figure 3 Locations of Cameras and Message Signs

Virginia has developed concepts of ICM, ATM, managed lanes, and parking management in various parts of the state. Planning studies, pilot projects, and deployment projects are underway. An ATM system has been deployed on I-66 in Northern Virginia from Washington DC to Gainesville. Variable speed limit ATM projects are being designed and constructed for I-64 on Afton Mountain and I-77 on Fancy Gap Mountain. Real-time travel estimates are now posted on electronic message signs on interstates in several parts of the state. Work is also underway to study the accuracy of technologies that measure travel time on arterials. VDOT is also now posting comparative travel times for alternative routes in the Northern Virginia Region and in Hampton Roads, the Reach the Beach program. Hard shoulder running is in use on I-66 in Northern Virginia. Ramp metering is being used along I-395 in Northern Virginia to manage traffic

Strategy 1: Enhance operations traffic management

moving from arterials to interstates during congested periods. Reversible HOV lanes are present on I-64 in Norfolk and I-95 in Northern Virginia.

With respect to the tunnel program, lane control systems, supporting traffic management systems, and fire and life systems are present at all underwater crossings in Hampton Roads. Improvements are being designed for the I-66 urban Rosslyn Tunnel.

Open-road tolling, where all tolls are electronically collected, has been implemented on facilities in Hampton Roads, Richmond, and Northern Virginia. Several facilities in Virginia now exclusively use open-road tolling technology including the Pocahontas Parkway, I-495 Express Lanes, and the just-opened I-95 Express Lanes.

The transportation operations center (TOC) operates and controls the operations traffic management technology and devices located in the field. There are five regional transportation operation centers across the Commonwealth. The annual operating budget for the transportation operation centers and technologies is $28.2 M.

DESIRED FIVE-YEAR LEVEL OF CAPABILITY

The next level of capability will involve expanding the Integrated Corridor Management efforts, Active Traffic Management efforts, and to provide targeted technology resources along the VTRANS Corridors of Statewide Significance. VDOT and its partner agencies will continue implementing technology strategically with priorities that reflect the goals and priorities to make travel safer and more predictable for Virginia's citizens.

A corridor-based approach will be used. Rather than consider the travel conditions on separate roads, all facilities, including transit facilities, in a given region will be viewed as one transportation network. Improvements in the ease-of-use and convenience of transit, ridesharing, and parking may be expected to contain the growth of the number of vehicles on the interstates and arterials. As the ability to detect and anticipate problems improves, VDOT expects to be able to respond faster to incidents and adverse conditions. An increasing capability to deliver real-time information to travelers, with an emphasis on actionable information to help the traveling public make informed travel choices, is expected to contribute to improved reliability. Predictive capabilities will also be developed to support real-time operations and enhance traveler information.

ACTIONS

Currently Funded Initiatives:

- I-64 Active Traffic Management Program
- I-66 Active Traffic Management Program
- I-77 Active Traffic Management Program
- Arterial diversion route signing

New Initiatives:

- **I-81 Operational Improvements:**
  - Deployment of critical traffic monitoring and incident detection technologies on the I-81 corridor to improve safety and throughput
- **I-64 Richmond Active Traffic Management System**
  - Deployment of dynamic lane control and dynamic ramp metering technologies to improve safety and throughput on the I-64 corridor in Richmond
- **I-95 Richmond Active Traffic Management System**
  - Deployment of dynamic lane control and dynamic ramp metering technologies to improve safety and throughput on the I-95 corridor in Richmond

Strategy 1: Enhance operations traffic management

- **Richmond TOC Upgrade**
  - Upgrade of Richmond TOC and colocation with Virginia State Police
- **I-64 Hampton Roads Active Traffic Management System**
  - Deployment of integrated technologies to actively manage traffic in and around the congested HRBT facility
- **Monitor Merrimac Memorial Bridge Tunnel Traffic & Safety Improvements**
  - Upgrade of existing lane control and tunnel traffic safety systems to improve throughput and reduce bottlenecks at this critical bridge & tunnel facility
- **Hampton Roads Bridge Tunnel Traffic & Safety Improvements**
  - Upgrade of existing lane control and tunnel traffic safety systems to improve throughput and reduce bottlenecks at this critical bridge & tunnel facility
- **Rosslyn Tunnel Traffic & Safety Improvements**
  - Upgrade of existing lane control and tunnel traffic safety systems to improve throughput and reduce bottlenecks at this critical tunnel facility
- **I-95/I-395 ICM Program: Dynamic Ramp Metering**
  - Upgrade of existing ramp metering system to improve safety and traffic flow
- **I-95/I-395 ICM Program: Decision Support System**
  - Software decision support system to integrate all ICM elements in the I-95/I-395 corridor

EXPECTED OUTCOMES

These general outcomes are anticipated:

- Improved trip reliability to promote efficiency.
- Reduced travel times along corridors to promote convenience and efficiency.
- More efficient use of the total corridor capacity.
- Reductions in the number of secondary incidents.

EXPECTED BENEFITS

- 1% - 5% reduction in delay
- 3% - 11% improvement in travel time reliability
- 3% to 22% increase in overall capacity
- 40% - 50% decrease in secondary accidents

COSTS

Project	COSS	Currently Funded	5 Year Cost	Future Priorities
I-81 Operational Improvements	Crescent	$0	$5,000,000	$0
I-64 Richmond Active Traffic Management System	East-West	$0	$3,240,000	$0

Strategy 1: Enhance operations traffic management				
I-95 Richmond Active Traffic Management System	Washington to NC	$0	$6,035,000	$0
Richmond TOC Upgrade	Washington to NC	$0	$10,000,000	$0
I-64 Hampton Roads Active Traffic Management System	East-West	$0	$14,500,000	$0
MMMBT Tunnel Traffic & Safety Improvements	East-West	$0	$7,000,000	$0
HRBT Tunnel Traffic & Safety Improvements	East-West	$0	$5,445,371	$0
Rosslyn Tunnel Traffic & Safety Improvements	Northern Virginia	$0	$3,500,000	$0
I-95/I-395 ICM Program: Dynamic Ramp Metering	Washington to NC	$0	$3,500,000	$0
I-95/I-395 ICM Program: Decision Support System	Washington to NC	$0	$800,000	$0
Arterial diversion route signing	Statewide	$3,500,000	$0	$0
I-66 Active Traffic Management [1]	Northern Virginia Connector	$9,987,876	$0	$0
I-64 Active Traffic Management [1]	East-West	$2,478,860	$0	$0
I-77 Active Traffic Management [1]	Western Mountain	$4,758,946	$0	$0
Total		**$20,725,682**	**$59,020,371**	**$0**

[1] Planned expenditures for FY16 only, not total cost of projects

Strategy 2: Strengthen incident & emergency response

DESCRIPTION

Incident management and emergency response primarily refers to the detection, response and clearance of incidents on the roadway. Incidents include collisions, disabled vehicles, weather-related events, emergencies, and man-made disasters.

Traffic congestion from incidents, such as crashes and disabled vehicles, weather, or emergency roadwork, has a significant impact on the mobility and safety of the roadways. The key goal of an incident management program is to reduce the response and clearance time for incidents while maintaining motorist and responder safety. Lowering the response and clearance time will prevent secondary collisions in traffic backups and improve mobility.

Incident management and emergency response strategies support the TTP program goal of reducing median incident duration.

Incident management and emergency response involves coordination between multiple agencies to clear the incident from the roadway quickly. Depending on the incident, the number of agencies involved in the event may be large or small. It requires continuous communications between the incident responders and the operators in the Transportation Operations Center (TOC). Traffic cameras help the TOC operators monitor the roadways, help determine the right resources to clear the event, and verify the location of an incident. The operators provide updates to the traveling public via electronic message signs, the 511 *Virginia* system and media.

Bridge/Tunnel Management. Special systems to monitor and manage traffic on bridges and in tunnels. This includes lane controls, carbon monoxide sensors, and fire and life safety systems.

Besides traffic incidents, *incident and emergency response* includes weather events, work zones and special events. Key activities include planning for such events, providing updated conditions to both the public and responders, coordinating information from different sources, and assisting with traffic control and rerouting.

APPLICABLE TECHNOLOGIES

Some of the key technologies used by incident management include:

- *Traffic Cameras*
- *Electronic Message Signs*
- *Private Sector Data Providers*
- *Computer Aided Dispatch Systems*
- *Automated Vehicle Location (AVL) Systems*
- *Mobile Applications*
- *Radio Communications*

EXISTING PRACTICE

VDOT's incident management program has many stakeholders that include local, state, and federal partners. Coordination with regional stakeholders such as police, emergency management services, fire departments, transit, metropolitan planning organizations and other agencies, requires regional incident management plans. Incident Management Coordinators are responsible for coordination between VDOT and other agencies during incidents, special events and emergencies.

The Transportation Operation Centers (TOC) operate and control technology and devices that are located in the field to maintain and manage traffic. These devices include closed circuit television cameras, message signs, vehicle detectors, and highway advisory radio (HAR). VDOT has established 5 regional TOC facilities across the Commonwealth:

- Central Region (Richmond);
- Eastern Region (Hampton Roads); and
- Northern Region (Fairfax).
- Northwest Region (Staunton);

- Southwest Region (Salem);

These TOCs are the main hub of the traffic management program in the state. Offices can have co-located responding agencies. In the Northern Region, public safety personnel (Virginia State Police (VSP), Fairfax County) are co-located with the TOC staff to increase the efficiency of incident response. VDOT recently awarded a statewide contract for TOC and SSP operations to bring consistency and interoperability to statewide incident management and transportation operations through technology, people and processes.

The Safety Service Patrols (SSP) are responsible for identifying and responding to incidents that occur on the roadway. Incidents include natural and man-made events. SSP operations are located throughout the state (see **Figure** 4). The TOC coordinates with the SSP to perform incident clearance and on-scene traffic management. The SSP also identifies incident locations, verifies incidents, monitors the impact of incidents, shares incident information with the TOC and other agencies, and assists in clearing the incident.

The TOC dispatches safety service patrollers, state maintenance forces and turnkey asset maintenance services. They provide two-way radio capability and monitor the Virginia State Police (VSP) radio and computer-aided dispatch (CAD) system for detecting incidents. Connections to local jurisdictions' CAD systems are expanding throughout the state. Table 7 lists the jurisdictions with connections. The TOC is notified of the location, number of lanes affected, incident severity, and other relevant information about the event. The TOC uses cameras to verify the incident and monitor traffic conditions in and around the event.

Table 7: Direct VDOT TOC to Locality Connections

VDOT Region TOC	Connected Jurisdiction
Eastern	Chesapeake Hampton James City County Newport News Norfolk Suffolk Virginia Beach York
Northern	Fairfax Stafford
Northwest	Albemarle Fauquier Frederick Harrisonburg
Southwest	Roanoke County

Strategy 2: Strengthen incident & emergency response

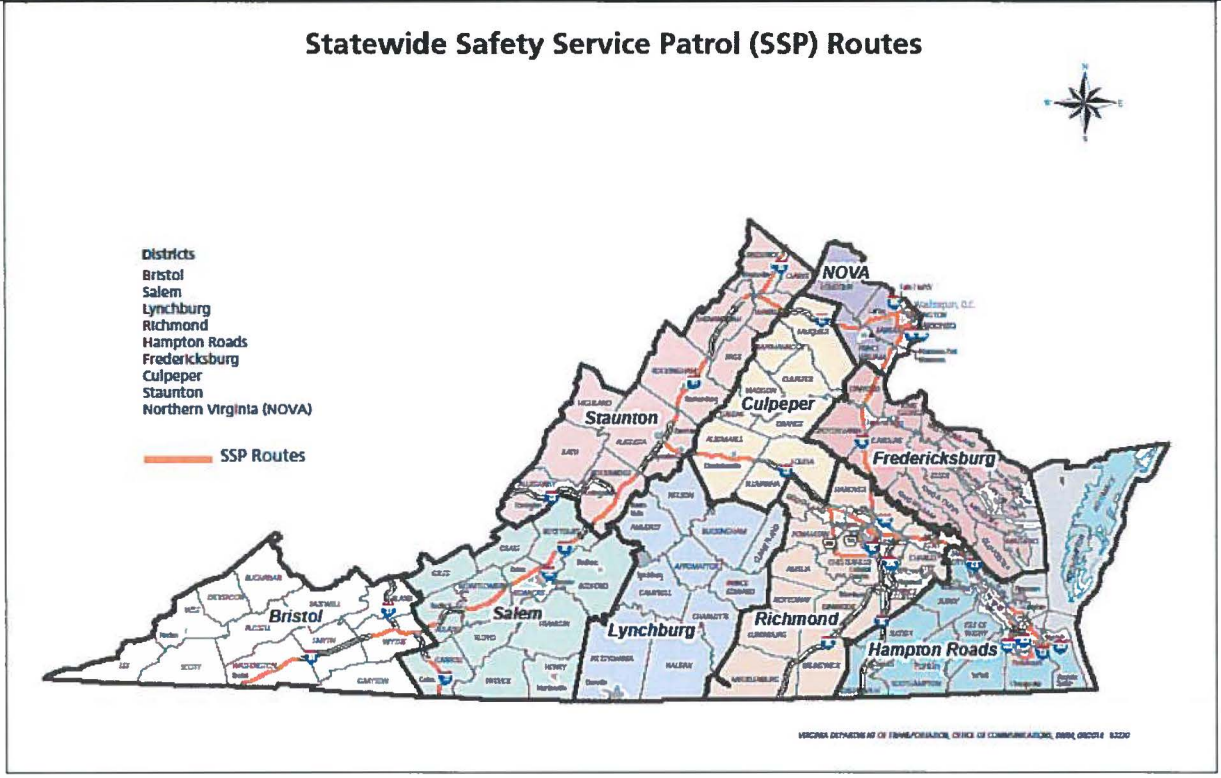


Figure 4 Safety Service Patrol Routes in Virginia

The incident information sharing responsibility mainly resides with the TOC; however, SSP shares information with other agencies' field staff such as police and fire personnel. During incidents in which traffic is expected to impact arterial corridors, TOC operators start the procedure to change traffic signal timing plans for altered traffic volumes and patterns. The TOC operators post incident alerts on message signs and provide incident information to private entities, media, statewide 511 services, social media sites, bordering state TOC's and other traveler information outlets.

DESIRED FIVE-YEAR LEVEL OF CAPABILITY

The next level of capability will be to minimize the impact of roadway incidents through improved emergency response efforts. Improvements include providing the right information and equipment to an incident or event to reduce its length and impact. Technologies will be applied to achieve this goal. As stated in VDOT's business plan, a corporate core performance metric is to reduce the median incident duration length one minute per year. VDOT desires to continue the median incident duration length reduction to have a five minute reduction in five years.

ACTIONS

Currently Funded Initiatives:

- Integration with local traffic operations centers
- Jamestown-Scotland Ferry signage

New Initiatives:

- **Integration of localities and Public Safety Answering Points (PSAPs)**: Integration of locality and PSAP operations centers with VDOT regional operations centers to improve incident response and management.
- **Apply technology to reduce incident clearance time.** Technology tools have become available to

Strategy 2: Strengthen incident & emergency response

shorten the incident clearance process. For major events, responders must survey and photograph a multivehicle collision. Advanced photography technologies exist to shorten this activity.

- **Pilot towing and recovery program.** Develop a program and identify the necessary equipment and technologies that support relocating large vehicles that are involved in incidents. VDOT is developing a Towing and Recovery Incentive Program (TRIP) as a solution to mitigate the congestion of tractor trailer incidents.

EXPECTED OUTCOMES

These general outcomes are anticipated:

- Improve safety through a reduction in secondary crashes.
- Reduce the time to respond to incidents.
- Improve coordinating and sharing data between agencies that respond to incidents. Having the right resources at the scene will reduce the length of an incident to improve safety and mobility.

EXPECTED BENEFITS

- 17% reduction in average incident duration by using SSP
- 50% – 60% of the delay attributable to incidents through a comprehensive incident management program

COSTS

Project	COSS	Currently Funded	5 Year Cost	Future Priorities
Integrate municipal TOC data/camera imagery to support integrated operations	Statewide	$408,000	$2,500,000	$1,000,000
Implement pilot towing and recovery program with private sector	Statewide	$0	$4,000,000	$1,000,000
Implement new technology to improve incident response and reduce clearance time	Statewide	$0	$2,500,000	$0
Jamestown-Scotland Ferry signage	East-West	$160,000	$0	$0
Total		**$568,000**	**$9,000,000**	**$2,000,000**

Strategy 3: Support for multimodal travel

DESCRIPTION

Transit is the service provided by operating vehicles that carry passengers from origin points to destination points. Traffic Demand Management (TDM) continues to be a vital element of the transit services provided, including formation of carpool and vanpools, guaranteed ride home, and traveler information. Together, transit and TDM services provided by operating vehicles carry passengers from origin points to destination points. Operations is a key function of transit and TDM service statewide. Technology applications for transit operations have helped the industry become more efficient and improve customer service. Technology applied to the vehicle, dispatch units and customer service interfaces is very relevant now and will continue to be in the future.

DRPT is the state agency that provides state funding, oversight and planning services for all public transit agencies in the Commonwealth. DRPT has completed a number of planning and strategic investments in oversight of transit technology for many years. Most recently DRPT led the Transit Service Delivery Advisory Committee (TSDAC) Performance-Based Funding Allocation Implementation Plan that recommends data collection standards, which will require a range of technology solutions to be implemented in collaboration with the transit agencies throughout the Commonwealth. Implementing the TSDAC data collection standards is an important step to more readily collect and rely on data, such as ridership, revenue hours and revenue miles as a performance measure for allocation of available state operating assistance funding.

DRPT is also supporting a number of projects statewide that utilize advanced technology such as the proposed Richmond Bus Rapid Transit line along Broad Street. This new service is proposed to implement transit signal priority to ensure good transit service is provided along the corridor.

In addition to technologies to improve transit travel times and reliability, new technologies are available to support bike and pedestrian travel.

A number of initiatives are included in this category; Automatic Vehicle Location (AVL), traffic signal priority, parking management systems, Traveler Information, Fare Payment Systems, and bike/pedestrian safety systems.

Multimodal travel strategies support TTP program goals for improving access to multimodal travel options and optimizing system throughput.

APPLICABLE TECHNOLOGIES

The following is a sample set of technologies used in this technology category:

- *Automatic Vehicle Location System*
- *Transit Signal Priority*
- *Electronic payment*
- *Traveler information*
- *Parking information*
- *Bike/pedestrian safety systems*

EXISTING PRACTICE

Transit operations in Virginia are varied with large small and medium size operators in rural, suburban and urban environments. There are 54 public transportation services operated by 44 transit agencies in the Commonwealth of Virginia. These agencies provide bus, commuter rail, light rail and heavy rail (Metrorail) services. Together these agencies provided approximately 200 million passenger trips in FY14. Each operator plans and deploys technology independently. DRPT leads the Commonwealth with guidance and funding for transit. Most operators are involved to some degree in:

- Automatic vehicle location technologies;
- Traveler information for:

Strategy 3: Support for multimodal travel

- Static trip planning
- Web site information
- Social media
- Real-time transit applications
- Real-time transit arrival displays

- Fare payment systems
- Automated passenger counting
- On-board applications including vehicle annunciation systems and on board Wi-Fi
- Maintenance yard management systems

DESIRED FIVE-YEAR LEVEL OF CAPABILITY

The next level of capability will involve continued implementation of technologies to enhance multimodal travel options and improve transit performance and reliability. DRPT through the Transit Service Delivery Advisory Committee (TSDAC) has initiated technology performance based criteria and requirements for annual funding. Ridership, revenue hours and revenue miles are the primary performance measures used for allocating state operating assistance of over $160M annually.

Every transit operator utilizes some form of technology from sophisticated vehicle location systems to phone enabled dispatching to determine the exact location of a bus or train on its route. Knowing the location of the vehicle for operations, safety, security and customer service is paramount. Another critical system for transit operators is fare payment. Fare payment is very relevant as it is part of the funding for services along with state and local funds. Handling and accounting for monies either on-vehicle or-off vehicle is important. Fare payment can be as simple as a cash box; however, more operators are moving toward cash light systems to minimize the handling of cash. The next generation of cash payment is being explored by all the Northern Virginia operators, as the Washington Metrorail System develops the next electronic payment program (NEPP). NEPP will eventually allow for wireless phone transfer and other advanced technology forms of payment for transit services.

Traveler information for transit has exploded with innovation within the last five years. Transit applications (apps) have emerged. Most large transit providers have either sponsored their own apps or support open data for private application developers. The applications acquire and use transit data such as "where is my bus" information, trip and fare planning information, and applications that share concern for the environment where users can get points for being "transit environmentally friendly". Currently the transit community is exploring the importance of crowd-sourcing. Crowd sourcing data is collecting social media data to show you an operational picture of what is happening. For example new mobile applications such as Waze are taking advantage of the traveling public's willingness to actively play a role in improving transportation choices by sharing on social media operational conditions for transportation. Some transit operators are using Twitter to communicate to transit riders and in turn transit riders are sharing operational conditions in real-time back to the operator dispatch center.

As part of our commitment to a corridor-based approach, several technology projects have been identified for funding as part of the multimodal component of the Integrated Corridor Management (ICM) programs for the I-95/I-395 and I-66 ICM programs. These include improved arterial operations, multimodal traveler information, and technologies that support transit travel time reliability and bike/pedestrian travel. In addition, one project aims to provide real-time parking space availability at select WMATA rail stations and another at VDOT Park and Ride lots.

Both the Federal Highway Administration and the Federal Transit Administration are working with multiple research institutions to define and implement more advanced connected vehicle technology and automated vehicle technology to support more seamless operations in multimodal transportation. Some transit operators in Virginia are engaging in the connected and automated vehicle research to determine how best to utilize and understand this technology to better operations and user experience.

Strategy 3: Support for multimodal travel

ACTIONS

Current Initiatives:

- **Richmond Bus Rapid Transit and Transit Signal Priority:** High capacity transit like bus rapid transit lines along arterial street corridors such as Broad Street in Richmond can be an effective mode to ensure people have mobility along congested corridors without use of a single occupant vehicle. Transit signal priority system can be utilized to reduce transit trip times and improve route reliability.

New Initiatives:

- **Implement recommendation from TSDAC** – elements include:
  - Data Collection:
    - Implement a standard set of methods for calculating core measures of the operating fund allocation model
    - Creation of a state accountability policy
    - Implement additions and revisions to the state's On-Line Grant Administration platform
    - Offer additional state technical assistance targeted for data collection
  - Current measures: Ridership and operating costs still remain valid measures and will continue to be collected and documented
- **Support enabling technologies for bike/pedestrian travel.** The ability to walk or ride a bicycle to work is becoming increasingly important in congested urban environments, particularly among millennials. Utilizing technology to support and improve those options is important as part of the overall multimodal approach to this plan.
- **Support enabling technologies to improve transit travel time and reliability**. Non-transit users often complain that bus transit is often unreliable and slow. Technologies such as transit signal priority, bus geolocation and travel time apps can improve transit travel time and reliability, encouraging new users.
- **I-95/I-395 ICM Program: Multimodal traveler information**. Providing travelers with real-time information on highway vs. transit travel is important to encouraging mode switch in this heavily congested corridor.
- **I-95/I-395 ICM Program: Parking management system**. Providing travelers with real-time information on parking availability at Park & Ride lots on this heavily congested corridor will enable motorists to make day-to-day decisions on how best to travel the corridor – HOT lanes, transit, slug line, etc.
- **Real-time parking information system at WMATA rail stations.** Providing travelers with real-time information on parking availability at select WMATA rail station parking lots will enable motorists to make day-to-day decisions on how best to travel the corridor – HOT lanes, transit, slug line, etc.

EXPECTED OUTCOMES

These general outcomes are anticipated:

- Enhanced Operations
- Improved Performance
- Increased Safety and Security
- Improved Customer Service

EXPECTED BENEFITS

- 13% - 38% reduction in bus boarding time
- 35% reduction in bus travel time variability

Strategy 3: Support for multimodal travel

- Enhanced bus operations
- Improved bicycle and pedestrian safety

COSTS

Project	COSS	Currently Funded	5 Year Cost	Future Priorities
Deploy pilot bus rapid transit (Richmond) The Broad Street project is partially funded through a United States Department of Transportation TIGER grant. The transit signal priority portion of the project is $3.6M.	East West	$3,600,000	$0	$0
Implement Transit Service Delivery data collection tools including automated passenger counters and fare collection systems	Statewide	$0	$5,000,000	$2,000,000
Support enabling technologies for bike/pedestrian travel	Statewide	$0	$1,000,000	$400,000
Support enabling technologies to improve transit travel time and reliability	Statewide	$0	$2,500,000	$1,000,000
I-95/I-395 ICM Program: Multimodal traveler information	Washington to North Carolina	$0	$5,700,000	$0
I-95/I-395 ICM Program: Parking management system	Washington to North Carolina	$0	$2,600,000	$0
Real-time parking information system at WMATA rail stations	Northern Virginia Connector	$0	$1,000,000	$1,000,000
Total		**$3,600,000**	**$17,800,000**	**$4,400,000**

Strategy 4: Manage arterials

DESCRIPTION

Arterial Management is a group of initiatives to monitor and manage traffic conditions on the arterial (primary routes) system. The Arterial Management technology strategy focuses on optimizing the performance of the arterial roadway system for all modes of transportation in real time. It relies heavily on data collection systems, traffic monitoring, and device communications.

Arterial management strategies support TTP program goals for improving system efficiency and optimizing system throughput.

The main technologies for Arterial Management are:

- **Real-time Traffic Signal Operations and Monitoring.** Rather than rely on historical time-of-day signal timing plans, technology now allows for real-time management. Traffic conditions are continuously monitored and signal operations are adjusted more efficiently.
- **Arterial and Signal Performance Monitoring (SPM).** Traditionally, arterial and signal performance metrics data were manually collected as part of a specific study process. The data represented a snap shot in time, such as peak hour traffic volume. Technology now provides an efficient and economical way to collect volume, speed, and travel time data continuously. In addition, new traffic signal controller features provide a means to match this data with the signal timing and vehicle detector information.
- **Traveler Information Systems.** Information regarding arterial traffic conditions and alternative travel modes are used by travelers to make mode and route choices. These technologies are discussed further as part of Strategy 5: Furnish Traveler Information.

APPLICABLE TECHNOLOGIES

The following is a sample set of technologies used in this technology category:

- *Advanced Transportation Controllers (ATCs) (next generation)*
- *Traffic monitoring and vehicle detection cameras*
- *Flashing Yellow Arrows (FYA)*
- *Bluetooth & Wi-Fi readers*
- *Electronic message signs*
- *Adaptive Signal Control Technology (ASCT)*
- *Emergency Vehicle Preemption (EVP)*
- *Transit Signal Priority (TSP)*
- *Alternative backup power equipment*
- *Broadband communications*
- *Central Signal Software/Management Systems*

EXISTING PRACTICE

Table 8 summarizes the state of existing technology in the area of signal operations, arterial and signal performance metrics, and traveler information:

Real-time Signal Operations

VDOT operates an extensive number of traffic signals. The following table provides information regarding the volume and communication modes to VDOT traffic signals.

Strategy 4: Manage arterials

Table 8: Statewide Signal System Technologies

VDOT Region / District	Traffic Signals	Signals with Communication	Signals with High Bandwidth Communication	Coordinated Signals
Central / Fredericksburg	181	155	0	70
Central / Richmond	541	414	10	365
Eastern / Hampton Roads	173	173	54	85
Northern / NOVA	1380	1380	610	1010
Northwest / Culpeper	138	80	19	60
Northwest / Staunton	210	129	35	71
Southwest / Bristol	103	7	3	20
Southwest / Lynchburg	111	56	52	27
Southwest / Salem	150	30	10	75
Total	**2987**	**2424**	**793**	**1783**

Next Generation and Advanced Transportation Controllers (ATC): Traditional traffic signal controller equipment has limited capabilities to communicate with or interact with external equipment and technologies due to the proprietary nature of the signal controllers. The Advance Transportation Controller (ATC) allows application (app) developers to create computer programs that work with the signal controller. This will be a critical component of all traffic signals as connected vehicle and autonomous vehicle technology begins to be deployed by the auto industry. In addition, the Advanced Transportation Controller (ATC) has internal performance metric capabilities. VDOT has replaced approximately 900 of its 3,000 signals (30 percent) with next generation traffic signal controller equipment, exclusively in the Northern Virginia District. Future efforts are underway to select and procure an ATC controller platform for statewide deployment.

Adaptive Signal Control Technology (ASCT): Current arterial management systems predominantly use fixed time-of-day traffic signal timing and coordination plans. Adaptive signal control technology provides for real-time, automated signal timing adjustments. Virginia has installed adaptive signal systems on 16 corridors at approximately 142 intersections throughout the Commonwealth.

Emergency Vehicle Preemption (EVP) and Transit Signal Priority (TSP): Emergency Vehicle Preemption (EVP) assigns right-of-way by changing the signal to green in the direction of emergency vehicles, such as ambulances and fire engines. The traditional EVP technology relies on infrared and/or radio signals. It is limited by the line-of-sight between the emergency vehicle (transmitter) and the traffic signal (receiver). New EVP technology is global positioning system (GPS) based and removes the line-of-sight constraint. GPS-based EVP also provides real-time routing of emergency vehicles, automated vehicle locating, and enhanced system management strategies. VDOT has installed traditional EVP on numerous signals in urban and suburban parts of the Commonwealth. VDOT is testing the new GPS-based EVP on two corridors in the Richmond District. Transit Signal Priority is not currently in use at VDOT signals.

Traffic detection cameras: Vehicle detection cameras are used at many signalized intersections across the Commonwealth. The technology is improving. VDOT has installed more than a half-dozen thermal cameras across the Commonwealth for vehicle detection in select locations where standard vehicle detection cameras are limited due to extreme shadows, sun glare, or other environmental factors. The video cameras installed with the adaptive signal control technology provide both traffic monitoring capabilities and vehicle detection.

Flashing Yellow Arrow (FYA): The new flashing yellow arrow traffic signals allow drivers to make left turns after yielding to oncoming traffic and will replace the old solid green ball used for left-turn lanes. The FYA is more effective than the circular green light at conveying to drivers the need to yield to oncoming traffic and pedestrians when turning left. In addition, the FYA allows for additional signal timing applications that the circular green ball limited. VDOT has installed the FYA at more than a dozen locations across the

Strategy 4: Manage arterials

Commonwealth and is expanding their use based on these successes. Flashing yellow arrows have become the new national standard.

Arterial & Signal Performance Metrics

Arterial Performance Data: Arterial performance is generally defined with a measure such as travel time. Technologies are available to measure the performance of not only the interstate highways, but also the arterials. Strategy 5: Furnish Traveler Information, discusses these technologies further.

High resolution signal data loggers: Signal system performance is generally measured in terms of volume throughput, delay, queues, and arrivals on green. VDOT's older traffic signal controllers do not have the ability to collect and store traffic signal performance data on a second-by-second basis (high resolution). The next generation of traffic controllers, such as the Advanced Transportation Controller (ATC), have the capability to collect, store and transmit traffic data at much higher resolutions, such as second-by-second. VDOT is currently testing the high resolution signal data logger technology at nearly a dozen signals in the Salem and Staunton Districts.

Advanced Traffic Management System (ATMS) and Central Signal System: VDOT has procured an ATMS that has customizable modules, such as a Traffic Signal System module. The ATMS will provide the capability to continuously monitor the entire transportation system, including freeways, arterials/signals, transit systems, and parking systems in a seamless fashion. Currently, the Northern Virginia District has a Central Signal System that provides continuous monitoring and reporting of the signal system. Efforts are underway to select and procure a statewide central signal system platform.

Traveler Information

Electronic Message Signs: Only a marginal quantity of electronic message signs are in position along arterial corridors, and primarily as a means of notifying motorists about freeway conditions (not the associated arterial corridors). These provide support to the ICM strategy.

Traffic Monitoring Cameras: VDOT has limited traffic monitoring cameras on arterials due to the need for broadband communications to transmit the video images. Vehicle detection cameras are used at many signalized intersections across the Commonwealth. Few of these provide traffic monitoring capabilities due to the lack of available broadband communications.

DESIRED FIVE-YEAR LEVEL OF CAPABILITY

The next level of capability will involve upgrading traffic signal equipment, providing real-time signal operations capabilities, establishing signal performance metrics, and preparing our arterials and signals for future connected vehicle and vehicle-to-infrastructure (V2I) technology. VDOT will continue to work with its partners and stakeholders to strategically implement technology solutions for providing a safe and efficient transportation system for travelers in Virginia.

Following are specific capabilities anticipated to be underway within the next five years:

Real-time Signal Operations

Deploy real-time arterial and signal management systems: In areas with high traffic volume variations and in conjunction with integrated corridor management (ICM) strategies, deploy real-time traffic signal management systems, such as adaptive signal control technologies or traffic responsive timing systems. These systems can adjust to the variations in demand without operator input.

Promote regional signal coordination: Design and procure a central system for traffic signal and arterial management that provides real-time signal control and monitoring features for the entire signal system. The central system will have interoperable capabilities between VDOT operations and local jurisdictions. The move to a central signal system, as well as real-time operations functionality, will provide opportunities and capability for community-wide signal system synchronization to improve traffic flow.

Strategy 4: Manage arterials

Prepare for Connected Vehicle Initiatives: Upgrade existing traffic signal controllers to more advanced models which have the ability to communicate with connected vehicles as well as other transportation technology infrastructure. The next generation of traffic signal controllers will allow users and vehicles to become more connected with the signals and arterial infrastructure. Infrastructure can alert motorists to adjust travel speeds or routes and modes in an effort to help increase mobility and improve safety.

Deploy multi-modal signal control technologies: Deploy traveler detection technologies and signal control strategies that support transit signal priority and enhanced and reliable pedestrian and bicycle detection.

Establish regional Emergency Vehicle Preemption standards: Promote coordination of emergency responses across jurisdictional boundaries and real-time routing through the use of GPS-based emergency vehicle preemption technology.

Arterial & Signal Performance Metrics

Develop automated signal data collection and analysis tools: Deploy advanced transportation controllers (ATC) for traffic signals capable of storing and transmitting traffic and controller data on a second-by-second basis. Develop automated data analysis to evaluate the data and recommend adjustments to the signalized intersection or corridor to improve travel flow. Supplement with system detectors and traffic monitoring cameras.

ACTIONS

New Initiatives:

- **Upgrade signal controller systems:** Install Advanced Transportation Controllers (ATCs). This includes new signal controllers and cabinets, backup power sources, traffic detection and monitoring cameras, signal and arterial performance monitoring equipment, and broadband communications.
- **Implement a Central Signal Control System:** Implement statewide central signal system with connection to the Advanced Traffic Management System (ATMS). Includes central software, servers, and various modules such as CCTV, adaptive signals, emergency vehicle priority, and transit signal priority.
- **Deploy Corridor-Specific Intelligent Signal Monitoring & Control Technology:** Deployment of intelligent signal monitoring and control technology along Corridors of Statewide Significance across the Commonwealth; includes traffic detection/monitoring cameras, signal/arterial performance monitoring equipment, and broadband communications. These projects will improve throughput and reliability of these parallel facilities during normal and emergency conditions.

EXPECTED OUTCOMES

These general outcomes are anticipated:

- Increased mobility
- Improved travel time reliability
- Enhanced real-time traffic monitoring
- Improved traveler safety and reduced crashes
- Improved response times for public safety, fire, and rescue
- Reduced fuel consumption and emissions

Strategy 4: Manage arterials

EXPECTED BENEFITS

- Up to 35% peak period travel time reduction due to adaptive traffic signal control
- 17% reduction in total crashes due to adaptive traffic signal control
- 30% reduction in corridor travel times due to coordinated traffic signal systems
- 37% reduction in number of stops due to adaptive traffic signal control

COSTS

Project	COSS	Currently Funded	5 Year Cost	Future Priorities
Deploy advanced traffic signal controllers	Statewide	$0	$3,000,000	$12,000,000
Implement a central signal system to include a community-wide synchronization	Statewide	$0	$3,000,000	$1,200,000
I-95/I-395 ICM Program: Parallel arterial operations	Washington to North Carolina	$0	$2,670,573	$0
Washington to North Carolina Corridor parallel route operation improvements (US1/US17)	Washington to North Carolina	$0	$4,340,000	$0
Washington to North Carolina Corridor parallel route operation improvements (US1)	Washington to North Carolina	$0	$3,891,250	$0
Southside Corridor arterial operation improvements (US58)	Southern	$0	$2,090,000	$0
Seminole Corridor arterial operation improvements (US29)	Seminole	$0	$1,414,998	$0
Northern Virginia Corridor parallel route operation improvements (I-66)	Northern Virginia	$0	$2,584,020	$0
North-South Corridor arterial operations improvements (US234)	North-South	$0	$1,360,000	$0
North Carolina to West Virginia Corridor arterial operations improvements (US220)	NC to WV	$0	$800,000	$0
Heartland Corridor arterial operations improvements (US460)	Heartland	$0	$2,079,000	$0
Eastern Shore Corridor arterial operations improvements (US13)	Eastern Shore	$0	$570,000	$0
East-West Corridor parallel route signal operation improvements (US60/US250)	East West	$0	$9,098,000	$0
I-81 Corridor parallel route signal operation improvements (US11)	Crescent	$0	$4,819,000	$0
Coastal Corridor arterial operations improvements (US17)	Coastal	$0	$4,220,000	$0
Total		**$0**	**$45,936,841**	**$13,200,000**

Strategy 5: Furnish traveler information

DESCRIPTION

Traveler Information refers to a broad spectrum of efforts to provide real time multimodal travel information to travelers prior to a trip and en-route (during the trip) through various methods. Together, they enable a driver to plan a trip with confidence and make informed changes during the trip as necessitated by travel conditions.

The objective of traveler information is to collect and provide timely, accurate and reliable information regarding travel conditions through the most accurate and real time sources available which currently include roadside devices, transit AVL, electronic media, crowd sourcing and public-private partnerships with information providers.

Providing information about traffic conditions and transportation services can significantly impact travel behavior and demand. Accurate and real time information about traffic conditions helps drivers decide which mode or route to take to reach their destination. The information can be made available across modes to motorists, commercial vehicle drivers, public transportation riders, pedestrians, bicyclists and teleworkers. The media to provide information vary. In Virginia, the 511 telephone system and website, and electronic message signs are predominantly used for traveler information. In recent years, mobile applications developed by the public or private sector are also being used to disseminate traveler information.

APPLICABLE TECHNOLOGIES

Some of the key technologies used for traveler information include:

- *511 Traveler Information System*
- *Electronic Message Signs*
- *Traffic Sensors*
- *Highway Advisory Radio*
- *Mobile Applications*
- *Private Sector Data Providers*
- *Traffic Cameras*
- *Overhead Lane Control Signs*

VDOT has invested in technologies and resources to collect and disseminate accurate traffic information with the public. Motorists can get information on traffic, incidents, lane closures and view traffic cameras. There is also information on how to get maps, learn about commuting options, get information about safety rest areas and welcome centers and learn about the state's interstate highways.

Traffic data is obtained from multiple sensors. These sources include traditional traffic counters, Blue Tooth and Wi-Fi reader technology, and external providers such as INRIX, HERE, and Tom-Tom. The interstate highways have high quality data. Arterial highway data availability varies.

VDOT launched the fourth generation traffic information service in 2012. The system offers streaming videos on the 511 website from traffic cameras across the state. The 511 system disseminates traffic data to the public through the 511 website, mobile applications, interactive voice response phone system, information displays at welcome centers, and Twitter and email alerts. Through the "Reach the Beach" campaign, VDOT is providing travel time information to beach travelers based on data from private data service providers and Bluetooth technology.

VDOT is continuously upgrading and expanding its 511 system to make traffic video and data accessible to the public and also media outlets. Currently, VDOT provides traffic and video data to first responders and media outlets. Opportunities also exist for the third party providers to share both video and traffic data provided by VDOT. Offering this service enables the Commonwealth to develop potential partnerships to further develop traveler information systems and traveler information distribution.

511 Virginia offers the public several options for receiving live video and data feeds, and enables promotion of the 511 system. For the I-95/I-395 corridor in Northern Virginia, VDOT has added transit information to its 511 system.

Strategy 5: Furnish traveler information

In addition to the 511 system, VDOT also provides travel time information on electronic message signs on several freeway corridors in the state. Comparative travel times between two alternate routes are also provided on message signs at a few selected locations.

The "On the Go in Virginia" travel portal (www.virginiadot.org/travel) provides information on ferries, tourism in Virginia, winter weather, a real time snowplow map, truck restrictions, and ridesharing.

The annual operating budget for the 511 Virginia program is approximately $4M.

DESIRED FIVE-YEAR LEVEL OF CAPABILITY

Continue expanding the range of multimodal data and modes of delivery.

- Collect various types of data such as transit data and parking data at a corridor level from different agencies and private data providers.
- Disseminate the data through a variety of mediums that are easily accessible to the public and commercial entities.

ACTIONS

Currently Funded Initiatives:

- Expansion of the Reach the Beach travel time signage program

New Initiatives:

- **Expand Travel Time Information**
  - Expand VDOT's statewide travel time program by identifying corridors in areas where travel time information is currently unavailable.
  - Additionally, obtain travel time data either from private data providers or VDOT-managed Bluetooth sensors to provide information on key arterial roadways.
  - Explore opportunities and develop plans to integrate predictive travel time data.
  - Provide traffic information at major hubs such as malls, airports, businesses, etc.
- **Enhance Current 511 System**
  - Enhance the current web/mobile 511 system to include features previously identified by users to improve the user's experience.

EXPECTED OUTCOMES

These general outcomes are anticipated:

- Availability of multimodal traveler information.
- Enhanced support for decision-making for travelers across different modes.
- Flexibility to use data from different sources.
- Ability to reach more travelers with more information specific to their needs and/or geographic location.

EXPECTED BENEFITS

- 5% - 16% improvement in travel time reliability

Strategy 5: Furnish traveler information

COSTS

Project	COSS	Currently Funded	5 Year Cost	Future Priorities
Expanded Reach the Beach signage expansion	East-West	$1,645,902	$0	$0
Expand travel time information statewide	Statewide	$0	$4,400,000	$0
511 enhancements	Statewide	$0	$2,300,000	$1,000,000
Total		**$1,645,902**	**$6,700,000**	**$1,000,000**

Strategy 6: Support commercial vehicle/freight activity

DESCRIPTION

Commercial Vehicle/Freight Activity refers to a group of Intelligent Transportation System specific initiatives that manage and support freight mobility, commercial vehicle safety and compliance, and commercial vehicle data exchange. These operations are focused on using technology to reduce incidents involving trucks, optimize freight mobility and facilitate commercial vehicle data exchange across states and jurisdictions. To support these objectives, Virginia has deployed weigh-in-motion technology to quickly screen trucks for size and weight compliance; implemented over-height vehicle technology to notify truckers far in advance of low bridges; and has been a long-standing member of the Commercial Vehicle Information Systems and Networks (CVISN) program, a federal initiative to improve commercial vehicle operations nationwide.

Commercial vehicle operations strategies support the TTP program goal for improving system efficiency.

CVISN is a collection of information systems and communications networks owned and operated by the Federal Motor Carrier Safety Administration (FMCSA) and other stakeholders. The vision of this program is to improve the safety and productivity of motor carriers and their drivers and reduce regulatory and administrative costs for public- and private-sector stakeholders through improved data sharing, electronic credentialing, and targeted automated screenings. Some of its actions include:

- Setting standards for data exchange across jurisdictions such as title information and hazardous materials
- Consolidating and archiving commercial vehicle information in a central location for agency access
- Monitoring state practices for commercial vehicle road compliance (weight, height, etc.)
- Enabling users to perform electronic transactions necessary for roadway compliance

Virginia is a long-standing member of the CVISN program and has continued to improve statewide commercial vehicle operations by making enhancements in the CVISN three core capability areas of *Safety Information Exchange, Credentials Administration and Electronic Screening.*

APPLICABLE TECHNOLOGIES

Key technologies that support commercial vehicle operations include the following:

- *Automated License Plate Readers*
- *Weigh-in-Motion (WIM) Systems*
- *Over-Height Sensors*
- *Infra-Red Inspection Technology*
- *On-board Transponders*
- *Dynamic Message Signs*
- *Dedicated Short-Range Communications (DSRC)*
- *Database Management Systems*

EXISTING PRACTICE

Virginia's commercial vehicle operations are performed predominantly through and align with the CVISN program. Virginia has implemented several initiatives to advance activities in CVISN's three core capability areas of Safety Information Exchange, Credentials Administration, and Electronic Screening. These activities are documented in the Virginia CVISN Expanded Program Plan/Top-Level Design document, which was developed in partnership with the Federal Motor Carrier Safety Administration. The following commercial vehicle/freight activities have been implemented in Virginia under each core capability area:

Safety Information Exchange

- EZFleet. A web-based program that allows a company to title and register vehicle fleets online, reporting stolen vehicles and a change in garage jurisdiction, transferring plates to vehicles, etc.
- Safety and Fitness Electronic Records (SAFER) System. A web-based national system that offers company safety data and related services to industry and the public. It allows users to search FMCSA databases, register for a USDOT number, pay fines online, order company safety profiles, access the Hazardous Material Route registry, etc.

Strategy 6: Support commercial vehicle/freight activity

- PreVIEW. A system used for the exchange of intrastate and interstate SAFER data within Virginia.
- Web-Based Hauling Permit System. Allows users to apply for and self-issue hauling permits electronically, which reduces permit issuance turnaround time.

Credentials Administration

- webCAT. An electronic credentialing system that allows carriers to apply for and receive titles, registration and tax credentials, and to file tax returns
- National Motor Vehicle Title Information System (NMVTIS). A web-based system that provides access to title information across jurisdictions.

Electronic Screening

Virginia has implemented the following Intelligent Transportation System devices at weigh stations in order to perform electronic screening to ease congestion at the stations and improve freight mobility:

- PrePass at eight mainline weight-in-motion (WIM) scales. PrePass is an automatic vehicle identification system that enables participating transponder-equipped commercial vehicles to be pre-screened throughout the nation at designated weigh stations, port-of-entry facilities and agricultural interdiction facilities. Cleared vehicles are then able to "bypass" the facility while traveling at highway speed, eliminating the need to stop
- Three WIM systems on ramps.
- Eight portable WIM systems.
- One stationary and three portable infrared inspection systems.
- Eight fixed and two portable automated license plate readers.

Drivewyze at 13 weigh station locations. Drivewyze is a mobile application that enables truckers to bypass weigh station screenings depending on their historical safety record. Through radio communications, an approaching truck equipped with Drivewyze automatically communicates with the weigh station and inspectors subsequently determine, per historical records, if the driver can proceed without a screening.

DESIRED FIVE-YEAR LEVEL OF CAPABILITY

The next level of capability will involve implementation of technology to improve commercial vehicle safety, mobility and reliability at critical bottlenecks. Weigh stations and tunnels are key bottleneck locations for commercial vehicles. Technologies to support improved freight mobility and safety at these facilities are proposed under this strategy area. Replacing the end-of-life weigh-in-motion system will improve freight mobility and speed time to market. Deployment of over-height detection systems well in advance of bridge/tunnel facilities will decrease the number of trucks forced to stop and turn around, closing the entire facility to traffic during the manoeuver. Lane management and other safety improvements at key tunnel bottlenecks will improve commercial vehicle safety and throughput at those facilities.

ACTIONS

Current Initiatives:

- **Upgrade Electronic Credentialing Systems.** webCAT will be rebuilt to add much needed functionality for more efficient processing of carrier functions including the ability for carriers to upload registration documents (lease agreements, etc.), perform filing in batches, and run automated inventory reports; and to upgrade the user interface for easier use. This will be a multi-year project. In the meantime, maintenance of the existing webCAT system will be ongoing.
- **Install and Replace Weigh-In-Motion Systems**. Some weigh-in-motion systems in Virginia were installed in the 1990s and are at the end of their lifespan. These scales will be replaced with new WIM scales and additional locations with static scales will be replaced with new WIM scales.

Strategy 6: Support commercial vehicle/freight activity

- **Expand Automated License Plate Readers.** Virginia is in the process of procuring a mobile license plate reader for scheduled deployment in northern Virginia in late Spring 2015 and plans to continue the deployment of mobile license plate readers as federal funding becomes available.
- **Interface License Plate Readers with PreVIEW Database System**. Currently, license plate readers are unable to screen trucks registered in other states and unable to access motor carrier safety records at weigh stations. An interface with the CVIEW system, which has these data, will enable these features to occur. Virginia will maintain PreVIEW membership. Virginia will continue to fund its PrePass membership annually and pay maintenance fees for the International Registration Plan (IRP), International Fuel Tax Agreement (IFTA) and XEROX support.
- **Upgrade IRP/IFTA System**. This project will connect the IRP/IFTA system (an internal system) with the DMV's (internal) recording system. This will enable a real-time data exchange and prevent time-consuming manual validation of records (title information, etc.) between both systems.
- **Support Commercial Freight Information System Development**. Pending the outcome of the GO-81 grant application to the FHWA, develop a pilot freight information system for the I-81 corridor.

New Initiatives:

- **Expand Over-Height Detection Capabilities**. Deployment of over-height detectors in advance of HRBT and I-95 overpasses in downtown Richmond where bridge/tunnel locations have been struck by trucks in the past or where the clearance is less than 14 feet. These systems will alert trucks that exceed the bridge clearance to use an alternate route.
- **Real-time Truck Parking Information at VDOT rest areas.** Pilot project to test and evaluate real-time truck parking information systems' effect on space utilization and driver behavior.

EXPECTED OUTCOMES

These general outcomes are anticipated:

- Improved commercial vehicle traffic flow at tunnel bottlenecks
- Reduction in commercial vehicle accidents
- Greater freight mobility
- Reduction in congestion at weigh stations
- Reduction in pavement damage due to overweight vehicles

EXPECTED BENEFITS

- 60% - 75% savings to motor carriers on credentialing costs
- New trucks commissioned into service 60% faster through electronic credentialing
- 1000's of truck accidents prevented annually
- Infrastructure protection

COSTS

Project	COSS	Currently Funded	5 Year Cost	Future Priorities
Commercial Vehicle Electronic Credentialing Systems	Statewide	$4,646,708	$0	$0
Upgrade/Replace Weigh in Motion Systems	Statewide	$6,800,000	$0	$0
Expand automated license plate readers	Statewide	$60,000	$0	$0
Real-time truck parking information at VDOT rest areas	Crescent	$0	$3,000,000	$0
Expand over-height detection capabilities: HRBT and I-95 in Richmond	East West	$0	$1,800,000	$0
Total		**$11,506,708**	**$4,800,000**	**$0**

Strategy 7: Conduct emerging technologies research

DESCRIPTION

The *Emerging Technologies* category refers to the next generation of transportation technologies that will help increase safety and reduce congestion.
Emerging technology research supports all TTP program objectives.

Emerging technologies cover the following group of technology initiatives:

Connected Vehicle. This technology is centered on vehicles that are equipped with the ability to securely communicate with each other and with the surrounding roadside infrastructure. Connected vehicles can increase safety by enabling vehicles to inform drivers of potentially hazardous roadway conditions and dangerous situations that might lead to accidents. Using the capability to communicate with other vehicles and the infrastructure, connected vehicles can monitor traffic conditions on the route. This can enable travelers to change their route, time, and mode of travel, based on the traffic conditions. A connected vehicle can provide speed and location data wirelessly for freeways, arterials and other roadways anonymously. This data can then be shared with both travelers who do not possess connected vehicle technology on their vehicles and with those who do. In addition to traffic data, connected vehicles can also provide roadway condition data for roadway repair and maintenance.

Autonomous Vehicles. These vehicles, also called driverless vehicles, have the ability to sense surrounding traffic and infrastructure conditions and navigate with minimal driver interaction. These vehicles, which have varying levels of "autonomy" are still in the research and demonstration phase. Autonomous vehicles can potentially eliminate accidents that are traditionally caused by driver error, reduce driver stress and increase roadway capacity.

Unmanned Aerial Vehicles (UAV). UAV or drones have the ability to collect aerial video and images of traffic events that cannot be obtained with fixed cameras. The technology can be used (1) during traffic incidents and special events, (2) for identifying roadway hazards (black ice and dirty roads), and (3) maintenance.

Bicycle and Pedestrian Applications. Demographic shifts indicate a growth in bicycle and pedestrian traffic. Continuing research is underway to determine the impact and future needs for these modes of transportation.

APPLICABLE TECHNOLOGIES

The following is a sample set of technologies used in this technology category:

- *Dedicated Short Range Communications (DSRC)*
- *Broadband Communications*
- *In-vehicle Traveler Information*
- *Smartphone / Hand-Held Devices*

EXISTING PRACTICE

The United States Department of Transportation has sponsored several connected vehicle research and pilot programs to bring this technology to the forefront of transportation system planning and operations. In light of recent advances in connected vehicles initiatives, VDOT continues to conduct research on this topic. VDOT has worked with universities on pilot deployments of the system. VDOT is currently the lead of a multi-state pooled fund research study regarding connected vehicles. This includes test beds on I-66 in Fairfax and on the Smart Road in Blacksburg, Virginia. The I-66 test-bed provides VDOT with the ability to test connected vehicle impacts and benefits to safety and mobility in a real world environment.

Transit operators are also conducting research to determine the applications of the connected vehicle program to improve transit operations and rider experience. Several pilot projects are being conducted across the country with commercial vehicles.

Autonomous vehicles, though not as close to deployment as connected vehicles, are gathering momentum. Several major automobile manufacturers have announced plans to launch semi-autonomous or autonomous vehicles by

2020. A number of research initiatives are focused on autonomous vehicles, and the pace of the research has increased rapidly in the last few years. Advanced crash avoidance technology in vehicles will continue to be researched and implemented by the auto industry. However other in-vehicle safety systems will need to interact with roadside infrastructure to function correctly.

Unmanned aerial vehicles (UAV), or drones, are also gaining interest as a tool to monitor traffic events. Applications of this technology are being researched. Virginia Polytechnic Institute and State University (Virginia Tech) is working with the Federal Aviation Administration on a UAV test program. Virginia Tech is one of six national sites with an approved test range.

DESIRED FIVE-YEAR LEVEL OF CAPABILITY

Ensure that Virginia retains its position as a lead location for testing and applying emerging transportation technologies. The Virginia Transportation Research Council (VTRC) and its University partners will continue to identify the benefits and impacts of emerging technology on safety, mobility and VDOT's operations program.

The growth of connected vehicles is anticipated to carry this technology through the pilot program and might lead to a measurable increase of vehicles equipped with connected vehicle technology in the next few years. Advances in communications infrastructure along roadways will be key in the program's growth and success.

Autonomous vehicles will likely remain in the research phase for the next few years and a concentrated effort will need to be applied to advance the research to a pilot program.

Applications of unmanned aerial vehicles will be evaluated as the technology and policies develop.

ACTIONS

- **Lead Research on Connected Vehicles.**
    - Continue to use the existing Virginia test beds to identify opportunities and challenges to connected vehicle implementation.
    - Apply for future grant funding to research and advance Connected Vehicle research.
    - Conduct demonstration programs to study the safety and mobility impact of connected vehicles in urban areas with traffic signal, bicycle and pedestrian interactions, and on rural roadways.
    - Integrate connected vehicle data into VDOT's Northern Virginia Traffic Operations Center for traveler information, incident management and arterial management operations. Applications from this first phase include traffic signal operations, incident management and incident scene safety, work zone management and safety, queue warnings, and ramp metering.
- **Identify Infrastructure and Communications Gaps in Connected Vehicle Implementation.**
    - Develop a conceptual framework for identifying gaps in communication and technology infrastructure that can potentially hinder connected vehicle implementation.
    - Develop conceptual plans for implementing communication and technology infrastructure along roadway corridors to support the expansion of connected vehicles into the marketplace.
- **Research bicycle and pedestrian applications.**
    - Continue researching bicycle and pedestrian applications and impacts.
    - Deploy an all-in-one bicycle and pedestrian counting station on the Virginia Capital Trail in the city of Richmond and a biking trail in Roanoke. This station will collect pedestrian and bicycle counts, archive the data and transfer data remotely on a daily basis.

EXPECTED OUTCOMES

These general outcomes are anticipated upon researching and where applicable, implementing the emerging technologies:

- Increased mobility
- Improved motorist safety
- Minimized infrastructure

By continuing to serve as a research and test site for emerging technologies, Virginia can be an attractive location for research entities and the private sector to pilot and invest in these applications.

EXPECTED BENEFITS

- Improved ability to deploy required technology to support connected and autonomous vehicles

COSTS

While the number and types of research projects is difficult to forecast, VTRC has a working annual budget to advance these types of research efforts. VDOT allocates approximately $1.2M annually to support research activities related to Systems Operations.

Additionally, research grants become available to support this effort. VDOT's VTRC and its university partners have been successful in obtaining grant funding to research Connected Vehicle programs.

Project	COSS	Currently Funded	5 Year Cost	Future Priorities
Annual allocation to the VTRC Systems Operations Research Advisory Committee to support connected vehicle and multimodal research	Statewide	$6,000,000	$0	$2,400,000
Total		**$6,000,000**	**$0**	**$2,400,000**

Strategy 8: Enhance enabling technology infrastructure

DESCRIPTION

Enabling Technology Infrastructure is a combination of technologies that, taken together, connect all parts of the transportation technology systems to form a complete system. These technologies represent the "glue" that connects and allows communications from roadside devices, such as traffic signals, cameras, and sensors, to the transportation operations centers. These technologies allow devices to be powered. They also provide control of the devices through Intelligent Transportation System software. Enabling technologies are fiber communications, wireless communications, power supplies and infrastructure and network security.

Enabling technology infrastructure supports all TTP program objectives.

These technologies support all other strategies including traffic demand management, transit management, and traveler information.

APPLICABLE TECHNOLOGIES

Key technologies that support the enabling technology infrastructure strategy include the following:

- *Fiber optic communications*
- *Cellular communications*
- *Radio communications*
- *Satellite communications*
- *Transportation management software*
- *Primary power supply systems*
- *Backup power supply systems*
- *Cloud computing hosted services*

EXISTING PRACTICE

Communications: Virginia's Intelligent Transportation Systems (ITS) devices, such as cameras and message signs, use a combination of dedicated fiber optic cables, wireless communications (radio and cellular) and leased telecommunication services through 3rd party providers to provide communication from the devices to a VDOT transportation operations center. Currently, VDOT manages its own communications network and shares other networks to connect traffic cameras, traffic signals, electronic message signs, weather stations, and ramp meters. Figure 5 shows the location of VDOT's 3,200 mile fiber optic communication network for transportation devices. The system continues to expand when more roadside devices and fiber optic networks along roadways and arterials are built.

Strategy 8: Enhance enabling technology infrastructure

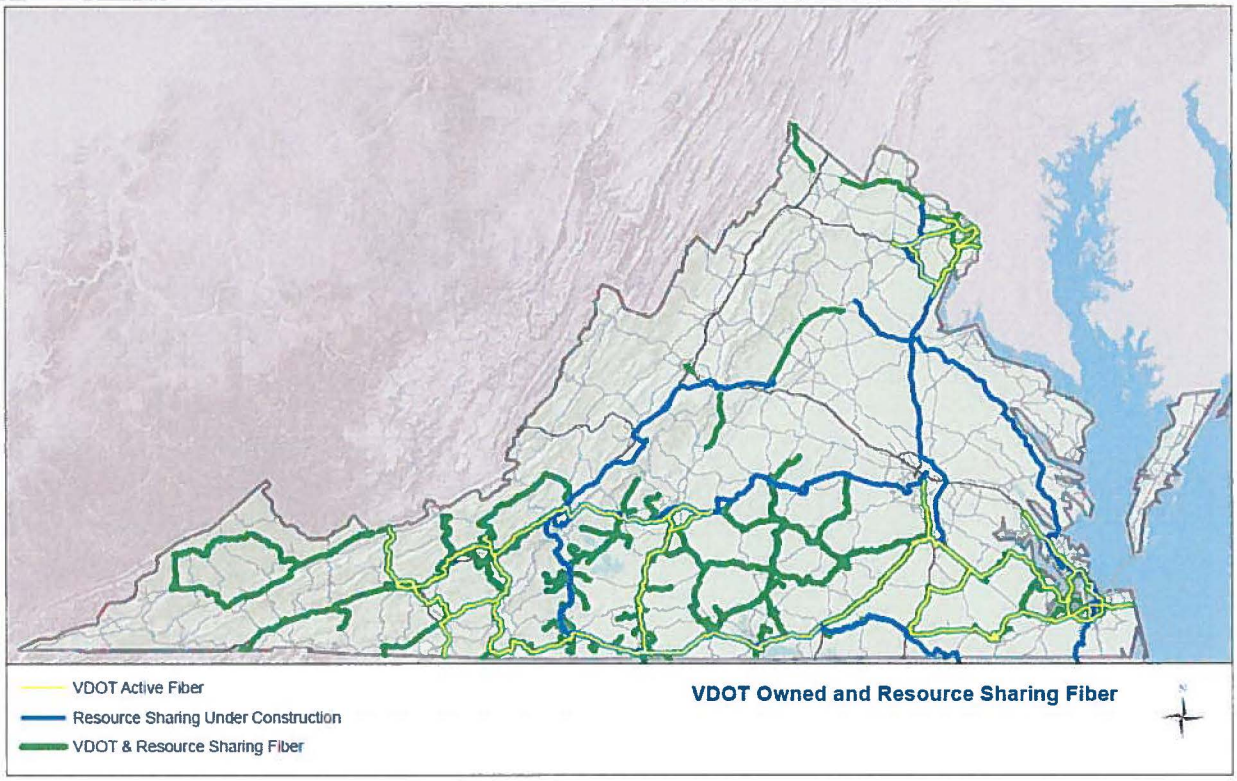


Figure 5 VDOT-Owned and Resource Sharing Fiber

DESIRED FIVE-YEAR LEVEL OF CAPABILITY

The next level of capability will expand the communications network to connect all five VDOT TOC facilities. This network expansion will also include connections to additional devices.

A more robust communications network with greater capacity is necessary to handle the expansion of device coverage on the roadways with new functions such as collecting and analyzing multimodal data. As the network grows, there is a greater need for a more reliable and secure network, especially along critical routes such as evacuation routes and routes and with critical infrastructure like tunnels. Greater redundancy is needed in case of network failure. A replacement of outdated communications hardware is also necessary.

ACTIONS

Current Initiatives:

- Fiber design to connect the Southwest Region Transportation Operations Center to the statewide fiber optic network.

ITTF Funded Initiatives:

- **Connect Northwest Region Transportation Operations Center to the Statewide Fiber Optic Network.** This action will allow the facility to have fail-over capabilities with redundancy options. Field equipment would continue to operate without disruption.
- **Connect Operations Support Center to the Statewide Fiber Optic Network.** This action will allow the facility to have fail-over capabilities with redundancy options. Field equipment would continue to operate without disruption.
- **Develop and Implement Statewide Advanced Traffic Management Software System:** This software

Strategy 8: Enhance enabling technology infrastructure

system is the backbone for all TOC operations statewide. The development of a unified, statewide system will allow for redundancy and fail-over capabilities at all TOCs statewide. In addition, modules within this system will support all new Active Traffic Management systems.

- **Connected Vehicle Traffic Signal Integration**
  - Traffic signal software integration to support connected vehicle applications
- **Statewide ATMS software**
  - Development of common traffic management software platform at all five (5) VDOT traffic operations centers

EXPECTED OUTCOMES

These general outcomes are anticipated:

- Standardized and coordinated approach to operations statewide
- More reliable transportation technology network
- Improved infrastructure and network security
- Continual system operations during evacuations and mobilization for disaster and incident response.

EXPECTED BENEFITS

- More reliable transportation network
- Improved infrastructure security
- Common statewide ATMS platform will allow for redundancy and fail-over capabilities at all TOCs statewide.

COSTS

Project	COSS	Currently Funded	5 Year Cost	Future Priorities
Fiber design to connect Southwest Region TOC to the statewide fiber optic network	Crescent	$300,000	$0	$0
Connect Southwest Region TOCs to the statewide fiber optic network	Statewide	$0	$2,873,000	$0
Connected vehicle/traffic signal integration	Northern Virginia	$0	$450,000	$2,000,000
Connect Operations Support Center to the statewide fiber optic network	Statewide	$0	$250,000	$0
Development of statewide ATMS software system	Statewide	$0	$1,301,000	$0
Total		**$300,000**	**$4,874,000**	**$2,000,000**

VDOT works with the private sector to expand the fiber optic communication system through a shared resource agreement. In general, a communications provider will install fiber optic lines in VDOT right of way. In exchange, VDOT gains dedicated fibers for its transportation technologies. While there are nominal costs for VDOT to connect devices and use fiber, the cost is minimal. When a private sector partner is not available, VDOT will design and install fiber optic lines. VDOT has a $3.173M project to connect its Northwest Region TOC to its fiber optic network. The remaining four TOC facilities either are connected to the fiber optic network or awaiting an upcoming shared resource agreement to be completed.

FIVE-YEAR SUMMARY OF PROJECTS AND COSTS

This section of the Plan summarizes transportation technology program costs over a five (5) year horizon by program area; with an additional two (2) years of investment requirements to demonstrate continuing program needs.

Table 9 summarizes the quantity and costs of the projects by each strategy over the five (5) year horizon, plus continuing program costs beyond that period that will need additional investment. Funding for projects beyond the initial five (5) year timeframe is likely to grow as additional needs arise and new technologies are developed to address those needs.

Table 9: Transportation Technology Plan Project Cost Summary

Technology Program Area	# Projects Years 1-5	5 Year Horizon Project Cost	# Projects Years 6 & 7	Years 6 & 7 Project Cost
Enhance Operations Traffic Management	14	$59,020,371	TBD	TBD
Strengthen Incident & Emergency Response	3	$9,000,000	2	$2,000,000
Support Multimodal Travel	6	$17,800,000	3	$4,400,000
Manage Arterials	34	$45,936,841	1	$13,200,000
Furnish Traveler Information	2	$6,700,000	1	$1,000,000
Support Commercial Vehicle / Freight Activity	3	$4,800,000	TBD	TBD
Enhance Enabling Technology Infrastructure	4	$4,874,000	1	$2,000,000
Total	**66**	**$148,131,212**	**8**	**$22,600,000**

APPENDIX A - HOUSE JOINT RESOLUTION 122

HOUSE JOINT RESOLUTION NO. 122

Requesting the Secretary of Transportation and the Department of Transportation to create and implement statewide transportation technology goals and a five-year plan of action. Report.

Agreed to by the House of Delegates, February 3, 2014
Agreed to by the Senate, February 25, 2014

WHEREAS, it is a goal of Virginia's transportation program to provide for the movement of people, goods, and services as efficiently, safely, and conveniently as possible; and

WHEREAS, transportation challenges can oftentimes be addressed and operations improved through the employment and adaptation of innovative technological solutions; and

WHEREAS, it is highly desirable that the Department of Transportation explore and evaluate the feasibility of bringing advanced and innovative technologies to bear in addressing the many challenges to all modes of transportation in the Commonwealth; and

WHEREAS, it is equally desirable that any such innovations be explored and employed on the basis of an achievable plan of action crafted to meet specific goals; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That the Secretary of Transportation and the Department of Transportation be requested to create and implement statewide transportation technology goals and a five-year plan of action. Such goals and plan shall be directed to the efficiency, safety, and convenience of all modes of transportation throughout the Commonwealth.

The Secretary of Transportation and the Department of Transportation shall submit to the Division of Legislative Automated Systems an executive summary and report of its progress in meeting the request of this resolution later than the first day of the 2015 Regular Session of the General Assembly. The executive summary and report shall be submitted for publication as a report document as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents and reports and shall be posted on the General Assembly's website.

APPENDIX B – LIST OF ABBREVIATIONS AND ACRONYMS

ABBREVIATION/ACRONYM	MEANING
ASCT	Adaptive Signal Control Technology
ATC	Advanced Transportation Controllers
ATM	Active Traffic Management
ATMS	Advanced Transportation Management System
AVI	Automatic Vehicle Identification
AVL	Automatic Vehicle Location
BRT	Bus Rapid Transit
CAD	Computer-Aided Dispatch
CCTV	Closed Circuit Television
COSS	Corridors of Statewide Significance
CVISN	Commercial Vehicle Information Systems and Network
DDS	Digital Data Service
DMS	Dynamic Message Sign
DMV	Department of Motor Vehicles
DRPT	Department of Rail and Public Transportation
DSRC	Dedicated Short-Range Communications
EVP	Emergency Vehicle Preemption
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FTA	Federal Transit Administration
FY	Fiscal Year
FYA	Flashing Yellow Arrow
GPS	Global Positioning System
HAR	Highway Advisory Radio
HB2	House Bill 2
HJR122	House Joint Resolution 122
HOT	High-Occupancy/Toll Lanes
HOV	High-Occupancy Vehicles
ICM	Integrated Corridor Management
IFTA	International Fuel Tax Agreement
IP	Internet Protocol
IRIS	Infrared Inspection System
IRP	International Registration Plan
ITS	Intelligent Transportation Systems
ITTF	Innovation and Technology Transportation Fund
MUTCD	Manual on Uniform Traffic Control Devices
NEPP	Next Electronic Payment Program
NMVTIS	National Motor Vehicle Title Information System
PTZ	Pan-Tilt-Zoom
PSAP	Public Safety Answering Point

SAFER	Safety and Fitness Electronic Records
SPM	Signal Performance Monitoring
SSP	Safety Service Patrol
TDM	Traffic Demand Management
TIM	Traffic Incident Management
TOC	Transportation Operations Center
TRIP	Towing and Recovery Incentive Program
TSDAC	Transit Service Delivery Advisory Committee
TSP	Transit Signal Priority
TSS	Traffic Signal System
UAV	Unmanned Aerial Vehicle
TTP	Transportation Technology Plan
UPS	Uninterrupted Power Supply
V2I	Vehicle-to-Infrastructure
VTRC	Virginia Transportation Research Council
VDOT	Virginia Department of Transportation
VSP	Virginia State Police
VTTI	Virginia Tech Transportation Institute
WIM	Weigh-in-Motion
WMATA	Washington Metropolitan Area Transit Authority

APPENDIX C – FIVE-YEAR TRANSPORTATION TECHNOLOGY PLAN

District	Corridor	Route	Segment	End Points	Availability of Modal Options	Availability of Redundant Facility	Safety (severe crashes/ million VMT)	Daily Person Hours of Delay	Daily Freight-Ton Hours of Delay	Average Weekday Peak Reliability	Selected Strategy	Selected Project	Project Description	Estimated Project Budget
HR/FR	Coastal	US 17	1	NC Border to Gloucester / Middlesex CL	YES	NO	1.7	13,800	1,800,000	0.013	Arterial Operations	US17 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,055,000
FR	Coastal	US17	2	Middlesex / Gloucester CL to I-95	NO	NO	2.5	1,800	11,000,000	0.08	Arterial Operations	US17 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,055,000
FR/CUL/STA	Coastal	US17	3	I-95 to Winchester	YES	NO	1.4	10,200	91,400,000	0.13	Arterial Operations	US17 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 2,110,000
BRI	Crescent	I-81	1	TN Border to Wythe / Pulaski CL	YES	YES	0.4	2,800	36,000,000	0.05	Arterial Operations	US11 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 686,000
BRI	Crescent	I-81	1	TN Border to Wythe / Pulaski CL	YES	YES	0.4	2,800	36,000,000	0.05	Operations Traffic Management	I-81 Operational Improvements	Deployment of traffic monitoring and incident detection technologies	$ 1,000,000
SAL	Crescent	I-81	2	Pulaski / Wythe CL to Botetourt County (mm 150)	YES	YES	0.6	6,600	46,000,000	0.12	Arterial Operations	US11 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 686,000
SAL	Crescent	I-81	2	Pulaski / Wythe CL to Botetourt County (mm 150)	YES	YES	0.6	6,600	46,000,000	0.12	Operations Traffic Management	I-81 Operational Improvements	Deployment of traffic monitoring and incident detection technologies	$ 1,000,000
SAL/STA	Crescent	I-81	3	Botetourt County (mm 150) to I-64 W	NO	YES	0.3	22	2,000,000	0.03	Arterial Operations	US11 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 590,000
SAL/STA	Crescent	I-81	3	Botetourt County (mm 150) to I-64 W	NO	YES	0.3	22	2,000,000	0.03	Operations Traffic Management	I-81 Operational Improvements	Deployment of traffic monitoring and incident detection technologies	$ 1,000,000
SAL/STA	Crescent	I-81	3	Botetourt County (mm 150) to I-64 W	NO	YES	0.3	22	2,000,000	0.03	Enabling Technology	NW Region Fiber Optic Integration	Fiber optic link from Staunton TOC to VDOT's statewide network to facilitate electronic information exchange and fail-over capabilities	$ 2,873,000
SAL/STA	Crescent	I-81	3	Botetourt County (mm 150) to I-64 W	NO	YES	0.3	22	2,000,000	0.03	Commercial Vehicle Operations	Real-Time Truck Parking Information at VDOT Rest Areas	Deployment of real-time, electronic parking space availability signage at select VDOT rest area locations	$ 3,000,000
STA	Crescent	I-81	4	I-64W to I-64E	NO	YES	0.1	0	2,000	0.02	Arterial Operations	US11 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 590,000
STA	Crescent	I-81	4	I-64W to I-64E	NO	YES	0.1	0	2,000	0.02	Operations Traffic Management	I-81 Operational Improvements	Deployment of traffic monitoring and incident detection technologies	$ 1,000,000
STA	Crescent	I-81	5	I-64E to WV Border	NO	YES	0.1	0	1,400,000	0.02	Arterial Operations	US11 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 2,267,000
STA	Crescent	I-81	5	I-64E to WV Border	NO	YES	0.1	0	1,400,000	0.02	Operations Traffic Management	I-81 Operational Improvements	Deployment of traffic monitoring and incident detection technologies	$ 1,000,000
STA	East-West	I-64	1	WV Border to I-81	NO	NO	0	1000	3,700,000	0.08	None currently recommended	None currently recommended		$ -
STA	East-West	I-64	2	I-81 to I-64E	NO	YES	0.5	0	3,000	0.02	None currently recommended	None currently recommended		$ -
STA/CUL/RIC	East-West	I-64	3	I-81 to Goochland CL	YES	YES	0.5	6000	12,800,000	0.11	Arterial Operations	US250 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,789,000
RIC	East-West	I-64	4	Goochland / Louisa CL to New Kent /James City CL	YES	YES	0.6	23,000	11,400,000	0.17	Arterial Operations	US250 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 4,735,000
RIC	East-West	I-64	4	Goochland / Louisa CL to New Kent /James City CL	YES	YES	0.6	23,000	11,400,000	0.17	Operations Traffic Management	I-64 Richmond Active Traffic Management System	Deployment of dynamic lane control and ramp metering technologies	$ 3,240,000

District	Corridor	Route	Segment	End Points	Availability of Modal Options	Availability of Redundant Facility	Safety (severe crashes/ million VMT)	Daily Person Hours of Delay	Daily Freight-Ton Hours of Delay	Average Weekday Peak Reliability	Selected Strategy	Selected Project	Project Description	Estimated Project Budget
RIC	East-West	I-64	4	Goochland / Louisa CL to New Kent /James City CL	YES	YES	0.6	23,000	11,400,000	0.17	Arterial Operations	US60 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,014,000
HR	East-West	I-64	5	York / James City CL to I-264	YES	YES	0.2	51,000	65,700,000	0.23	Operations Traffic Management	I-64 Hampton Roads Active Traffic Management System: Phase 1 Westbound	Deployment of camera, sensor, lane control and variable speed limit technologies to actively manage westbound traffic approaching HRBT	$ 14,500,000
HR	East-West	I-64	5	York / James City CL to I-264	YES	YES	0.2	51,000	65,700,000	0.23	Arterial Operations	US60/US17/Rt. 143/199 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,560,000
HR	East-West	I-64	5	York / James City CL to I-264	YES	YES	0.2	51,000	65,700,000	0.23	Commercial Vehicle Operations	I-64 Integrated Overheight Detection Systems	Deployment of technology to detect and divert overheight vehicles in advance of HRBT	$ 900,000
HR	East-West	I-64	5	York / James City CL to I-264	YES	YES	0.2	51,000	65,700,000	0.23	Operations Traffic Management	MMBT Tunnel Traffic & Safety Improvements	Upgrade of existing lane control and tunnel traffic safety systems	$ 7,000,000
HR	East-West	I-64	5	York / James City CL to I-264	YES	YES	0.2	51,000	65,700,000	0.23	Operations Traffic Management	HRBT Tunnel Traffic & Safety Improvements	Upgrade of existing lane control and tunnel traffic safety systems	$ 5,445,371
HR	Eastern Shore	US13	1	NC Border to Northampton CL / Virginia Beach	YES	NO	1.3	11,000	12,100,000	0.13	Arterial Operations	US13 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 570,000
HR	Eastern Shore	US13	2	Northampton CL to MD Border	YES	NO	0.1	2,000	3,200,000	0.09	None currently recommended	None currently recommended		$ -
BRI	Heartland	US460	1	KY Border to WV Border	YES	NO	2	2,000	200,000	0.09	Arterial Operations	US460 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 380,000
SAL	Heartland	US460	2	West Virginia / Giles CL to Bedford / Campbell CL	YES	NO	1.1	8,000	30,200,000	0.11	Arterial Operations	US460 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 569,000
LYN/RIC	Heartland	US460	3	Bedford / Campbell CL to Nottoway / Dinwiddie CL	YES	NO	0.9	1,000	1,800,000	0.05	Arterial Operations	US460 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 340,000
RIC/HR	Heartland	US460	4	Dinwiddie / Nottaway CL to Southampton /Isle of Wight CL	YES	NO	0.3	1,000	3,000,000	0.08	Arterial Operations	US460 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 220,000
HR	Heartland	US460	5	Isle of Wight / Southampton CL to Norfolk	YES	NO	1.5	1,000	29,500,000	0.18	Arterial Operations	US460/US13 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 570,000
SAL	NC to WV	US220	1	NC Border to Roanoke	NO	NO	2.3	2,100	3,300,000	0.09	Arterial Operations	US220 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 460,000
SAL/STA	NC to WV	US220	2	Roanoke to I-64W	YES	NO	0.5	38,000	30,000,000	0.09	Arterial Operations	US220 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 240,000
STA	NC to WV	US220	3	I-64W to WV Border	YES	NO	0.4	472	2,400,000	0.07	Arterial Operations	US220 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 100,000
NOVA	North-South	VA234	1	I-95 to I-66	YES	NO	8.4	9,100	15,000,000	0.18	Arterial Operations	VA234 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,360,000
NOVA	North-South	VA234	2	I-66 to Rt. 7 (unbuilt)	YES	NO	0	0	0	0	None currently recommended	None currently recommended		$ -
STA/NOVA	Northern Virginia	I-66	1	I-81 to Prince William CL	YES	NO	0.7	4,500	20,000,000	0.08	None currently recommended	None currently recommended		$ -
NOVA	Northern Virginia	I-66	2	Prince William / Fauquier CL to District of Columbia	YES	NO	0.7	4,500	20,000,000	0.08	Multimodal	Real-Time Parking Information at WMATA Rail Stations	Deployment of real-time, electronic parking space availability signage at select WMATA rail stations in Northern Virginia	$ 1,000,000

District	Corridor	Route	Segment	End Points	Availability of Modal Options	Availability of Redundant Facility	Safety (severe crashes/ million VMT)	Daily Person Hours of Delay	Daily Freight-Ton Hours of Delay	Average Weekday Peak Reliability	Selected Strategy	Selected Project	Project Description	Estimated Project Budget
NOVA	Northern Virginia	I-66	2	Prince William / Fauquier CL to District of Columbia	YES	NO	0.7	4,500	20,000,000	0.08	Enabling Technology	Connected Vehicle / Traffic Signal Integration	Traffic signal software integration to support connected and automated vehicle applications	$ 450,000
NOVA	Northern Virginia	I-66	2	Prince William / Fauquier CL to District of Columbia	YES	NO	0.7	4,500	20,000,000	0.08	Operations Traffic Management	Rosslyn Tunnel Traffic & Safety Improvements	Upgrade of existing lane control and tunnel traffic safety systems	$ 3,500,000
NOVA	Northern Virginia	I-66	2	Prince William / Fauquier CL to District of Columbia	YES	NO	0.7	4,500	20,000,000	0.08	Arterial Operations	I-66 ICM Program: Parallel Arterial Operations Improvements	Deployment of signal communication, monitoring and control technology to improve travel on parallel routes in the I-66 corridor	$ 2,584,020
LYN	Seminole	US29	1	KY Border to Henry / Pittsylvania CL	YES	NO	0.8	4,000	4,300,000	0.07	None currently recommended	None currently recommended		$ -
CUL/LYN	Seminole	US29	2	Nelson / Amherst CL to Albemarle / Greene CL	YES	NO	3.5	7,000	4,500,000	0.13	Arterial Operations	US29 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 471,666
CUL	Seminole	US29	3	Albemarle / Greene CL to Fauquire / Prince William CL	YES	NO	2.3	5,000	7,600,000	0.1	Arterial Operations	US29 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 471,666
NOVA	Seminole	US29	4	Prince William / Fauquier CL to District of Columbia	YES	YES	1.7	80,000	6,000,000	0.27	Arterial Operations	US29 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 471,666
BRI/SAL	Southside	US58	1	Kentucky Border to Pittsylvania CL	YES	NO	0.2	5,000	11,900,000	0.07	Arterial Operations	US58 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 610,000
LYN/RIC/HR	Southside	US58	2	Henry / Pittsylvania CL to Southampton / Suffolk CL	NO	NO	0.1	3,000	9,900,000	0.1	Arterial Operations	US58 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 280,000
HR	Southside	US58	3	Suffolk to Virginia Beach	YES	NO	3.5	14,000	10,200,000	0.15	Arterial Operations	US58 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,200,000
RIC/HR	Washington to NC	I-95	1	NC Border to Prince George /Chesterfield CL	YES	YES	0.2	3,000	14,600,000	0.08	None currently recommended	None currently recommended		$ -
RIC	Washington to NC	I-95	2	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	YES	YES	0.3	16,000	70,600,000	0.15	Arterial Operations	US1/17 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 4,340,000
RIC	Washington to NC	I-95	2	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	YES	YES	0.3	16,000	70,600,000	0.15	Arterial Operations	US1 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 3,891,250
RIC	Washington to NC	I-95	2	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	YES	YES	0.3	16,000	70,600,000	0.15	Commercial Vehicle Operations	I-95 Integrated Overheight Detection Systems	Deployment of over-height vehicle detection technology to catch and divert overheight vehicles in advance of I-95 overpasses	$ 900,000
RIC	Washington to NC	I-95	2	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	YES	YES	0.3	16,000	70,600,000	0.15	Enabling Technology	Operations Support Center Fiber Optic Integration	Fiber optic link between Central Office Operations Support Center and VDOT's statewide network	$ 250,000
RIC	Washington to NC	I-95	2	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	YES	YES	0.3	16,000	70,600,000	0.15	Operations Traffic Management	I-95 Richmond Active Traffic Management System	Deployment of dynamic lane control and ramp metering technologies	$ 6,035,000
RIC	Washington to NC	I-95	2	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	YES	YES	0.3	16,000	70,600,000	0.15	Operations Traffic Management	Richmond TOC Upgrade	Upgrade of Richmond TOC and colocation with Virginia State Police	$ 10,000,000
NOVA/FR	Washington to NC	I-95	3	Caroline / Spotsylvania CL Maryland Border	YES	YES	0.3	146,000	1,781,800,000	0.39	Arterial Operations	I-95/I-395 ICM Program: Parallel Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies to improve travel on parallel routes in the I-95 corridor	$ 2,670,573
NOVA/FR	Washington to NC	I-95	3	Caroline / Spotsylvania CL Maryland Border	YES	YES	0.3	146,000	1,781,800,000	0.39	Operations Traffic Management	I-95/I-395 ICM Program: Dynamic Ramp Metering	Upgrade of existing ramp metering system	$ 3,500,000
NOVA/FR	Washington to NC	I-95	3	Caroline / Spotsylvania CL Maryland Border	YES	YES	0.3	146,000	1,781,800,000	0.39	Multimodal	I-95/I-395 ICM Program: Parking Management	Deployment of real-time, electronic signage at additional Park & Ride lots to better inform travelers about parking availability	$ 2,600,000

District	Corridor	Route	Segment	End Points	Availability of Modal Options	Availability of Redundant Facility	Safety (severe crashes/ million VMT)	Daily Person Hours of Delay	Daily Freight-Ton Hours of Delay	Average Weekday Peak Reliability	Selected Strategy	Selected Project	Project Description	Estimated Project Budget
NOVA/FR	Washington to NC	I-95	3	Caroline / Spotsylvania CL Maryland Border	YES	YES	0.3	146,000	1,781,800,000	0.39	Operations Traffic Management	I-95/I-395 ICM Program: Decision Support System	Software system to support corridor management activities across multiple facilities and modes	$ 800,000
NOVA/FR	Washington to NC	I-95	3	Caroline / Spotsylvania CL Maryland Border	YES	YES	0.3	146,000	1,781,800,000	0.39	Multimodal	I-95/I-395 ICM Program: Multimodal Traveler Information	Electronic signage displaying roadway, transit and parking information to allow travelers to more easily change mode and route of travel	$ 5,700,000
BRI	Western Mountain	I-77	1	NC Border to I-81	NO	NO	0	300	22,000,000	0.03	None currently recommended	None currently recommended		$ -
BRI	Western Mountain	I-77	2	I-81 to WV Border	NO	YES	0.3	500	24,900,000	0.05	None currently recommended	None currently recommended		$ -
	Statewide Program	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Enabling Technology	Statewide ATMS Software	Development of single, statewide interoperable traffic management software platform at all five traffic operations centers	$ 1,301,000
	Statewide Program	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Incident Management	Emergency/Incident Response Technologies	Deployment of technologies to improve incident identification, emergency response and clearance times	$ 2,500,000
	Statewide Program	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Incident Management	Advanced Towing and Recovery Program	Implementation of pilot program to partner with towing and recovery contractors to stage and deploy assets quicker during peak period travel times	$ 4,000,000
	Statewide Program	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Multimodal	Bicycle/Pedestrian Safety Technologies	Deployment of safety-enhancing technologies to improve the viability and safety of bike/ped travel in congested areas	$ 1,000,000
	Statewide Program	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Multimodal	Transit Efficiency Enabling Technologies	Deployment of technologies, including transit signal preemption, to support transit system reliability and improve travel times	$ 2,500,000
	Statewide Program	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arterial Operations	Advanced Traffic Signal Controllers	Deployment of new signal controller technology to improve arterial operations and prepare for connected and autonomous vehicle needs	$ 3,000,000
	Statewide Program	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arterial Operations	Community-wide Adaptive Signal System	Deployment of adaptive signal and centralized signal control technologies on key arterial corridors	$ 3,000,000
	Statewide Program	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Incident Management	Integration of Localities/ PSAPs into VDOT Network	Deployment of technology to integrate VDOT data and video imagery with key locality operations centers	$ 2,500,000
	Statewide Program	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Multimodal	TSDAC Electronic Fare Payment Systems	Deployment of technologies to transit service providers to enable on-board systems to improve travel data collection, system performance and traveler information	$ 5,000,000
	Statewide Program	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Traveler Information	VDOT 511 System Enhancements	Development of new features to enhance the 511 mobile app and phone/web systems	$ 2,300,000
	Statewide Program	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Traveler Information	Travel Time Signage Program Expansion	Deployment of electronic signage to provide destination travel time information to motorists	$ 4,400,000
												TOTAL 5-YEAR TTP PROGRAM COST:		$ 148,131,212

APPENDIX D – PROJECT SCORING METHODOLOGY AND FINAL PROJECT RANKING

Linking Project Ranking and Selection Criteria to TTP Plan Objectives

TTP Plan Objectives	Ranking Criteria	Criteria Scoring
Increase mobility by improving access to multimodal travel options	Supports multimodal travel	0 = No 1 = Yes – one mode 2 = Yes – two or more modes
Improve transportation system efficiency by mitigating recurring and nonrecurring causes of congestion	Reduce the number of vehicle hours of delay per year	0 = No impact to Vehicle Hours of Delay 1 = Vehicle Hours of Delay < 600,000 hours/year 2 = Vehicle Hours of Delay ≥ 600,000 hours/year
	Reduce the buffer time index	0 = No impact to Buffer Time Index 1 = Buffer Time Index < 0.2 2 = Buffer Time Index ≥ 0.2
Reduce median duration of incidents	Supports improved incident management [3]	0 = None 1 = Limited 2 = Substantial
Optimize existing system throughput by improving freeway, arterial and transit operations, encouraging route and mode switch, and providing better information to travelers	Optimize system throughput	0 = No 1 = Limited 2 = Substantial
Accelerate deployment of projects with near-term benefits	Project readiness	0 = 3+ years to deployment 1 = 1-3 years to deployment 2 = Immediate deployment

All projects were scored on these six (6) factors then ranked in descending order by final score.

[3] Aligned with HB2 Incident Impact scoring methodology

VTrans2040 Corridor/Segment	Route	District*	Segment End Points	Selected Strategy	Selected Project	Project Description	Estimated Project Budget	Final Score	Funding Source **
Washington to NC Segment 3	I-95	NOVA/FR	Caroline / Spotsylvania CL Maryland Border	Multimodal	I-95/I-395 ICM Program: Multimodal Traveler Information	Electronic signage displaying roadway, transit and parking information to allow travelers to more easily change mode and route of travel	$ 5,700,000	10	ITTF
East-West Segment 5	I-64	HR	York / James City CL to I-264	Commercial Vehicle Operations	I-64 Integrated Overheight Detection Systems	Deployment of technology to detect and divert overheight vehicles in advance of HRBT	$ 900,000	10	ITTF
East-West Segment 5	I-64	HR	York / James City CL to I-264	Arterial Operations	US60/US17/Rt. 143/199 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,560,000	10	ITTF
East-West Segment 5	I-64	HR	York / James City CL to I-264	Operations Traffic Management	HRBT Tunnel Traffic & Safety Improvements	Upgrade of existing lane control and tunnel traffic safety systems	$ 5,445,371	9	SRT
East-West Segment 5	I-64	HR	York / James City CL to I-264	Operations Traffic Management	I-64 Hampton Roads Active Traffic Management System: Phase 1 Westbound	Deployment of camera, sensor, lane control and variable speed limit technologies to actively manage westbound traffic approaching HRBT	$ 14,500,000	9	ITTF
Northern Virginia Segment 2	I-66	NOVA	Prince William / Fauquier CL to District of Columbia	Operations Traffic Management	Rosslyn Tunnel Traffic & Safety Improvements	Upgrade of existing lane control and tunnel traffic safety systems	$ 3,500,000	9	SRT
East-West Segment 5	I-64	HR	York / James City CL to I-264	Operations Traffic Management	MMMBT Tunnel Traffic & Safety Improvements	Upgrade of existing lane control and tunnel traffic safety systems	$ 7,000,000	9	ITTF
Washington to NC Segment 3	I-95	NOVA/FR	Caroline / Spotsylvania CL Maryland Border	Operations Traffic Management	I-95/I-395 ICM Program: Dynamic Ramp Metering	Upgrade of existing ramp metering system	$ 3,500,000	8	SRT
Washington to NC Segment 2	I-95	RIC/FR	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	Commercial Vehicle Operations	I-95 Integrated Overheight Detection Systems	Deployment of over-height vehicle detection technology to catch and divert overheight vehicles in advance of I-95 overpasses	$ 900,000	8	ITTF
Washington to NC Segment 2	I-95	RIC/FR	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	Operations Traffic Management	I-95 Richmond Active Traffic Management System	Deployment of dynamic lane control and ramp metering technologies	$ 6,035,000	8	ITTF
Washington to NC Segment 3	I-95	NOVA/FR	Caroline / Spotsylvania CL Maryland Border	Arterial Operations	I-95/I-395 ICM Program: Parallel Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies to improve travel on parallel routes in the I-95 corridor	$ 2,670,573	8	SRT
Washington to NC Segment 2	I-95	RIC/FR	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	Arterial Operations	US1/US17 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 4,340,000	8	SRT

VTrans2040 Corridor/Segment	Route	District*	Segment End Points	Selected Strategy	Selected Project	Project Description	Estimated Project Budget	Final Score	Funding Source **
Washington to NC Segment 2	I-95	RIC/FR	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	Arterial Operations	US1 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 3,891,250	8	SRT
Northern Virginia Segment 2	I-66	NOVA	Prince William / Fauquier CL to District of Columbia	Arterial Operations	I-66 ICM Program: Parallel Arterial Operations Improvements	Deployment of signal communication, monitoring and control technology to improve travel on parallel routes in the I-66 corridor	$ 2,584,020	8	SRT
Seminole Segment 4	US29	NOVA	Prince William / Fauquier CL to District of Columbia	Arterial Operations	US29 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 471,666	8	ITTF
Crescent Segment 4	I-81	STA	I-64W to I-64E	Arterial Operations	US11 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 590,000	8	ITTF
Crescent Segment 5	I-81	STA	I-64E to WV Border	Arterial Operations	US11 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 2,267,000	8	ITTF
East-West Segment 4	I-64	RIC	Goochland / Louisa CL to New Kent /James City CL	Operations Traffic Management	I-64 Richmond Active Traffic Management System	Deployment of dynamic lane control and ramp metering technologies	$ 3,240,000	7	ITTF
Washington to NC Segment 2	I-95	RIC/FR	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	Operations Traffic Management	Richmond TOC Upgrade	Upgrade of Richmond TOC and colocation with Virginia State Police	$ 10,000,000	7	ITTF
Northern Virginia Segment 2	I-66	NOVA	Prince William / Fauquier CL to District of Columbia	Multimodal	Real-Time Parking Information at WMATA Rail Stations	Deployment of real-time, electronic parking space availability signage at select WMATA rail stations in Northern Virginia	$ 1,000,000	7	ITTF
North-South Segment 1	VA234	NOVA	I-95 to I-66	Arterial Operations	VA234 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,360,000	7	ITTF
Southside Segment 3	US58	HR	Suffolk to Virginia Beach	Arterial Operations	US58 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,200,000	7	UNF
East-West Segment 3	I-64	STA/CUL/RIC	I-81 to Goochland CL	Arterial Operations	US250 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,789,000	7	UNF

VTrans2040 Corridor/Segment	Route	District*	Segment End Points	Selected Strategy	Selected Project	Project Description	Estimated Project Budget	Final Score	Funding Source **
East-West Segment 4	I-64	RIC	Goochland / Louisa CL to New Kent /James City CL	Arterial Operations	US250 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 4,735,000	7	UNF
East-West Segment 4	I-64	RIC	Goochland / Louisa CL to New Kent /James City CL	Arterial Operations	US60 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,014,000	7	ITTF
Heartland Segment 2	US460	SAL	West Virginia / Giles CL to Bedford / Campbell CL	Arterial Operations	US460 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 569,000	7	UNF
Heartland Segment 3	US460	LYN/RIC	Bedford / Campbell CL to Nottoway / Dinwiddie CL	Arterial Operations	US460 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 340,000	7	UNF
Seminole Segment 2	US29	CUL / LYN	Nelson / Amherst CL to Albemarle / Greene CL	Arterial Operations	US29 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 471,666	7	ITTF
Crescent Segment 1	I-81	BRI	TN Border to Wythe / Pulaski CL	Arterial Operations	US11 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 686,000	7	ITTF
Crescent Segment 2	I-81	SAL	Pulaski / Wythe CL to Botetourt County (mm 150)	Arterial Operations	US11 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 686,000	7	ITTF
Crescent Segment 3	I-81	SAL/STA	Botetourt County (mm 150) to I-64 W	Arterial Operations	US11 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 590,000	7	ITTF
Washington to NC Segment 3	I-95	NOVA/FR	Caroline / Spotsylvania CL Maryland Border	Multimodal	I-95/I-395 ICM Program: Parking Management	Deployment of real-time, electronic signage at additional Park & Ride lots to better inform travelers about parking availability	$ 2,600,000	6	UNF
Washington to NC Segment 3	I-95	NOVA/FR	Caroline / Spotsylvania CL Maryland Border	Multimodal	I-95/I-395 ICM Program: Decision Support System	Software system to support corridor management activities across multiple facilities and modes	$ 800,000	6	UNF
Coastal Segment 1	US 17	HR/FR	NC Border to Gloucester / Middlesex CL	Arterial Operations	US17 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,055,000	6	UNF

VTrans2040 Corridor/Segment	Route	District*	Segment End Points	Selected Strategy	Selected Project	Project Description	Estimated Project Budget	Final Score	Funding Source **
Coastal Segment 2	US17	FR	Middlesex / Gloucester CL to I-95	Arterial Operations	US17 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 1,055,000	6	UNF
Coastal Segment 3	US17	FR/CUL/STA	I-95 to Winchester	Arterial Operations	US17 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 2,110,000	6	UNF
Eastern Shore Segment 1	US13	HR	NC Border to Northampton CL / Virginia Beach	Arterial Operations	US13 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 570,000	6	UNF
Heartland Segment 1	US460	BRI	KY Border to WV Border	Arterial Operations	US460 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 380,000	6	UNF
Heartland Segment 5	US460	HR	Isle of Wight / Southampton CL to Norfolk	Arterial Operations	US460/US13 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 570,000	6	UNF
NC to WV Segment 1	US220	SAL	NC Border to Roanoke	Arterial Operations	US220 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 460,000	6	UNF
NC to WV Segment 2	US220	SAL/STA	Roanoke to I-64W	Arterial Operations	US220 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 240,000	6	UNF
NC to WV Segment 3	US220	STA	I-64W to WV Border	Arterial Operations	US220 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 100,000	6	UNF
Seminole Segment 3	US29	CUL	Albemarle / Greene CL to Fauquier / Prince William CL	Arterial Operations	US29 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 471,666	6	UNF
Southside Segment 1	US58	BRI/SAL	KY Border to Henry / Pittsylvania CL	Arterial Operations	US58 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 610,000	6	UNF
Southside Segment 2	US58	LYN/RIC/HR	Henry / Pittsylvania CL to Southampton / Suffolk CL	Arterial Operations	US58 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 280,000	6	UNF

VTrans2040 Corridor/Segment	Route	District*	Segment End Points	Selected Strategy	Selected Project	Project Description	Estimated Project Budget	Final Score	Funding Source **
Heartland Segment 4	US460	RIC/HR	Dinwiddie / Nottaway CL to Southampton /Isle of Wight CL	Arterial Operations	US460 Arterial Operations Improvements	Deployment of signal communication, monitoring and control technologies	$ 220,000	6	UNF
Crescent Segment 1	I-81	BRI	TN Border to Wythe / Pulaski CL	Operations Traffic Management	I-81 Operational Improvements	Deployment of traffic monitoring and incident detection technologies	$ 1,000,000	5	UNF
Crescent Segment 2	I-81	SAL	Pulaski / Wythe CL to Botetourt County (mm 150)	Operations Traffic Management	I-81 Operational Improvements	Deployment of traffic monitoring and incident detection technologies	$ 1,000,000	5	UNF
Crescent Segment 3	I-81	SAL/STA	Botetourt County (mm 150) to I-64 W	Operations Traffic Management	I-81 Operational Improvements	Deployment of traffic monitoring and incident detection technologies	$ 1,000,000	5	UNF
Crescent Segment 4	I-81	STA	I-64W to I-64E	Operations Traffic Management	I-81 Operational Improvements	Deployment of traffic monitoring and incident detection technologies	$ 1,000,000	5	UNF
Crescent Segment 5	I-81	STA	I-64E to WV Border	Operations Traffic Management	I-81 Operational Improvements	Deployment of traffic monitoring and incident detection technologies	$ 1,000,000	5	UNF
Northern Virginia Segment 2	I-66	NOVA	Prince William / Fauquier CL to District of Columbia	Enabling Technology	Connected Vehicle / Traffic Signal Integration Pilot	Traffic signal software integration to support connected and automated vehicle applications	$ 450,000	3	UNF
Washington to NC Segment 2	I-95	RIC	Prince George /Chesterfield CL to Caroline / Spotsylvania CL	Enabling Technology	Operations Support Center Fiber Optic Integration	Fiber optic link between Central Office Operations Support Center and VDOT's statewide network	$ 250,000	2	UNF
Crescent Segment 3	I-81	STA	Botetourt County (mm 150) to I-64 W	Enabling Technology	NW Region Fiber Optic Integration	Fiber optic link from Staunton TOC to VDOT's statewide network to facilitate electronic information exchange and fail-over capabilities	$ 2,873,000	2	UNF
Crescent Segment 3	I-81	STA	Botetourt County (mm 150) to I-64 W	Commercial Vehicle Operations	Real-Time Truck Parking Information at VDOT Rest Areas	Deployment of real-time, electronic parking space availability signage at select VDOT rest area locations	$ 3,000,000	1	UNF
Statewide Program	n/a	n/a	n/a	Enabling Technology	Statewide ATMS Software	Development of single, statewide interoperable traffic management software platform at all five traffic operations centers	$ 1,301,000	n/a	UNF
Statewide Program	n/a	n/a	n/a	Incident Management	Emergency/Incident Response Technologies	Deployment of technologies to improve incident identification, emergency response and clearance times	$ 2,500,000	n/a	UNF
Statewide Program	n/a	n/a	n/a	Incident Management	Advanced Towing and Recovery Program	Implementation of pilot program to partner with towing and recovery contractors to stage and deploy assets quicker during peak period travel times	$ 4,000,000	n/a	ITTF

VTrans2040 Corridor/Segment	Route	District*	Segment End Points	Selected Strategy	Selected Project	Project Description	Estimated Project Budget	Final Score	Funding Source **
Statewide Program	n/a	n/a	n/a	Multimodal	Bicycle/Pedestrian Safety Technologies	Deployment of safety-enhancing technologies to improve the viability and safety of bike/ped travel in congested areas	$ 1,000,000	n/a	ITTF
Statewide Program	n/a	n/a	n/a	Multimodal	Transit Efficiency Enabling Technologies	Deployment of technologies, including transit signal preemption, to support transit system reliability and improve travel times	$ 2,500,000	n/a	ITTF
Statewide Program	n/a	n/a	n/a	Arterial Operations	Advanced Traffic Signal Controllers	Deployment of new signal controller technology to improve arterial operations and prepare for connected and autonomous vehicle needs	$ 3,000,000	n/a	ITTF
Statewide Program	n/a	n/a	n/a	Arterial Operations	Community-wide Adaptive Signal System	Deployment of adaptive signal and centralized signal control technologies on key arterial corridors	$ 3,000,000	n/a	ITTF
Statewide Program	n/a	n/a	n/a	Incident Management	Integration of Localities/PSAPs into VDOT Network	Deployment of technology to integrate VDOT data and video imagery with key locality operations centers	$ 2,500,000	n/a	UNF
Statewide Program	n/a	n/a	n/a	Multimodal	TSDAC Electronic Fare Payment Systems	Deployment of technologies to transit service providers to enable on-board systems to improve travel data collection, system performance and traveler information	$ 5,000,000	n/a	UNF
Statewide Program	n/a	n/a	n/a	Traveler Information	VDOT 511 System Enhancements	Development of new features to enhance the 511 mobile app and phone/web systems	$ 2,300,000	n/a	ITTF
Statewide Program	n/a	n/a	n/a	Traveler Information	Travel Time Signage Program Expansion	Deployment of electronic signage to provide destination travel time information to motorists	$ 4,400,000	n/a	UNF

* District Codes
BRI=Bristol
CUL=Culpeper
FR=Fredericksburg
HR=Hampton Roads
LYN=Lynchburg
NOVA=Northern VA
RIC=Richmond
SAL=Salem
STA=Staunton

** Funding Codes
ITTF=Innovation and Technology Transportation Fund
SRT=Smart Road Technology Fund
UNF=Unfunded

ITTF Funded:	$ 74,771,332
SRT Funded:	$ 25,931,214
Unfunded:	$ 47,428,666
Total Cost:	$148,131,212