Northern Virginia East-West ICM Corridor Planning Study

Concept of Operations

FINAL

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kapsch

Kimley»Horn

ACKNOWLEDGEMENTS

The project team is indebted to the Virginia Department of Transportation (VDOT), under the leadership of Paul Szatkowski and Amy Tang McElwain, for its visioning and strategic guidance throughout the integrated corridor management (ICM) planning process. Numerous partners and stakeholders contributed to this Implementation Plan, providing a wealth of insights, expertise, and suggestions. Contributors included members of the ICM Program Advisory Group: Dean Gustafson and Hari Sripathi (VDOT); Todd Horsley and Tim Roseboom (Virginia Department of Rail and Public Transportation (DRPT)); Monica Backmon and Keith Jasper (Northern Virginia Transportation Authority (NVTA)); Cyndi Ward (Metropolitan Washington Airports Authority (MWAA)); Mark Phillips (Washington Metropolitan Area Transit Authority (WMATA)); Larry Marcus and Jon Lawler (Arlington County); and Iris Vaughan (Federal Highway Administration (FHWA)).

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EXECUTIVE SUMMARY

Integrated corridor management (ICM) takes a multi-modal, integrated approach to congestion management. Rather than address the shortcomings of the separate roadways and modes in isolation, ICM treats the individual transportation components (highways/roads, transit, parking lots, bicycle and pedestrian trails, etc.) as elements of an interrelated regional transportation corridor. ICM uses technology and operational strategies to optimize performance of the transportation infrastructure. General benefits of ICM include improved mobility, reliability, and safety and reductions in fuel consumption and fuel emissions.

This document presents the Concept of Operations for deploying ICM along the East-West Travel Shed in Northern Virginia. The travel shed, west of Washington, D.C., is anchored by Interstate 66 and the Dulles Toll Road (RT-267). It traverses portions of US Routes 50, 29, and 15, and State Routes 7, 123, 620, 286, and 28. Metro Rail's Silver and Orange lines, the Virginia Railway Express, and multiple commuter and transit bus services operate in the study area, as do park-and-ride lots and bike and pedestrian trails.

The ICM planning effort is funded through an ICM Deployment Grant from the U.S. Federal Highway Administration (FHWA), with additional funding furnished by the Virginia Department of Transportation (VDOT). The planning process has involved extensive stakeholder collaboration and broad-based regional support, including project governance by a Program Advisory Group and Stakeholder Coordinating Committee. The objectives of the planning grant are to prepare (1) an ICM Concept of Operations, and (2) an ICM Implementation Plan. The Implementation Plan will be reported on in a separate volume.

Goals of the ICM Concept. Through a dual process of data-driven analysis of study corridor conditions and stakeholder deliberations, three sets of goals for the ICM program in the East-West corridor have been identified, as follows:

- *Goal 1 – Optimization: Optimize performance of the existing transportation infrastructure.*
  - Ensure that all elements of the transportation infrastructure perform at peak efficiency.
- *Goal 2 – Reliability: Enhance travel time reliability in the study area.*
  - Improve the accuracy of travel time prediction, such that the time needed to complete individual trips in or through the study corridor can be more effectively judged.
- *Goal 3 – Choice: Support on-demand, multi-modal trip options for travelers.*
  - Furnish timely, detailed, actionable information to travelers to guide them in making "intelligent" travel choices.

ICM Foundational Initiatives. To achieve these ICM goals, five foundational initiatives in the East-West corridor were proposed and are described below:

- *Expanded Real-Time Conditions Monitoring:*
  - To effectively respond to travel conditions in the study area, the operations team needs to be cognizant of real-time conditions. Currently conditions are generally well-monitored on the interstates, but much less so on arterials and transit systems, etc. Hence, this initiative will focus on filling in the "gaps" in coverage, relying predominantly on third-party data to address deficiencies.
- Data Warehouse:
  - The warehouse serves as the common data repository for the sharing and exchange of information among the regional partners and third-party providers. Partners will be able to upload and download data to and from the warehouse, which will contain both real-time and archived data. The warehouse, which may build on complementary statewide, "cloud-computing" efforts, will support other foundational initiatives, including conditions monitoring, decision support, and traveler information. It will also include analytic and query functionality.

- *Enhanced Decision Support:*
  - Decision support refers to a structured process for responding operationally to recurring and non-recurring congestion. The concept here will be to begin with consistent, structured response plans that are multi-agency and multi-modal, and to expand the capability to increasingly sophisticated automated tools that evaluate conditions and generate real-time response alternatives.
- *Next-Generation Traveler Information:*
  - This initiative will move beyond providing travelers with "fixed" information on travel conditions on specified roads and segments. It will furnish on-demand, real-time and predictive, multi-modal trip guidance personalized to the needs of travelers, including assistance on travel mode options and identification of the optimal times to travel. The program will rely principally on private, third-party providers to deliver traveler information to customers; to be granted access to regional data generated by VDOT and its partners, providers will need to meet minimum program requirements and standards. VDOT may fill in traveler information "gaps" not addressed by the marketplace.

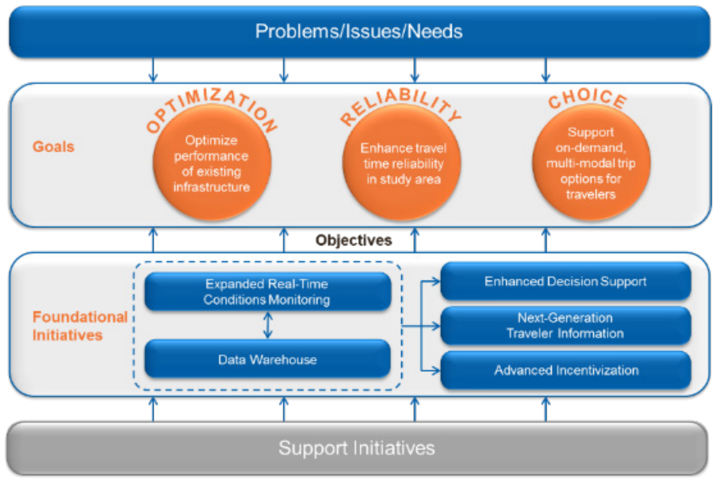

Figure E-1: ICM Conceptual Framework

- *Advanced Incentivization:*
  - Whereas the other foundational initiatives focus on managing congestion, this initiative emphasizes proactively managing demand, i.e., strategies to reduce the number of vehicles and people on the transportation grid during peak periods. It will include education and outreach activities to encourage commuters to adjust their patterns of travel, but will extend to out-of-the-box strategies that "reward" travelers for exemplary behaviors that ease congestion.

Each foundational initiative is visualized as advancing along a continuum of increasing "maturity." Five levels of maturity – from "least-advanced" to "most-advanced" – are associated with each initiative. For instance, the initiative, Real-Time Conditions Monitoring, progresses from "Access to conditions data on ad-hoc basis" (least-advanced) to "Access to real-time and predictive data on all facilities and modes" (most-advanced). The maturity model is intended to institutionalize a process of "continuous, incremental improvement," enabling stakeholder partners to get up to speed at a realistic pace and for the region to work together, systematically and structurally, toward a common vision.

The five foundational initiatives, taken together, comprise the centerpiece of the ICM concept. Beyond the foundational concepts, additional secondary "support" initiatives are specified in the body of the report.

Anticipated Outcomes. The aim of this ICM program is to bring structure, stability, and balance to multi-modal transportation across the East-West Travel Shed. The vision is one of continuous situational awareness on conditions in the corridor, so that operations teams can respond quickly and appropriately to changing circumstances. The aim is an integrated corridor in which travelers have steady, easy access to a suite of real-time transportation options, enabling them to arrive at informed traveler choices. Travel-time reliability will be significantly improved, so that the time needed to complete individual trips can be more effectively judged. Travelers will be exposed to incentives and strategies to curb peak-period transportation demand.

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1. PREAMBLE

This document presents the Concept of Operations for deploying integrated corridor management (ICM) along the East-West Travel Shed in Northern Virginia. ICM uses an integrated, multi-modal approach to congestion management. Rather than address the shortcomings of individual roadways in isolation, ICM treats the separate components as elements of an interrelated regional transportation network or corridor. The corridor is not limited to highways and roads, but includes transit systems, parking lots, bike and pedestrian trails, etc. The concept of an integrated corridor is that circumstances – both positive and negative – in one part of the corridor or mode impacts conditions in other parts and modes. An ICM deployment uses technology and operational strategies to help ensure the transportation infrastructure performs at peak efficiency. One key ICM strategy, referred to as “load-balancing,” redirects excess travel demand away from congested conditions to “pockets” of under-utilized capacity in other parts of the corridor or modes.

This section of the report summarizes evolution of the ICM concept in the East-West Travel Shed, from project organization and structure, through identification of the needs and strategies that set the stage for establishment of the ICM conceptual framework and operational scenarios. The full report details the ICM planning process and outcomes, including examination of the corridor’s relevant operational characteristics and parameters.

The ICM study area, as shown in Figure 1 passes through Prince William, Loudoun, Fairfax, and Arlington counties, and the cities of Fairfax and Falls Church. It is anchored by Interstate 66, a major commuting corridor that links downtown Washington, D.C. to its western suburbs. The travel shed traverses a host of additional roadways and arterials, including portions of Interstate 495; US Routes 50, 29, and 15; and State Routes 267 (Dulles Tool Road and Dulles Greenway), 7, 123, 620, 286 (Fairfax County Parkway), and 28. Metro Rail’s Silver and Orange lines, the Virginia Railway Express, and numerous commuter and transit bus services operate in the study area. Park-and-ride lots dot the landscape, as do multi-use trails for bicycles and pedestrians.

The ICM planning effort is funded through an ICM Deployment Grant from the U.S. Federal Highway Administration (FHWA), with additional funding furnished by the Virginia Department of Transportation (VDOT). The objectives of the planning grant are to prepare (1) a Concept of Operations, and (2) an Implementation Plan. The Implementation Plan, which will present a roadmap for achieving the ICM concept, will be reported on in a companion volume.

Project Structure and Stakeholder Support. The ICM planning process has been characterized by collaboration and broad-based regional support. Six agencies have partnered together, in the form of a Program Advisory Group (PAG), to advise and guide the planning process. These are: (1) VDOT, (2) FHWA, (3) the Virginia Department of Rail and Public Transit (DRPT), (4) the Washington Metropolitan Area Transit Administration (WMATA), which operates the Metro Rail and Metro Bus systems, (5) the Metropolitan Washington Airports Authority (MWAA), which operates the Dulles Toll Road, and (6) Arlington County, representing local jurisdictions across the ICM study corridor. A broader team of regional stakeholders, known as the Stakeholder Coordinating Committee (SCC), has served as the coordinating body for developing the ICM concept. Members of the SCC include local departments of transportation, transit agencies, incident managers, regional planning entities, neighboring states and jurisdictions, and others.

The SCC appointed seven resource forums to carry out the detailed examination of topics related to ICM implementation. The seven resource areas are: (1) roadway operations, (2) incident and emergency management, (3) transit and transportation demand management, (4) bicycles and pedestrians, (5) freight, (6) traveler information and communications, and (6) innovation. Each resource forum is meeting multiple times to identify study corridor needs, define candidate ICM strategies, and specify steps for ICM implementation. Membership in the resource forums include both public- and private-sector specialists.

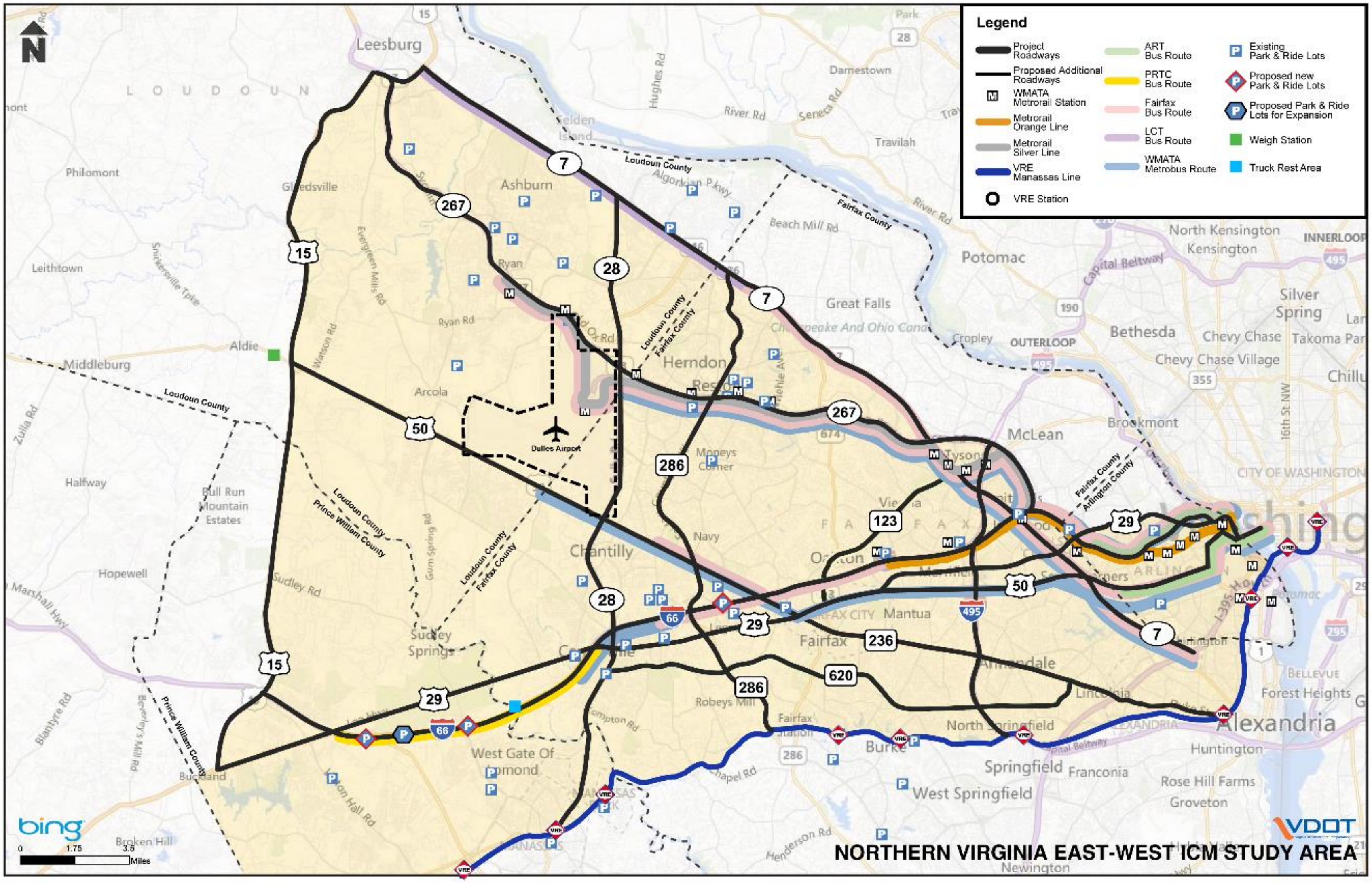

Figure 1: Northern Virginia East-West ICM Study Area

Suitability of the Corridor for ICM Implementation. The East-West Travel Shed is one of the most consistently congested corridors in the Washington, D.C. region, and even the nation. While commuters head for destinations in all directions, including Washington, D.C., the heaviest areas of employment tend to be in the eastern sections of the corridor (Fairfax County, Arlington County, and Washington, D.C.). Activity centers are particularly heavily concentrated along I-66 and SR-267. Numerous segments of the corridor experience high levels of recurring congestion during AM and PM peak periods, and many of the segments are congested during non-peak periods as well. When incidents occur, gridlock conditions often rapidly develop and commuters are constantly frustrated at their inability to reliably predict the time needed to complete their trips. A significant number of trips within the corridor occur by bus and rail – transit systems in the region have among the highest ridership levels in the United States.

Yet, for all these hardships and limitations, analyses of data indicate opportunities for improvement. For example, even during peak periods, there are “pockets” of under-utilized roadway capacity across the corridor. Additionally, while rail travel utilization in the corridor is high, there are still rail trips and travel periods where ridership is well below the seating capacity of trains. Similar patterns occur on some bus routes. Many commuter lots are full during peak periods, but others have capacity to spare. Bicycle and pedestrian trails in the corridor are generally well-utilized, but most are nowhere near maximum capacity. The potential exists for increased shared-vehicle travel in the corridor, and for shifting a portion of peak-period travel to other times of the day.

In general, a host of key factors make the East-West Travel Shed well-suited to ICM implementation: under-utilized capacity in the corridor; the growing concentration of job and residences around activity centers; the multi-modal nature of the corridor; the prevalence of park-and-ride lots adjacent to rail and bus transit facilities; an effective, though incomplete, network of existing ITS infrastructure; a history of multi-jurisdictional collaboration in the operation and maintenance of the transportation network; and an emerging culture of shared and “open” data. Furthermore, the planned addition of high-occupancy toll (HOT) lanes on I-66 complements the ICM concept, insofar as it is likely to encourage carpooling and bus travel.

Top-Level Needs and Strategies. Stakeholders, working together, identified a host of corridor-level needs – and the corresponding strategies to address those needs – across each of the seven resource areas. When analyzed for recurrent themes, the following overarching needs and corresponding strategies emerged:

- Need accurate, reliable, real-time information on travel conditions along the key arterials in the study area:
  - Use 3rd-party data to identify real-time conditions on arterials.
- Need accurate, reliable, real-time information on transit and commuter system status:
  - Use system data to identify real-time transit system status.
  - Implement and use technology to identify real-time parking lot availability status.
- Need expanded operational coordination and information-exchange across agencies, jurisdictions, and modes:
  - Execute agency-level MOU’s governing operational coordination and information exchange.
  - Establish a data warehouse for the aggregation of real-time travel conditions and status information across the study area.
  - Enhance incident response.
  - Optimize arterial signal management.
  - Define and implement decision-support processes and procedures.

- Need on-demand, real-time, predictive user-centric traveler information encompassing end-to-end trips:
  - Establish a data warehouse for the aggregation of real-time travel conditions and status information across the study area.
  - Furnish regional inputs and guidance towards development of pertinent tools, including a data cloud for public-sector and 3rd-party app development.
  - Integrate conditions and trip-planning functions, including first/last mile information.
  - Implement a point-to-point trip planning tool.
  - Implement functionality to predict emerging travel conditions, status, and traveler behavior; enhance travel time reliability.
  - Support flexible, on-demand clearinghouse access by users, including in-vehicle connectivity.
- Need to promote and *empower* incentivized "smart" traveler choices:
  - Implement programs to incentivize reductions in travel using single-occupant vehicles, travel during peak periods, etc.
  - Adopt statewide policies and innovative strategies to incentivize travelers.

Goals of the ICM Concept. Based on the top-level needs and strategies delineated above, three sets of goals for the ICM program were identified, as follows:

- *Goal 1– Optimization: Optimize performance of the existing transportation infrastructure.*
  - Ensure that all elements of the transportation infrastructure perform at peak efficiency.
- *Goal 2 – Reliability: Enhance travel time reliability in the study area.*
  - Improve the accuracy of travel time prediction, such that the amount of time needed to complete individual trips in or through the study corridor can be more effectively judged.
- *Goal 3 – Choice: Support on-demand, multi-modal trip options for travelers.*
  - Furnish timely, detailed, actionable information to travelers to guide them in making "intelligent" travel choices.

More detailed objectives are associated with each of these three goals.

ICM Foundational Initiatives. To achieve the ICM goals, five foundational initiatives were proposed. These initiatives are identified and defined below:

- *Expanded real-time conditions monitoring:*
  - To effectively respond to travel conditions in the study area, the operations team needs to be cognizant of real-time conditions. Currently conditions are generally well-monitored on the interstates, but much less so on arterials and transit systems, etc. Hence, this initiative will focus on filling in the "gaps" in coverage, relying predominantly on third-party data to address deficiencies.
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  - The warehouse serves as the common data repository for the sharing and exchange of information among the regional partners and third-party providers. Partners will be able to upload and download data to and from the warehouse, which will contain both real-time and archived data. The warehouse, which may build on complementary statewide, "cloud-computing" efforts, will support other foundational initiatives, including conditions monitoring, decision support, and traveler information. It will also include analytic and query functionality.

- *Enhanced decision support:*
  - Decision support refers to a structured process for responding operationally to recurring and non-recurring congestion. The concept here will be to begin with consistent, structured response plans that are multi-agency and multi-modal, and to expand the capability to increasingly sophisticated automated tools that evaluate conditions and generate real-time response alternatives.
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  - This initiative will move beyond providing travelers with “fixed” information on travel conditions on specified roads and segments. It will furnish on-demand, real-time and predictive, multi-modal trip guidance personalized to the needs of travelers, including assistance on travel mode options and identification of the optimal times to travel. The program will rely principally on private, third-party providers to deliver traveler information to customers; to be granted access to regional data generated by VDOT and its partners, providers will need to meet minimum program requirements and standards. VDOT may fill in traveler information “gaps” not addressed by the marketplace
- *Advanced incentivization:*
  - Whereas the other foundational initiatives focus on managing congestion*,* this initiative emphasizes proactively managing demand*,* i.e., strategies to reduce the number of vehicles and people on the transportation grid during peak periods. It will include education and outreach activities to encourage commuters to adjust their patterns of travel, but will extend to out-of-the-box strategies that “reward” travelers for exemplary behaviors that ease congestion.

The relationship between needs, goals, and the foundational initiatives are depicted in Figure 2: ICM Framework.

Each foundational initiative is visualized as advancing along a continuum of increasing “maturity.” Five levels of maturity – from “least-advanced” to “most-advanced” – are associated with each initiative. For instance, the initiative, Real-Time Conditions Monitoring, progresses from “Access to conditions data on ad-hoc basis” (least-advanced) to “Access to real-time and predictive data on all facilities and modes” (most-advanced). The maturity model is intended to institutionalize a process of “continuous, incremental improvement,” enabling stakeholder partners to get up to speed at a realistic pace and for the region to work together, systematically and structurally, toward a common vision.

The five foundational initiatives, taken together, comprise the centerpiece of the ICM concept. In addition to these, multiple “support” initiatives were identified under each of the seven focus areas. These support initiatives are specified in the body of the report.

Operational Scenarios. Two operational scenarios were applied to the ICM concept to illustrate the operational impacts and benefits of ICM implementation. The two scenarios depict (1) recurring congestion (i.e., normal operations), and (3) non-recurring congestion (i.e., unplanned freeway events and coordinated multi-modal response). Unplanned events include a minor traffic incident, major traffic incident, and weather event. Both scenarios examine operational activity on SR-267 (Dulles Toll Road) and Metro Rail’s Silver Line through Tysons Corner; they also take account of activity on I-66, I-495, and SR-7. The scenarios examine the roles and responsibilities of ICM partners and stakeholders. They compare current strategies used to respond to the scenarios versus the enhanced strategies following ICM implementation.

In general, the scenarios indicate that, with ICM deployment, operations staff should be able to deliver more effective response actions, and travelers should be able to make improved response decisions for dealing with conditions. ICM is intended to help both operators and travelers become more aware of available transportation supply and demand.

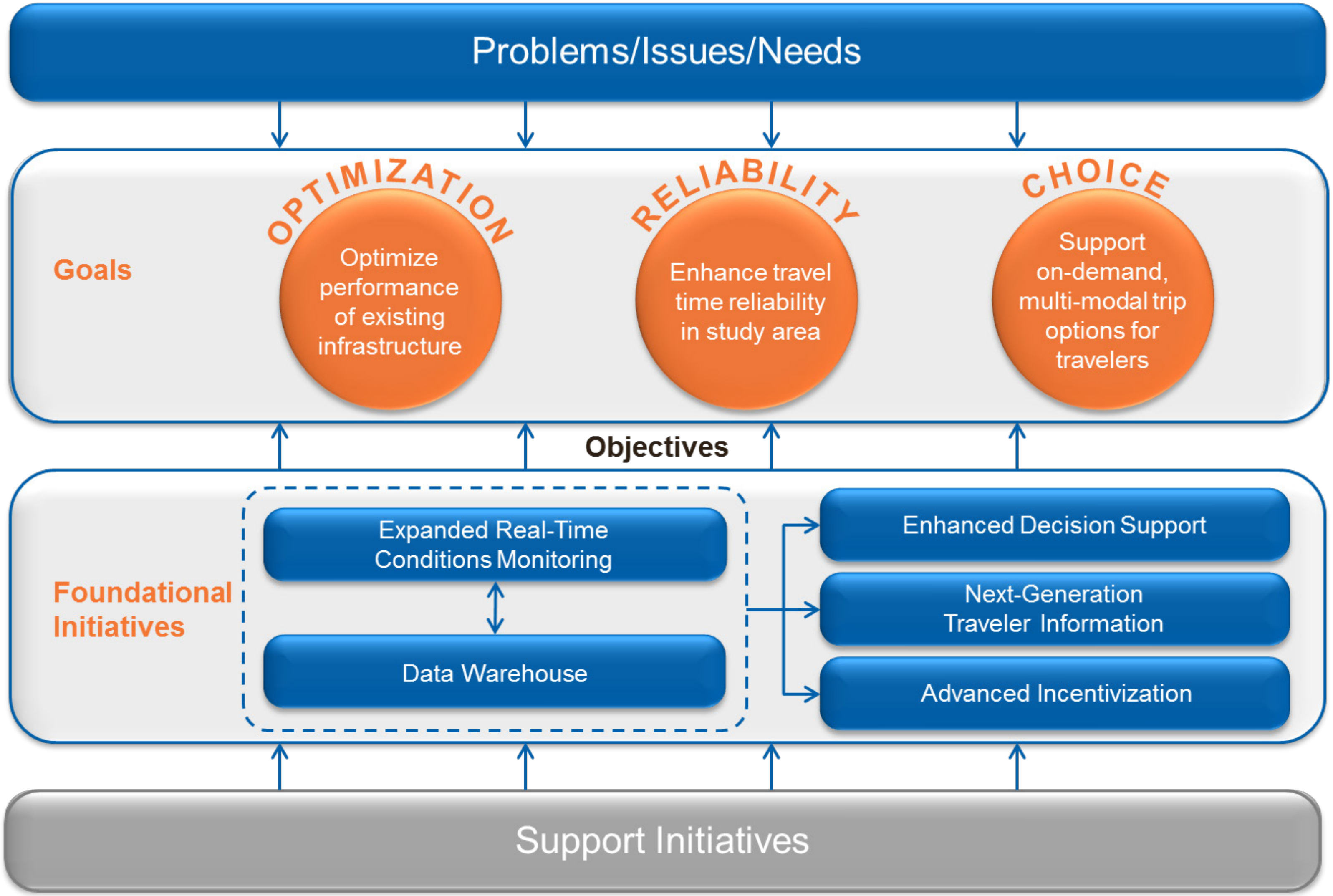

Figure 2: ICM Framework

2. INTRODUCTION

This document presents the Concept of Operations (ConOps) for Integrated Corridor Management (ICM) along the East-West Travel Shed in Northern Virginia (NOVA). The transportation challenges in Northern Virginia in general – and in the study corridor in particular – are significant. Congestion and transportation system reliability are growing problems. With much of the work in Northern Virginia in recent years on improving traffic movements north and south, this project adds east-west travel as a critical area of focus. The concept of ICM is a logical extension of recent and on-going initiatives in the study area, including the Active Traffic Management (ATM) and the Transform 66 multi-modal corridor improvement initiatives.

The document progresses logically from a discussion of characteristics and conditions in the study area, through identification of study area issues and needs, to establishment of the ICM framework for addressing those needs. It concludes with an examination of operational scenarios.

The ConOps is comprised of the following key sections:

- Project Approach and planning Methodology,
- Existing Corridor Scope and Operational Characteristics,
- Corridor Issues and Needs,
- ICM Operational Concept,
- Operational Scenarios, and
- Quick Wins.

This study was funded, in part, under a grant from the U.S. Federal Highway Administration (FHWA). The report was prepared by the Virginia Department of Transportation (VDOT) in coordination with stakeholder partners across the region. Kapsch TrafficCom Transportation and Kimley-Horn and Associates assisted with preparation of the report.

3. PROJECT APPROACH AND PLANNING METHODOLOGY

3.1. Overview

This planning study is focused on defining a (1) Concept of Operations, and (2) Implementation Plan to deploy ICM in the NoVA East-West Travel Shed. It emphasizes collaboration among the partner agencies – and the ongoing engagement of stakeholders across the region – to enable the deployment of ICM concepts and to sustain operational support beyond the planning period. The planning effort is funded through an ICM Deployment Grant from the Federal Highway Administration (FHWA) and additional funding furnished by VDOT.

3.2. Project Tasks

The project has been organized into the following major tasks, involving stakeholders throughout the process in support of a regionally plan:

- **Start-up and organize project.** This task established the project organization structure (see Section 3.4), initiated dialogue among stakeholders, and refined the study area boundaries.
- **Profile study corridor.** This task extensively documented existing conditions in the study area, including operational characteristics of various travel modes, assets and ITS infrastructure, planned projects and improvements, and institutional characteristics. This profile is highlighted in Chapter 4 of this document.
- **Define ICM framework and identify operational needs in corridor.** This task convened a committee of knowledgeable stakeholders and resource forums tailored to various study focus areas to define the framework for ICM and identify baseline corridor needs. These needs are highlighted in Chapter 5 of this document. The ICM framework is highlighted in Chapter 6.
- **Identify, explore, and prioritize ICM strategies to address operational needs.** This task again convened the committee of knowledgeable stakeholders and focus-area resource forums to identify, validate, and prioritize candidate ICM strategies to meet the previously-identified corridor needs. These needs are noted in Section 6.1.
- **Prepare a Concept of Operations.** This task synthesized the inputs, investigations, and findings to date to produce this Concept of Operations.
- **Prepare an Implementation Plan.** This task will define an implementation framework identifying projects to be deployed, including system requirements, lead agencies and stakeholders, pertinent technologies, and cost estimates.
- **Request broad regional support for the ICM concept.** The final task of this effort will be conducted in conjunction with development of the Implementation Plan and will involve briefing appropriate governing, advisory, and stakeholder organizations across the region on the ICM concept.

3.3. Period-of-Performance

The period-of-performance for the ICM planning study is approximately 20 months, with an anticipated completion date of Spring 2017.

3.4. Project Organization Structure

The project organization structure was developed with stakeholder ownership and sustainability of the plan implementation in mind. Figure 3 shows the project organization structure, which has been organized to maximize input from stakeholders, including those at the executive level within jurisdictions and agencies, as well as technical experts within these groups. While the project management team consists of representatives from VDOT's Northern Region Operations (NRO) and Central Office, the direction of and input to the project have come from the following groups:

- The **Program Advisory Group (PAG)** advises and governs the ICM effort, providing strategic direction to the effort and defining the broad-based scope. This group represents the perspectives of the governing agencies, as well as the interests of the broader region and study area. It will ultimately meet approximately five times over the life of the planning study and review drafts of key project deliverables. This group will continue oversight of the ICM effort beyond the planning project, governing the overall ICM *program* for the region.
- The **Stakeholder Coordinating Committee (SCC)** is a public-sector stakeholder coordinating body representing stakeholder perspectives during ICM planning and deliberations. This group of approximately fifty stakeholders will meet four times over the life of the planning study and has at least one representative from all relevant agencies and jurisdictions. This group is responsible for nominating additional members from their organizations to participate in the focus area Resource Forums and reconcile outputs and recommendations from these forums. The SCC will review drafts of this Concept of Operations and the Implementation Plan. Collectively, this group will is encouraging regional and organizational support for the ICM effort.
- Seven distinct **Resource Forums (RFs)** were established, each devoted to a different focus area topic. Each forum will meet three times over the life of the planning study, focusing, respectively, on (1) identifying study corridor needs, (2) defining candidate ICM strategies, and (3) guiding details and steps for ICM implementation. The forums are comprised of dozens of public- and private-sector specialists in pertinent transportation topics and led by one or two Champions (identified by the SCC). The seven focus area topics are:
  - Roadway Operations,
  - Incident and Emergency Management,
  - Transit and Transportation Demand Management,
  - Bicycles and Pedestrians,
  - Freight,
  - Traveler Information and Communications, and
  - Innovation.
- The **Project Management Support Team** consists of additional VDOT staff and consultant resources tasked with assisting in stakeholder coordination, workshop facilitation, and documentation. FHWA provides oversight over the entire project.

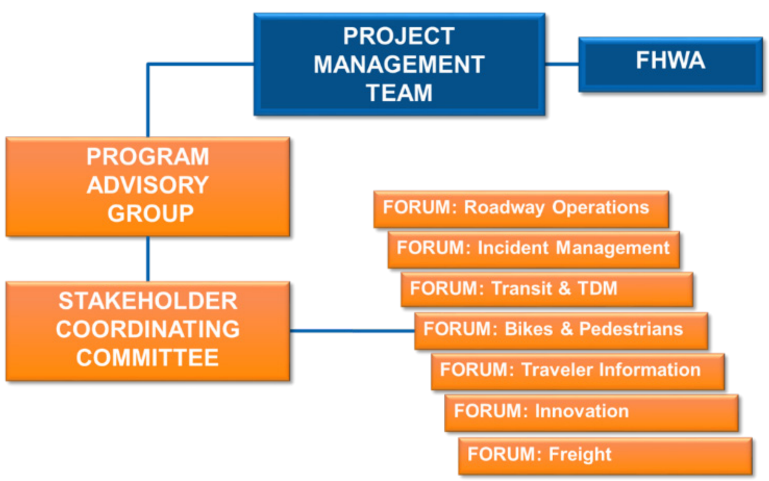

Figure 3: Project Organization Structure

3.5. Stakeholder Chronology

Table 1 lists the workshops and meetings to-date with the PAG, SCC, and Resource Forums. Additional meetings with each group are scheduled for early 2017.

Table 1: Chronology of Stakeholder Outreach to Date

Date	Meeting
August 14, 2015	Kick-Off with FHWA
October 26, 2015	Project Kick-Off
December 15, 2015	PAG Meeting #1
February 18, 2016	SCC Meeting #1
March 14-17, 2016	Resource Forum Workshops #1
May 2-5, 2016	Resource Forum Workshops #2
May 24, 2016	PAG Meeting #2
June 14, 2016	SCC Meeting #2
September 7, 2016	VDOT Framework Workshop
November 10, 2016	PAG Meeting #3
November 16, 2016	SCC Meeting #3

4. EXISTING CORRIDOR SCOPE AND OPERATIONAL CHARACTERISTICS

4.1. Study Area Overview

The ICM travel shed for this study is located within Prince William, Loudoun, Fairfax, and Arlington counties in Northern Virginia, along with the independent cities of Alexandria, Fairfax, Falls Church, Manassas, and Manassas Park and the towns of Vienna and Herndon. The corridor is primarily anchored by I-66, a major commuting corridor between downtown Washington, D.C., and its western suburbs. A map of the corridor is shown in Figure 4.

The travel shed includes the following east-west (parallel) highways and arterials:

- I-66, a major interstate limited-access facility
- SR 267 (Dulles Toll Road and Dulles Greenway), a tolled non-interstate limited-access facility
- US 50, a principal arterial
- US 29, a principal arterial
- Route 236, a principal arterial
- SR 7, a principal arterial
- SR 123, a principal arterial
- SR 620 (Braddock Road), a minor arterial

The travel shed includes the following north-south (connecting) highways and arterials:

- I-495, a major interstate limited-access facility
- SR 286 (Fairfax County Parkway), a major arterial with several freeway-grade sections
- SR 28, a major arterial that has been converted to a freeway north of I-66
- US 15, a major arterial

The Northern Virginia East-West corridor is an important multi-modal corridor, and a range of transit options is available for long- and short-distance commuters, including the following:

- Multiple rail transit options, including Metrorail's Orange and Silver Lines, which are considered heavy rail, and the Virginia Railway Express (VRE), a commuter rail service which runs near I-66 between Manassas and Washington, D.C. The Orange Line mainly runs along I-66, while the Silver Line predominantly runs along the Dulles Toll Road before connecting to I-66. The VRE Manassas Line constitutes the southern border of the project study area.
- Multiple express bus services, including commuter bus services provided by WMATA Metrobus, Loudoun County Transit, the Potomac and Rappahannock Transportation Commission (40), and Fairfax Connector.
- Major park-and-ride lots, many of which are associated with Metrorail stations, VRE stations, or termini for commuter bus services.
- High-occupancy vehicle (HOV) lanes and facilities. East of I-495 (i.e., inside the Beltway), I-66 is limited to HOV-only during weekday peak periods in the peak direction (eastbound during the AM peak and westbound during the PM peak); peak-period HOV lanes are also provided in the left-most lane along I-66 west of I-495 and along SR 267 between I-495 and SR 28. Two barrier-separated high-occupancy vehicle or toll (HOT) lanes are provided along I-495 in each direction through the study area; these lanes are free for vehicles with three or more people and have a

variable toll for other users. Other facilities in the region, including I-66, are planned to be reconstructed to include HOT lanes in the near future. These projects are discussed further in Section 4.4.

- A network of multi-use trails for bicycles and pedestrians, including trails heavily utilized by commuters parallel to segments of the freeway and arterial corridor.
- Various options for carpooling, vanpooling, and ridesharing, including many recent on-demand services accessible via a mobile app.
- Multiple options for teleworking and co-working.
- Amtrak, which operates several stations within the corridor and provides passenger rail service along Amtrak's Northeast Regional, Crescent, and Cardinal routes, running from Washington, D.C., to the south and west along the US 29 corridor.

The study corridor also contains Dulles International Airport and Reagan National Airport, both of which are located within ten miles of I-66. These airports handle significant passenger and freight flows into and out of the region. Dulles Airport is the largest cargo airport in the Commonwealth of Virginia. Two significant freight rail lines – Norfolk Southern's Piedmont Division and Washington District lines – are also located in the study area and provide rail access to areas along the east coast.

4.1.1. Overall Corridor Travel Patterns and Growth

The East-West study corridor generally consists of heavier areas of employment in the eastern section of the corridor (closer to Washington, D.C.) and heavier areas of residential activity to the west. The patterns of vehicular and transit flows in the corridor generally reflect this. Commuter travel within the corridor generally occurs in the eastbound and westbound directions, as commuters travel from more residential communities in the western suburbs to destinations in Fairfax County, Arlington County, Washington, D.C., and Maryland. The study corridor exists entirely within the Northern Virginia portion of the Metropolitan Washington Area, and accommodates large amounts of traffic local to the region, as well as traffic originating from outside the region. Travel between the Metropolitan Washington Area and West Virginia accounts for approximately four percent of intercity passenger travel in the region, while travel between the Metropolitan Washington Area and the Winchester area accounts for an additional three percent. These trips are likely to use portions of the corridor. The graphic presented in Figure 5 illustrates high-level origin-destination travel patterns in Northern Virginia.

More generally, the heaviest person-flows in the region tend toward activity centers. Activity centers are defined by the Metropolitan Washington Council of Government (MWCOG) as those areas that already (or are expected to) accommodate a large portion of the region's employment, population, and household growth in coming years. Based on geographic location, size, land uses, and density of employment and housing, these locations are further classified as:

- Washington, D.C., Core
- Mixed-Use Centers (e.g. Tysons Corner)
- Employment Centers (e.g. portions of Arlington County along Lee Highway)
- Suburban Employment Centers (e.g. Reston Town Center)
- Emerging Employment Centers (e.g. eastern Loudoun County)

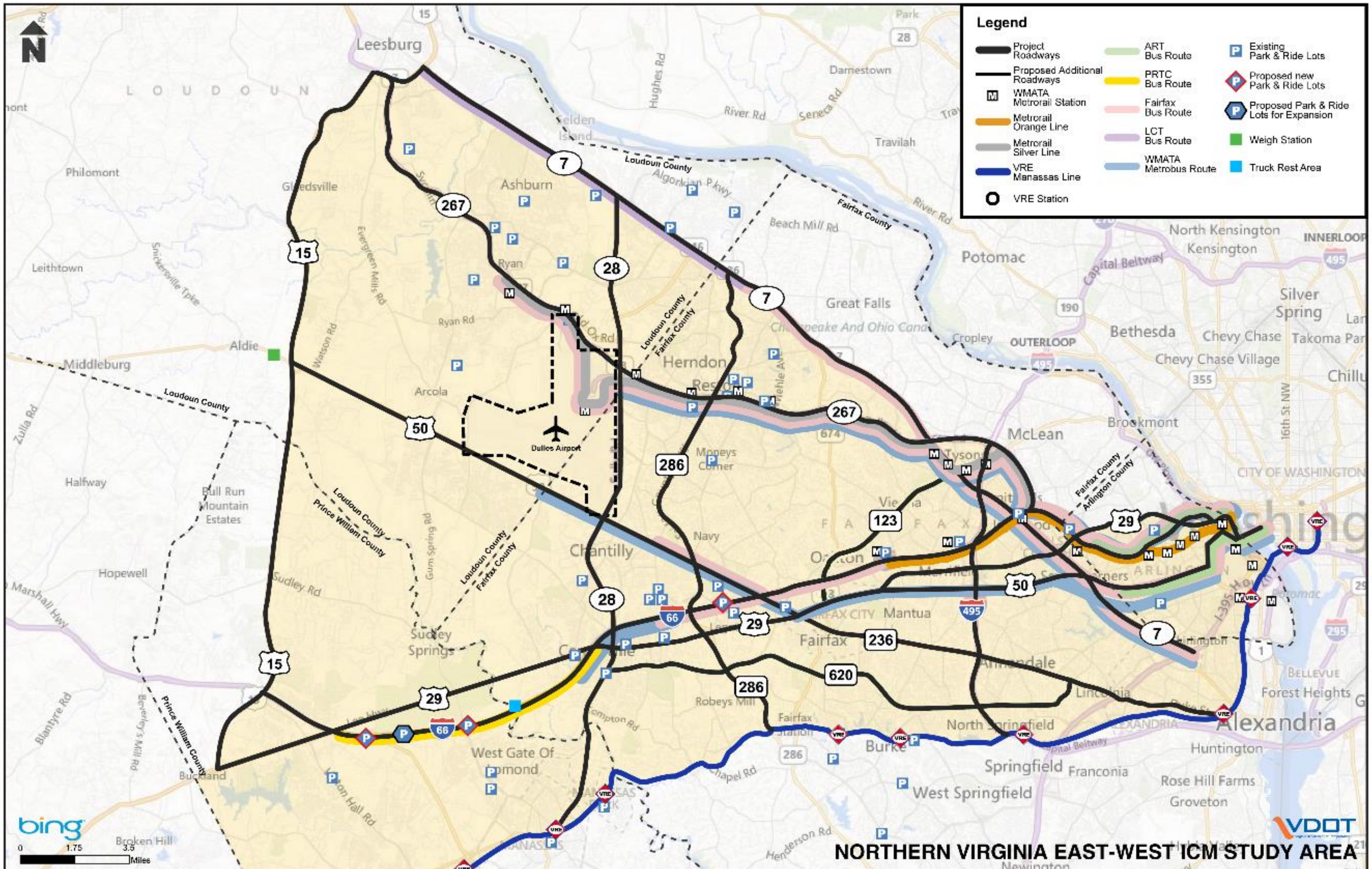

Figure 4: Northern Virginia East-West ICM Study Corridor

Figure 6 shows the regional activity centers in the study corridor. Many of these activity centers are located along or adjacent to I-66 or SR 267, the two major east-west freeways in the corridor which also feature heavy rail transit along their medians in the eastern half of the corridor. Figure 7 shows the forecasted "activity growth" – i.e., combined growth in jobs and population per square acre – for the study corridor. Much of this growth is concentrated around the activity centers along the I-66 and SR 267 corridors, with the heaviest growth forecasted to be along the Metrorail Silver Line in Tysons and the Reston/Herndon areas. Notably, significant growth is also forecasted in the western jurisdictions of the study corridor – in Prince William County and eastern Loudoun County.

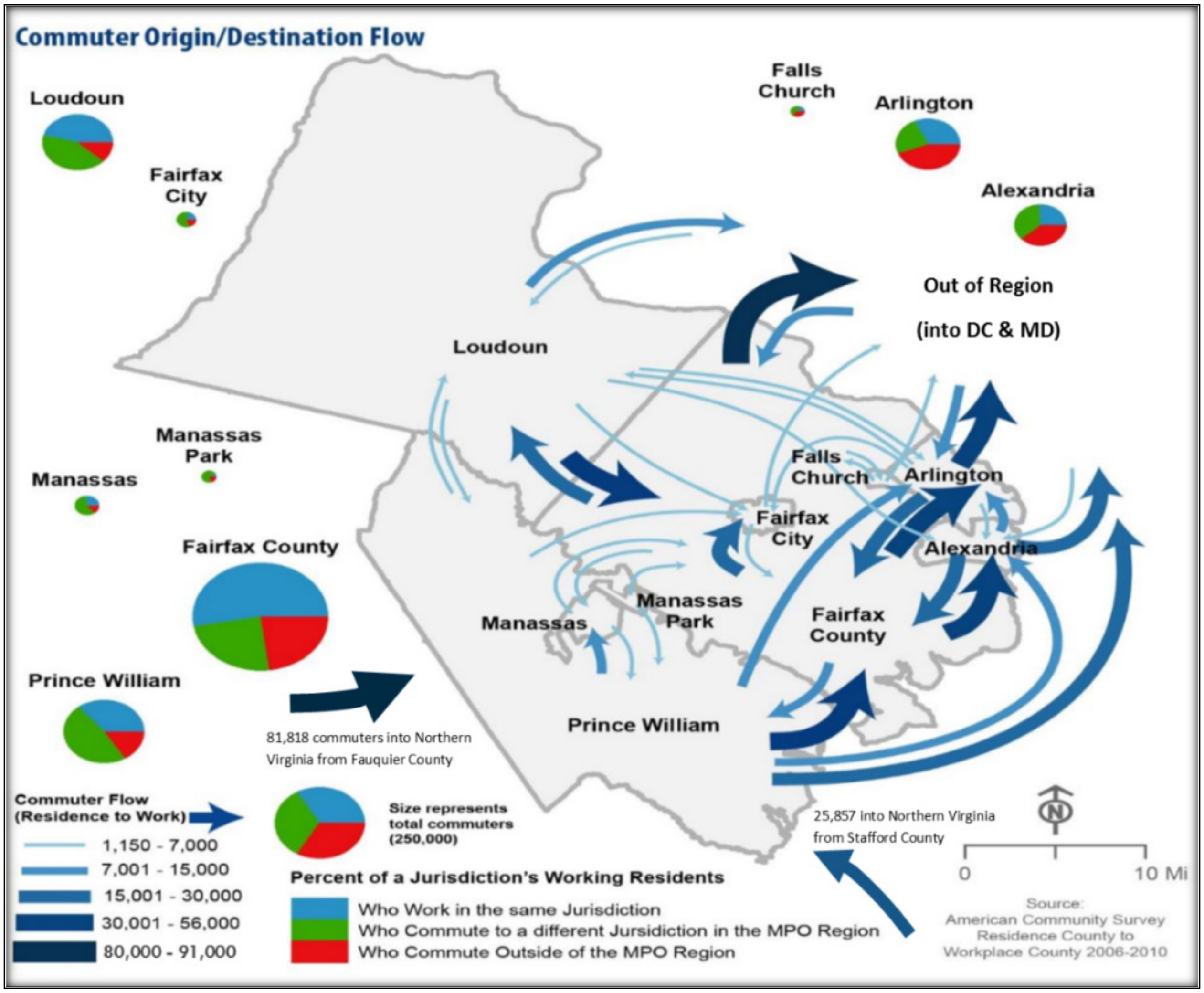

Figure 5: Commuter Origin-Destination Flows in Northern Virginia (Source: VTRANS 2040)

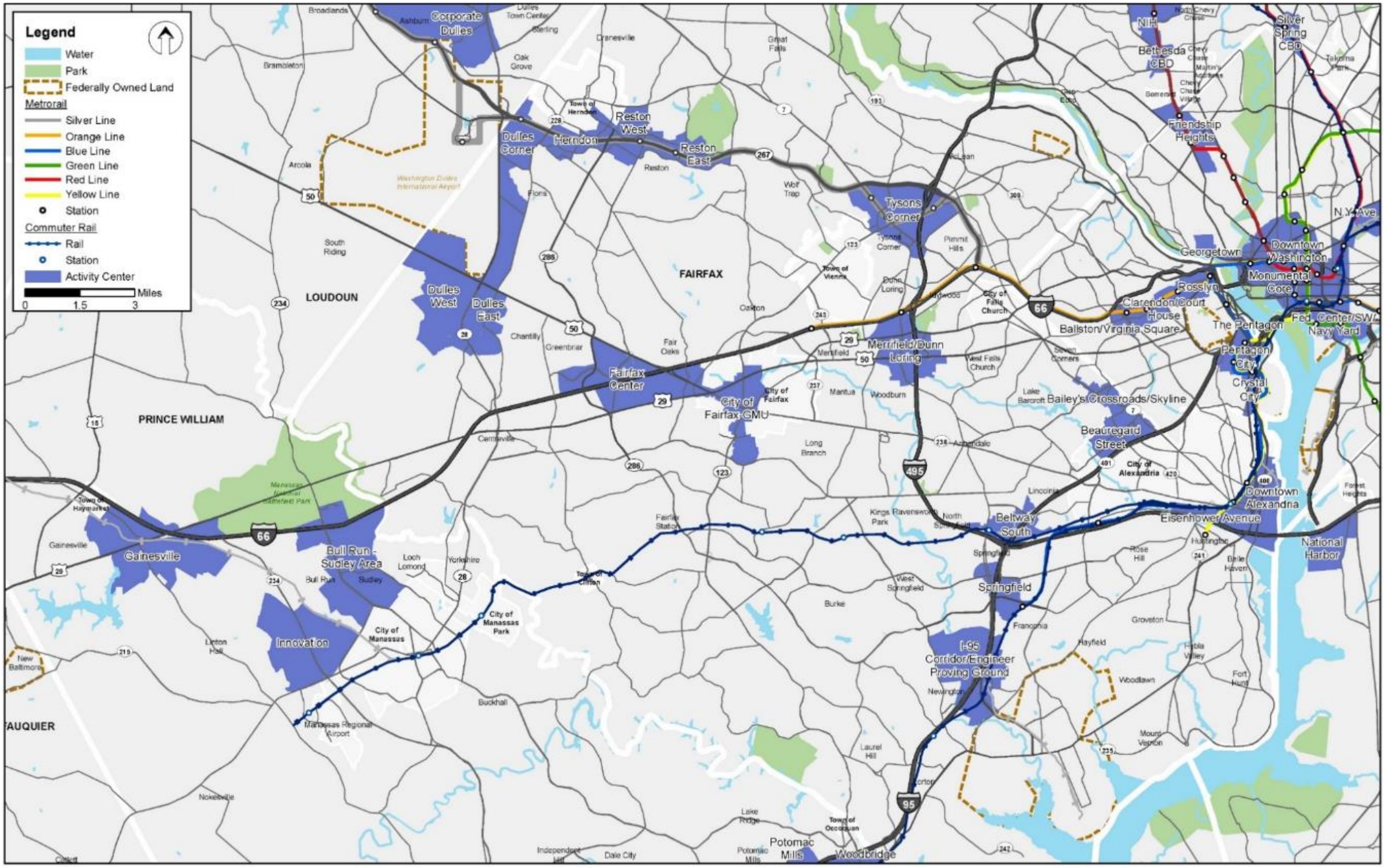

Figure 6: Regional Activity Centers (Source: I-66 Transit/TDM Technical Report, 2015)

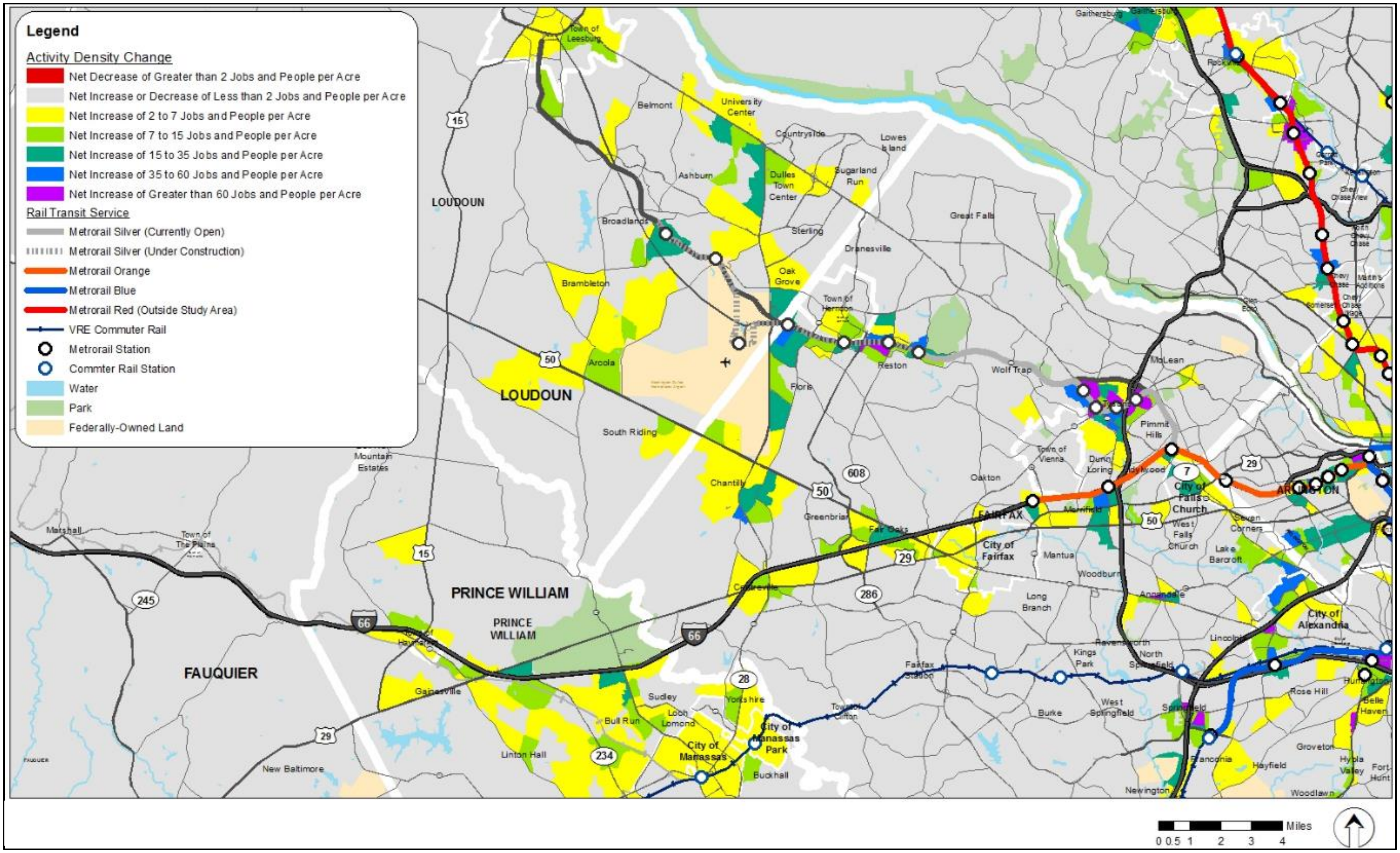

Figure 7: Corridor Forecasted Activity Density Change, 2015-2040 (Source: MWCOG, 2015)

4.2. Operational Characteristics and Profile

This section provides an overview of the operational characteristics of key transportation modes in the corridor: freeways and arterials, transit (including rail and bus and their associated park-and-ride lots), bicycles and pedestrians, and freight movements. Available performance metrics and data for each mode are provided or described. Also described is the nature of the capacity (and capacity constraints) at various locations within the corridor transportation network – by mode and by time-of-day.

4.2.1. Freeways and Arterials

4.2.1.1. Corridor Travel Patterns

Commuter travel within the corridor generally occurs in the eastbound and westbound directions, as commuters travel from more residential communities in the western suburbs to destinations in Fairfax County, Arlington County, Washington, D.C., and Maryland. However, as noted previously, travel is generally oriented toward activity centers, and these activity centers are located throughout the corridor. Much of the traffic originating in the western-most regions of the corridor is not destined for Washington, D.C., or even the eastern-most regions of the corridor. As an example, approximate daily distributions of origins and destinations along the I-66 corridor were developed as part of the *I-66 Corridor Improvements Project – Existing Conditions Report* in 2016.[1] Table 2 provides estimated origins and destinations for trips traveling along I-66 in eastern Fairfax County (east of I-495); Table 3 provides these for trips along I-66 in western Fairfax County (between SR 28 and SR 286); Table 4 provides these for trips traveling along I-66 in Prince William County (east of US 15). Several noticeable trends can be observed:

- Nearly 75% of the traffic at the I-66/I-495 interchange is generated within Fairfax County. Of that, nearly half is generated by the SR 123 and Nutley Street interchanges, which are less than 5 miles from the I-66/I-495 interchange.
- Very little volume travels the entire I-66 corridor between US 15 and I-495 (less than 10%).
- The distribution of traffic traveling to/from the north on I-495 is roughly the same as the distribution of traffic traveling to/from the east on I-66, despite the latter being an HOV-restricted facility during peak periods.
- SR 28 and the Fairfax County Parkway, both partially limited access facilities that serve as north-south collector roadways, are the most attractive origins and destinations for trips that do not traverse the entire length of the study corridor.

Origin-destination (O-D) data for other segments of the study area corridor has become more readily available in the past few years due to the advent of private vehicle probe data providers. Vendors such as StreetLight use GPS probe data[2] to aggregate trips between zones by trip types (personal/commercial) and purpose (home-based-work, etc.). This data is available to transportation agencies and consultants for purchase and can be used to identify many of the trends described above for the I-66 corridor. GPS probe data is a rapidly-evolving field that already can provide a wealth of historical data for planning purposes as well as form the foundation for predictive modeling.

4.2.1.2. Congestion on Corridor Roadways

Travel time index is defined as the ratio of average travel time to free-flow travel time. It indicates the typical travel times that a motorist will experience during a selected time of day. Figure 8 displays the travel time index along the major freeway and arterial facilities in the study area during the AM peak; the 8:00 AM hour was selected for the purposes of this graphic. Figure 9 displays the travel time index along the major facilities in the study area during the PM peak (5:00 PM hour).

[1] Approximated using the 2015 *MWCOG Regional Travel Demand Model*.
[2] http://blog.streetlightdata.com/where-does-streetlights-gps-data-come-from

Table 2: Entry and Exit Points for Traffic along I-66 in Eastern Fairfax County (East of I-495)

	Eastbound Traffic			Westbound Traffic	
	West of US 15	4%	Percent Coming From:	I-495 North	43%
	US 15	1%		I-495 South	23%
	US 29 (Gainesville)	2%		I-66 East	33%
	Route 234 Bypass	20%			
	Route 234 Business	7%	Percent Going To:	Nutley Street	14%
	US 29 (Centreville)	7%		Route 123	9%
	Route 28	11%		US 50	21%
	Fairfax County Parkway	5%		Fairfax County Parkway	7%
	US 50	20%		Route 28	15%
	Route 123	9%		US 29 (Centreville)	6%
	Nutley Street	14%		Route 234 Business	9%
				Route 234 Bypass	14%
Percent Going To:	I-66 East	38%		US 29 (Gainesville)	2%
	I-495 North	38%		US 15	0%
	I-495 South	24%		West of US 15	2%

Table 3: Entry and Exit Points for Traffic Along I-66 in Western Fairfax County (Between SR 28 and SR 286)

	Eastbound Traffic			Westbound Traffic	
Percent Coming From:	West of US 15	6%	Percent Coming From:	I-495 North	30%
	US 15	1%		I-495 South	12%
	US 29 (Gainesville)	5%		I-66 East	13%
	Route 234 Bypass	35%		Nutley Street	9%
	Route 234 Business	17%		Route 123	12%
	US 29 (Centreville)	13%		US 50	11%
	Route 28	24%		Fairfax County Parkway	14%
Percent Going To:	Fairfax County Parkway	16%	Percent Going To:	Route 28	27%
	US 50	7%		US 29 (Centreville)	13%
	Route 123	12%		Route 234 Business	20%
	Nutley Street	9%		Route 234 Bypass	30%
	I-66 East	17%		US 29 (Gainesville)	6%
	I-495 North	21%		US 15	0%
	I-495 South	18%		West of US 15	4%

Table 4: Entry and Exit Points for Traffic Along I-66 in Prince William County (East of US 15)

	Eastbound Traffic			Westbound Traffic	
	US 15	2%	Percent Coming From:	I-495 North	16%
	US 29 (Gainesville)	8%		I-495 South	6%
	Route 234 Bypass	22%		I-66 East	6%
	Route 234 Business	6%		Nutley Street	3%
	US 29 (Centreville)	1%		Route 123	3%
	Route 28	11%		US 50	5%
	Fairfax County Parkway	4%		Fairfax County Parkway	5%
	US 50	2%		Route 28	12%
	Route 123	3%		US 29 (Centreville)	3%
	Nutley Street	3%		Route 234 Business	7%
	I-66 East	10%		Route 234 Bypass	22%
	I-495 North	17%		US 29 (Gainesville)	8%
	I-495 South	11%		US 15	2%

Table 5 lists major congested segments by facility during the AM and PM peak hours along the east-west (parallel) facilities in the corridor. Table 6 provides this listing for north-south (connecting) facilities in the corridor. These tables reflect the characteristics displayed on the travel time index maps in Figure 8 and Figure 9. During the AM peak, many of the corridor facilities generally have congested segments in the eastbound direction, while during the PM peak, many of the corridor facilities are congested in segments in the westbound direction. However, during both peak periods, there exist several locations of "reverse-commute" congestion, especially east of I-495. During both peak periods, the connecting north-south facilities, especially I-495, SR 286, and SR 28, experience congestion in both directions between I-66 and the Dulles Toll Road, the two major parallel freeway facilities in the corridor.

The facilities within the ICM study corridor are not just defined by the extent of congestion (i.e., the number of locations or miles of congested facilities), but also by the duration of congestion – the number of hours in which congested segments remain problematic. As noted in the I-66 Existing Conditions Technical Report for the Revised Tier 2 Environmental Assessment, congestion on I-66 in the AM peak can last from prior to 6:00 AM to after 9:30 AM; during the PM peak, congestion begins as early as 3:00 PM and can last until nearly 8:00 PM. Many of the other facilities in the corridor experience multi-hour peak periods in which lengthy sections of roadway are operating at capacity.

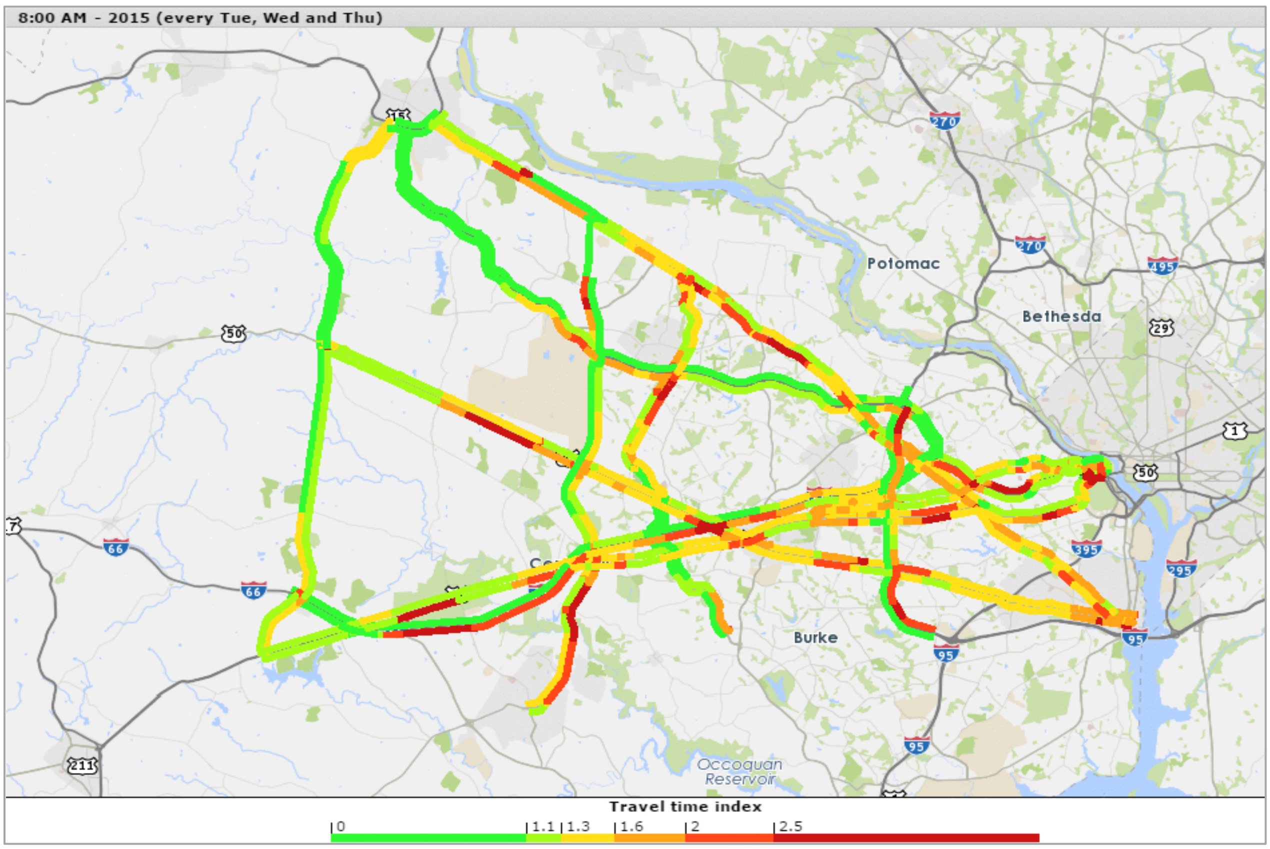

Figure 8: Corridor Travel Time Index – 2015 AM Peak (8:00 AM)

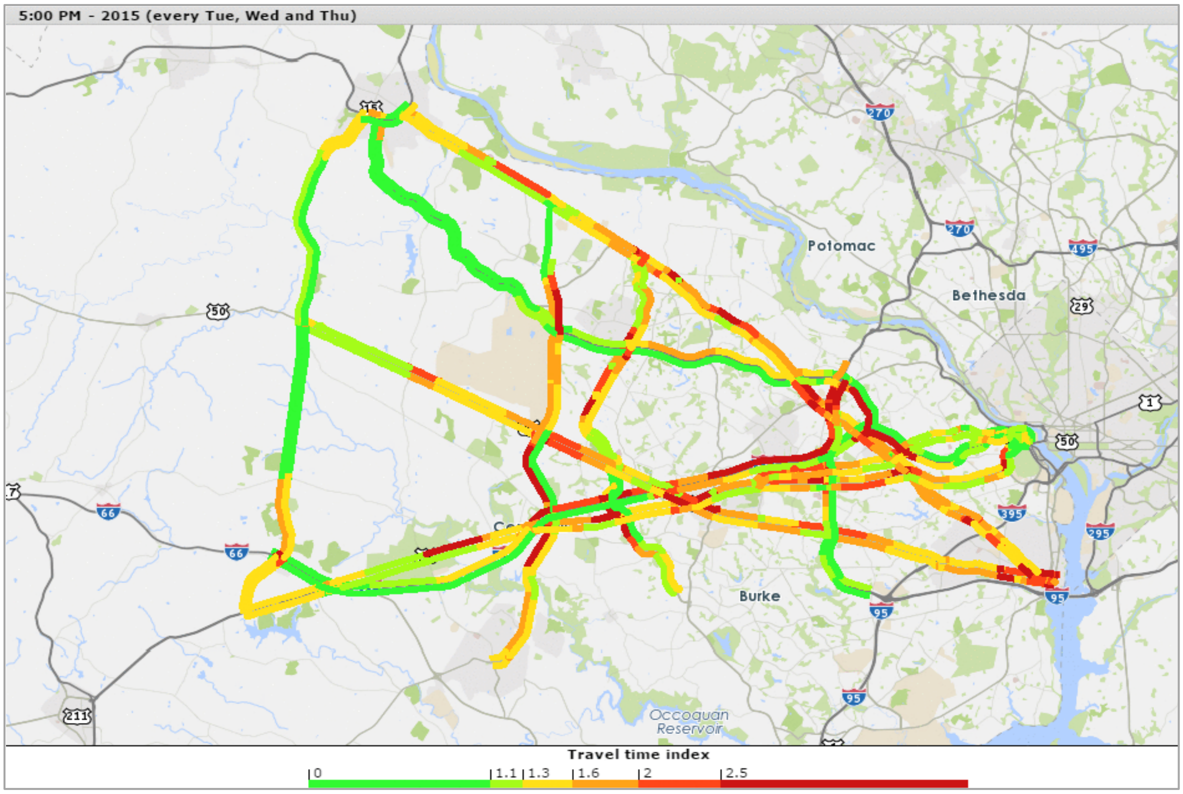

Figure 9: Corridor Travel Time Index – 2015 PM Peak (5:00 PM)

Table 5: Congested Segments along Corridor East-West Facilities

Facility	AM Congested Segments	PM Congested Segments
I-66	■ EB from SR 234 Bypass (Prince William Parkway / Exit 44) to SR 28 (Sully Rd / Exit 53) ■ EB from east of US 50 (Exit 57) to I-495 (Exit 64) ■ EB from Dulles Toll Road (Exit 67) to Glebe Road / Fairfax Drive (Exit 71) ■ WB from Glebe Road / Fairfax Drive (Exit 71) to Sycamore St (Exit 69)	■ EB from east of Dulles Toll Road (Exit 67) to Glebe Road / Fairfax Drive (Exit 71) ■ WB from Glebe Road / Fairfax Drive (Exit 71) to Sycamore St (Exit 69) ■ WB from I-495 (Exit 64) to US 50 (Exit 57) ■ WB from Fairfax County Parkway (Exit 55) to SR 234 (Sudley Road / Exit 47)
SR 267	■ EB from west of the mainline toll plaza between SR 606 and SR 28 to Fairfax County Parkway ■ EB from West of the mainline toll plaza between SR 7 and Spring Hill Road	■ EB from SR 123 to I-66 EB (Inside the Beltway). ■ WB from west of the mainline toll plaza between SR 7 and Spring Hill Road to Fairfax County Parkway ■ WB approaching SR 28 ■ WB approaching East of US 15 / SR 7 Leesburg Bypass
US 29	■ EB/NB from Pageland Lane to Sudley Road ■ EB/NB from Pleasant Valley Road to Stone Road ■ EB/NB from Union Mill Road to Stringfellow Road ■ EB/NB from Rust Road to Chain Bridge Road ■ EB/NB from Annandale Road to E Broad Street/SR 7	■ EB/NB from Shirley Gate Road to Rust Road ■ WB/SB from I-66 (Exit 69) to SR 7/Leesburg Pike ■ WB/SB from I-495 interchange to Cedar Lane ■ WB/SB from Hunter Road to Blake Lane ■ WB/SB from Chain Bridge Road to Waples Mill Road ■ WB/SB from Fairfax County Parkway to Clifton

Facility	AM Congested Segments	PM Congested Segments
	■ EB/NB from N George Mason Drive to N Glebe Road	Road ■ WB/SB from SR 28 to west of I-66 (Exit 52)
US 50	■ EB from Loudoun County Parkway to SR 28 ■ EB from West Ox Road to Waples Mill Road ■ EB from east of I-495 to Annandale Road ■ WB approaching Graham Road	■ EB from SR 28 to Stringfellow Road ■ EB from I-66 to US 29/Lee Highway ■ EB from east of I-495 to Annandale Road ■ WB approaching Pershing Road ■ WB from Annandale Road to Graham Road ■ WB from US 29/Lee Highway to Waples Mill Road ■ WB from Lees Corner Road to Centreville Road ■ WB through the SR 28 interchange ■ WB from Loudoun County Parkway to Gum Spring Road
SR 7	■ EB from Belmont Ridge Road to Claiborne Parkway ■ EB from Fairfax County Parkway to Georgetown Pike ■ EB from Reston Parkway to Beulah Road ■ EB from Lewinsville Road through the Dulles Toll Road interchange ■ EB from the I-395 interchange to N. Quaker Lane	■ EB from the Dulles Toll Road to I-495 (through Tysons) ■ EB from I-66 to West Street ■ WB from SR 123/Chain Bridge Road to the Dulles Toll Road ■ WB from Colvin Run Road to Springvale Road ■ WB from Georgetown Pike to Fairfax County Parkway ■ WB west of SR 28
SR 236	■ EB from Fairfax City Line to Wakefield Chapel Road	■ EB from the Fairfax City Line to Wakefield Chapel Road ■ WB from I-495 to Prosperity Avenue
SR 123	■ EB/NB from Nutley Street to Park Street ■ EB/NB from I-495 to Old Dominion Drive ■ EB/NB from George Washington Parkway to Washington, D.C. line ■ WB/SB from Old Dominion Drive to I-495	■ WB/SB from Georgetown Pike to I-495 ■ WB/SB from I-495 to I-66 (through Tysons and the Town of Vienna) ■ EB/NB from I-495 to Old Dominion Drive ■ EB/NB from George Washington Parkway to Washington, D.C. line
SR 620 (Braddock Road)	■ EB approaching SR 123 ■ EB between Rolling Road and I-495 ■ WB approaching SR 123	■ WB from I-495 to Rolling Road ■ WB approaching SR 123 ■ WB between Fairfax County Parkway and SR 28

Table 6: Congested Segments along Corridor North-South Facilities

Facility	AM Congested Segments	PM Congested Segments
I-495	■ NB from I-395 (Exit 57) to SR 236/Little River Turnpike (Exit 52) ■ NB from SR 7/Leesburg Pike (Exit 47) to George Washington Parkway (Exit 43)	■ NB from SR 7/Leesburg Pike (Exit 47) to Maryland State Line ■ SB from Dulles Toll Road (Exit 45) to Gallows Road (Exit 52)
SR 286	■ NB from south of SR 123 to Popes Head Road ■ NB from W. Ox Road to Dulles Toll Road ■ SB from SR 7Leesburg Pike to Wiehle Ave	■ NB from Sunrise Valley Drive to Spring Street ■ SB from Elden Street to Sunrise Valley Drive ■ SB from Fox Mill Road to Franklin Farm Road ■ SB from I-66 to Popes Head Road

SR 28	■ NB from Manassas VRE station to the I-66 interchange ■ SB from Waxpool Road to the Dulles Toll Road	■ NB from Dulles Toll Road to Waxpool Road ■ SB from N. Sterling Blvd (north of Dulles Toll Road) to I-66
US 15		■ NB from SR 7 to Maryland State Line ■ SB north of I-66

4.2.1.3. Crash History

Figure 10 provides a map of crash frequencies for the entire corridor. The project team compiled the total number of crashes per linear mile on a facility between 2010 and 2013, the most recently available years of data. The map displays this metric, an indicator of where crash events are most likely to occur. It does not take into account severity of crashes or the traffic volumes on a facility; however, it is used as a high-level indicator of where the roadway network is likely to experience incidents which could impact network reliability.

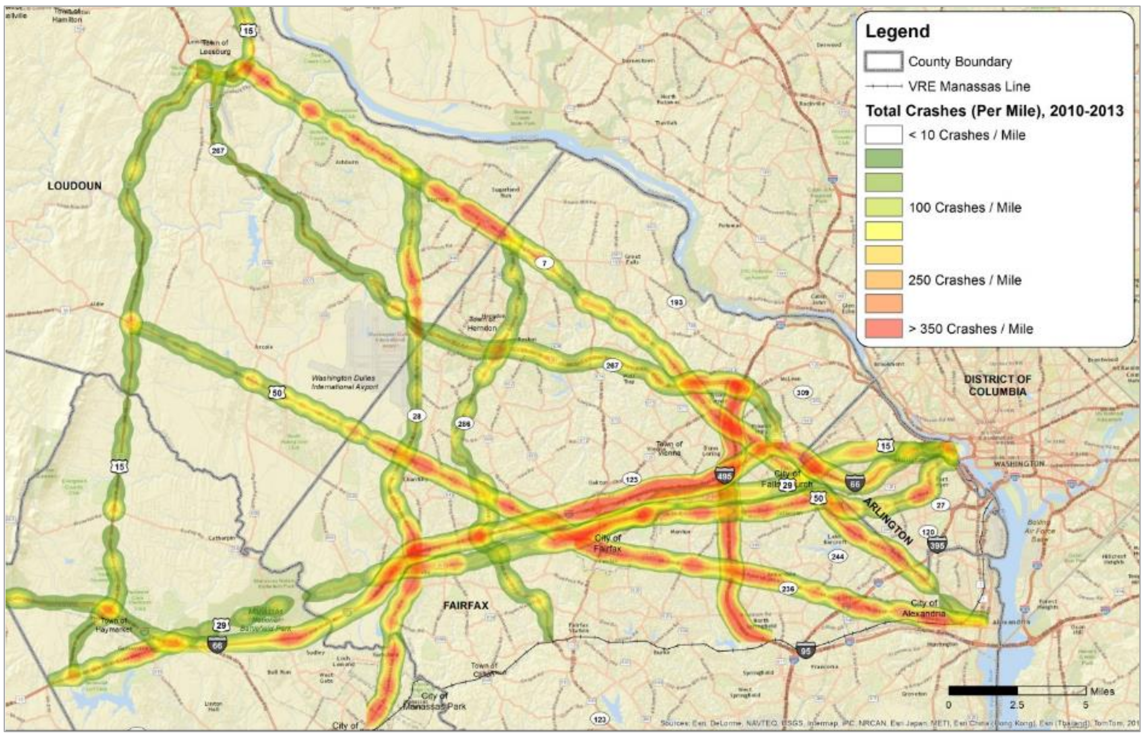

Figure 10: Corridor Roadways Total Crashes (Per Mile), 2010-2013

As shown in Figure 10, the locations with the greatest number of crashes in the corridor generally correlate to roadway segments with the highest volumes of congestion (as shown in Figure 8 and Figure 9). Segments of especially high crash frequency include:

- Most sections of I-66 east of US 15, especially the segment between US 29 in Centreville and Fairfax County Parkway, as well as the segment between US 50 and I-495.
- Nearly all of I-495 between SR 236 and SR 267.
- SR 28 just north of I-66 and north of SR 267.
- SR 7 in Loudoun County and through Tysons.
- US 50 through Fairfax County.

4.2.1.4. Incident Management and Durations

Incident duration is the time elapsed between incident detection and clearance. The bar chart in Figure 11 shows median incident durations for all incident types that in 2014 and 2015 on roadways in the study corridor. It provides a comparison to the statewide median incident durations to indicate potential roadways that may require improvements to incident management. Figure 12 shows median incident durations for tractor-trailer incidents only and the corresponding statewide incident durations. For all incident types, facilities in the study area corridor generally fall below the statewide median duration, with the exception of SR 7 and US 15. For tractor trailers, facilities in the study area corridor generally were at or above the statewide median in 2015. Notably, I-66 and I-495 have lower median incident durations for both tractor trailers and all vehicle types. These facilities are covered by VDOT's Safety Service Patrol (SSP), which operates on all interstate facilities in the region. Figure 13 shows Safety Service Patrol (SSP) routes in Northern Virginia.

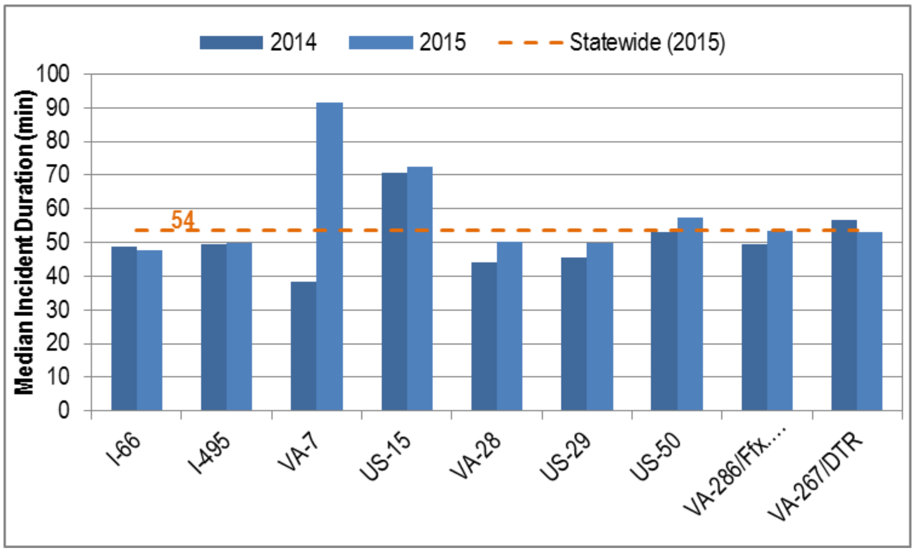

Figure 11: Median Incident Duration along Corridor Roadways – All Incident Types (In Minutes)

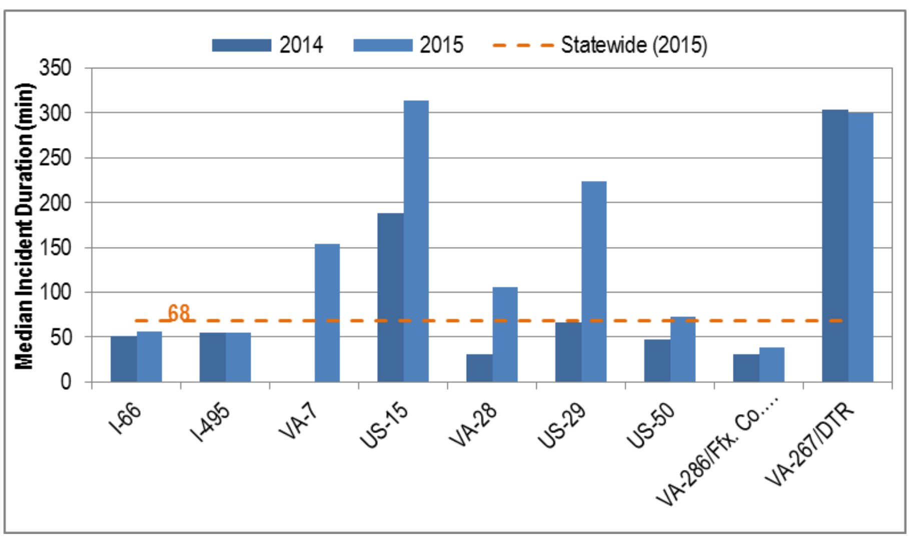

Figure 12: Median Incident Durations along Corridor Roadways – Tractor-Trailer Incidents (In Minutes)

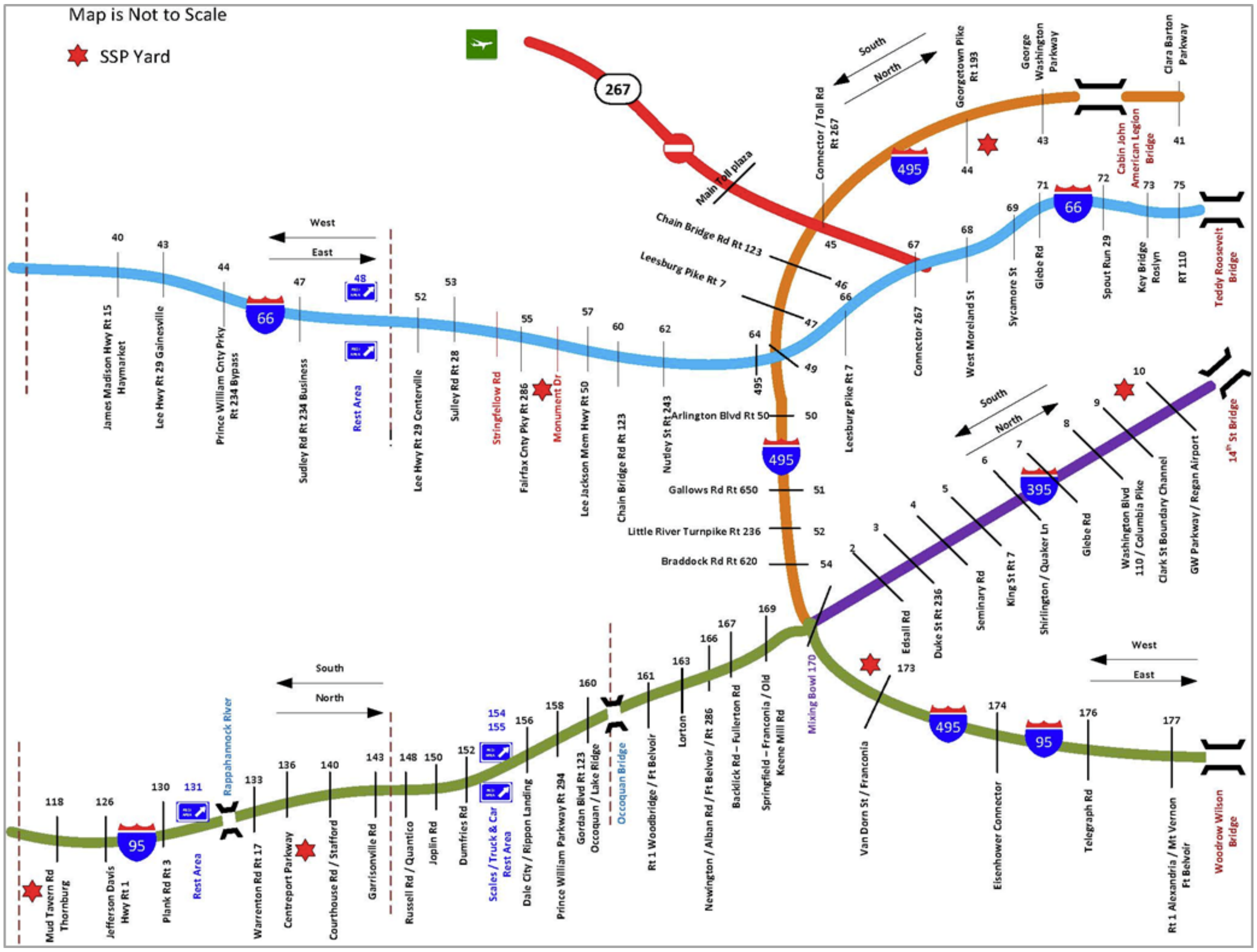

Figure 13: VDOT Safety Service Patrol Coverage Area in Northern Virginia

4.2.2. Transit

Existing commuter rail and bus transit in the study corridor consists of:

- **Commuter rail service** provided by the Metrorail Orange and Silver Lines and the VRE Manassas Line.
- **Commuter bus service** provided by Metrobus, Potomac and Rappahannock Transportation Commission (PRTC), Fairfax Connector, Loudoun County Transit, and privately-owned shuttle buses.

4.2.2.1. Heavy Rail

WMATA's Orange and Silver Metrorail lines serve the East-West study area corridor with heavy rail service. Both lines originate west of the Capital Beltway (I-495) and run through Washington, D.C., into Prince George's County, MD. The Orange Line begins at the Vienna-Fairfax station in the center of I-66 and runs east along the median of I-66, serving three more stations in the center of I-66 before traveling underground through the high-density neighborhoods of northern Arlington County and into Washington, D.C., where it remains underground. The Silver Line, which began service in July 2014, currently begins at the Wiehle-Reston East station in the center of SR 267 and runs east along the median of SR 267. It leaves its alignment with SR 267 in Tysons, becoming grade-separated and serving four stations in the rapidly-growing Tysons area before re-joining SR 267. The Silver Line joins with the Orange Line where

SR 267 meets I-66 inside the Beltway and runs concurrently through Arlington and Washington, D.C. along the same tracks. Both rail lines serve 6-minute headways during AM and PM peak rush periods.

Travel Patterns and Ridership

WMATA is able to compile origin-destination data for trips within the Metrorail system, as users must swipe a farecard to get in and out at each station. WMATA provides aggregated O-D data for third parties to use via its PlanIt Metro planning website.[3] As of August 2016, WMATA has made available its ridership by station for each month from 2010 through 2015, as well as detailed 15-minute interval O-D tabulations for individual months. The most recent month available with detailed data is October 2015. This data can be used to estimate ridership between stations and overall capacity available given the train schedule.

Table 7 and Table 8 show the estimated percent utilization of Orange and Silver line rail cars in the morning and evening peak periods per fifteen-minute period in the peak direction. The peak directions on both rail lines run west to east in the morning (toward Washington, D.C.) and east to west in the evening. Both tables show the changes in ridership levels throughout the peak periods and assume six cars per train and a 65-seat capacity per car.[4] Ridership amounts in excess of 65 riders indicate a train car that is over capacity, although standing room allows up to nearly 150 riders per car. Figure 14 and Figure 15, using the utilization rates from Table 7 and Table 8,Table 8 illustrate *peak hour* utilization between stations on the Orange and Silver lines. These figures show that trains are fairly crowded near the Washington, D.C. core during the peak hour, but there is significant capacity available on trains west of Arlington, especially along the Silver Line through Tysons. Furthermore, Metrorail trains run peak service in both directions, and “reverse-commute” trains (such as Arlington to Tysons in the AM) have significant capacity available to take on more riders.

To obtain information on “ultimate” origins and destinations beyond rail stations, WMATA conducts periodic surveys of riders to determine, by county, where trips begin and end and how riders reach the rail stations. WMATA conducted one such survey in 2012 prior to the opening of the Silver Line; a second survey is in the process of being completed in 2016 to understand ridership trends from before and after the opening of the Silver Line.

On-Time Performance

Metrorail frequency can be disrupted by issues such as track problems and railcars being out of service. WMATA releases quarterly and annual Vital Signs reports on on-time performance and fleet reliability.[5] The most recent publicly available report is from Q3 2015 (July-September). WMATA noted the following key performance indicators for Metrorail:

- Rail on-time performance fell below 80 percent in Q3 2015, which is the lowest reported since WMATA began reporting Vital Signs.
- Rail fleet reliability, which measures the rate at which rail fleet delays occur while trains are in service, was below target each month in Q3 2015 and 25 percent worse than the same quarter in 2014.
- Rail fleet availability, which measures the rate at which railcars make it into service, was frequently below the minimum 954 car threshold for weekday service. WMATA reduced the number of 8-car trains so that more cars were available for maintenance activity for longer periods.

These metrics show that Metrorail is not always operating at the theoretical peak capacity estimated earlier in this section; frequently, delays reduce the number of trains running in each direction along the lines in the system, including the Orange and Silver Lines. In September 2016, WMATA reported a 9

[3] http://planitmetro.com/data.
[4] These figures were developed using WMATA’s October 2014 *Origin-Destination Ridership* data. Analysis assumes 6-minute headways on each line (10 trains/hour west of East Falls Church and 20 trains/hour on the combined segments east of East Falls Church).
[5] https://www.wmata.com/about_metro/scorecard/

percent decrease in ridership from 2015 to 2016; experts inside and outside of WMATA cited a range of factors, including levels and quality of service, transportation alternatives such as Capital Bikeshare and Uber/Lyft, lower gas prices, and the Federal transit subsidy.[6] WMATA reported increasingly unpredictable trips between 2013 and 2015, including significant increases in median travel time and 95th-percentile travel time. Along the Orange Line from Vienna to Farragut West, the median travel time increased by 7 percent and the 95th-percentile increased by 16 percent.[7]

Table 7: WMATA Metrorail Ridership as a Factor of Seating Capacity per Train Car AM Peak Period (5:00 AM – 9:30 AM)

Line	Segment	5:00 AM	5:15 AM	5:30 AM	5:45 AM	6:00 AM	6:15 AM	6:30 AM	6:45 AM	7:00 AM	7:15 AM	7:30 AM	7:45 AM	8:00 AM	8:15 AM	8:30 AM	8:45 AM	9:00 AM	9:15 AM
SV	Wiehle to Spring Hill	6%	8%	9%	15%	22%	26%	28%	37%	40%	40%	48%	49%	45%	40%	38%	28%	20%	15%
SV	Spring Hill to Greensboro	6%	8%	9%	15%	22%	28%	29%	38%	43%	43%	52%	52%	49%	45%	42%	31%	25%	17%
SV	Greensboro to Tysons	6%	8%	11%	15%	22%	28%	29%	40%	45%	45%	54%	54%	51%	48%	43%	32%	25%	18%
SV	Tysons to McLean	8%	9%	9%	17%	23%	29%	32%	42%	46%	46%	57%	57%	54%	51%	46%	34%	28%	18%
SV	McLean to East Falls Church	8%	9%	11%	17%	23%	29%	34%	43%	49%	51%	62%	63%	62%	58%	52%	38%	31%	22%
OR	Vienna to Dunn Loring	9%	14%	15%	25%	31%	42%	45%	52%	60%	68%	77%	80%	85%	75%	63%	48%	37%	26%
OR	Dunn Loring to West Falls Church	11%	15%	18%	29%	38%	51%	52%	66%	77%	88%	98%	105%	112%	102%	86%	66%	52%	38%
OR	West Falls Church to East Falls Church	12%	17%	22%	31%	43%	55%	60%	75%	88%	103%	120%	128%	138%	128%	108%	85%	65%	48%
BOTH	East Falls Church to Ballston	12%	14%	17%	26%	35%	46%	52%	65%	75%	88%	102%	108%	112%	106%	92%	72%	55%	40%
BOTH	Ballston to Virginia Square	12%	15%	18%	26%	37%	48%	55%	68%	83%	97%	114%	123%	132%	129%	115%	88%	68%	49%
BOTH	Virginia Square to Clarendon	14%	15%	18%	28%	37%	49%	57%	69%	86%	100%	120%	131%	143%	140%	128%	97%	74%	54%
BOTH	Clarendon to Court House	14%	15%	18%	28%	38%	51%	58%	72%	89%	105%	126%	137%	152%	152%	140%	108%	82%	60%
BOTH	Court House to Rosslyn	14%	17%	20%	28%	40%	52%	60%	74%	94%	112%	134%	148%	168%	171%	158%	123%	92%	68%

[6] http://greatergreaterwashington.org/post/33512/metro-ridership-is-dropping-heres-what-some-experts-think-is-the-cause/
[7] http://wmata.com/about_metro/board_of_directors/board_docs/090816_3BEconomicandRidershipTrendsPanelFINALCORRECTED.pdf#page=38

**Table 8: WMATA Metrorail Ridership as a Factor of Capacity Seating per Train Car
PM Peak Period (3:00 PM to 7:00 PM)**

Line	Segment	3:00 PM	3:15 PM	3:30 PM	3:45 PM	4:00 PM	4:15 PM	4:30 PM	4:45 PM	5:00 PM	5:15 PM	5:30 PM	5:45 PM	6:00 PM	6:15 PM	6:30 PM	6:45 PM
BOTH	Rosslyn to Court House	42%	45%	54%	58%	86%	86%	108%	111%	157%	149%	149%	126%	117%	92%	74%	58%
BOTH	Court House to Clarendon	40%	42%	51%	55%	82%	82%	102%	105%	146%	137%	134%	114%	106%	83%	66%	52%
BOTH	Clarendon to Virginia Square	38%	40%	49%	54%	78%	77%	97%	98%	134%	125%	123%	105%	97%	75%	58%	46%
BOTH	Virginia Square to Ballston	37%	38%	46%	51%	75%	72%	92%	92%	126%	115%	114%	95%	89%	69%	54%	43%
BOTH	Ballston to East Falls Church	32%	34%	43%	46%	69%	66%	82%	83%	109%	100%	97%	80%	75%	57%	45%	35%
OR	East Falls Church to West Falls Church	35%	37%	46%	51%	78%	74%	92%	95%	126%	114%	111%	92%	88%	68%	52%	42%
OR	West Falls Church to Dunn Loring	31%	32%	42%	45%	68%	63%	78%	80%	106%	94%	92%	75%	71%	55%	43%	34%
OR	Dunn Loring to Vienna	25%	26%	34%	35%	54%	49%	62%	62%	80%	71%	68%	55%	52%	40%	31%	25%
SV	East Falls Church to McLean	23%	26%	31%	34%	49%	46%	57%	54%	68%	62%	60%	49%	45%	32%	26%	20%
SV	McLean to Tysons	23%	25%	29%	32%	46%	45%	52%	51%	63%	57%	54%	45%	40%	29%	23%	18%
SV	Tysons to Greensboro	18%	20%	25%	28%	42%	40%	46%	46%	57%	51%	49%	38%	35%	26%	20%	15%
SV	Greensboro to Spring Hill	18%	20%	25%	28%	40%	38%	45%	45%	54%	48%	46%	37%	34%	25%	20%	15%
SV	Spring Hill to Wiehle	17%	18%	22%	25%	37%	35%	42%	40%	49%	43%	42%	34%	32%	23%	18%	14%

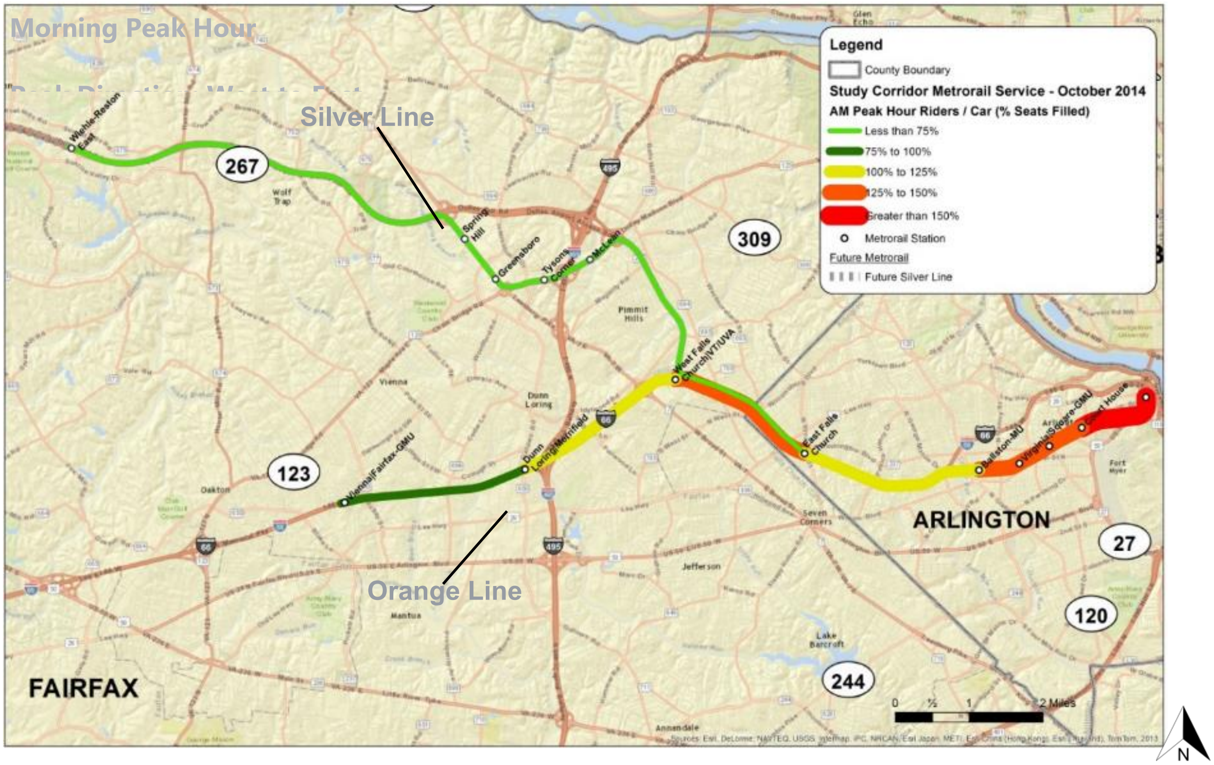

Figure 14: WMATA Silver and Orange Line Per-Car Occupancy – AM Peak Hour

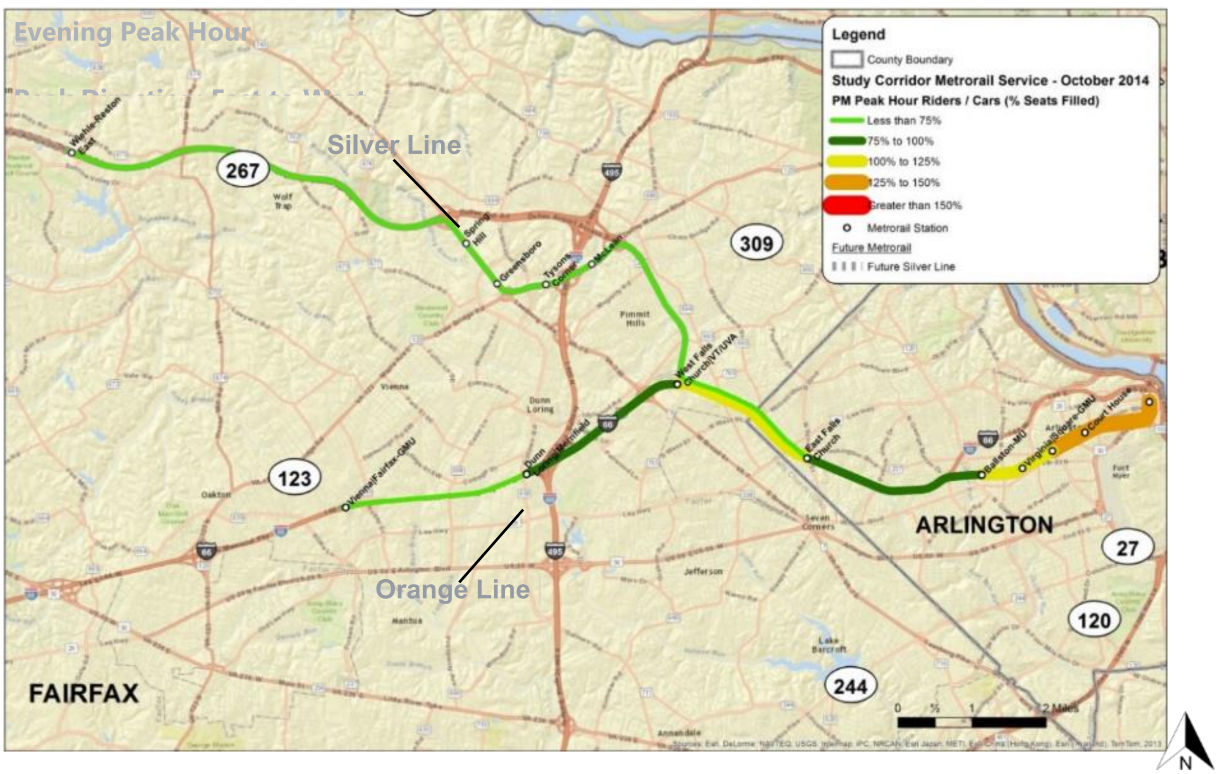

Figure 15: WMATA Silver and Orange Line Per-Car Occupancy – PM Peak Hour

Metrorail SafeTrack

In Spring 2016, due to a growing backlog of maintenance issues and high-profile incidents, WMATA announced that it would be implementing an accelerated track work plan to address safety recommendations and rehabilitate the Metrorail system to improve safety and reliability. The plan, known as SafeTrack, accelerates three years' worth of work into approximately one year.[8] The plan significantly expands maintenance time on weeknights, weekends, and midday hours and includes 15 "Safety Surges" – long-duration track outages for major projects in key parts of the system. Due to reduced capacity and expected longer travel times, WMATA has been encouraging Metrorail riders to consider using alternate travel options, including parallel commuter rail, bus, biking, and car-sharing. MWCOG has conducted analyses of the impacts of various SafeTrack surges in Summer 2016 and noted that clear impacts on travel times have been observed on alternative routes parallel to affected rail lines. For example, during a June closure of the Silver and Orange lines, portions of I-66 and SR 267 saw travel time increases of more than 100 percent during the morning commute.[9] Figure 16 shows the aggregate impact on congestion along freeways in the region during various SafeTrack surges in 2016. These impacts show how critical Metrorail is to the ICM study corridor.

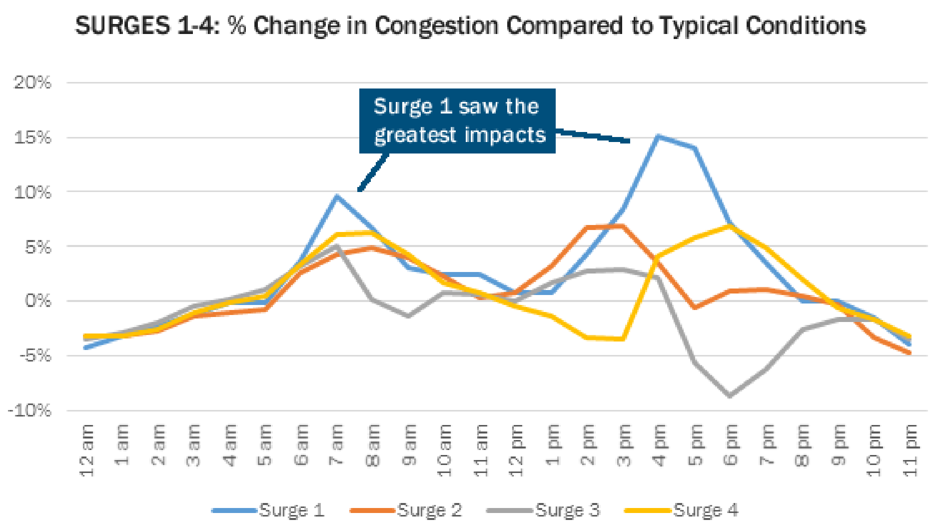

Figure 16. Percent Change in Congestion Compared to Typical Conditions during WMATA SafeTrack, Surges 1-4 (Source: MWCOG, 2016)

4.2.2.2. Commuter Rail

The Virginia Railway Express (VRE) operates a commuter rail transit line in the corridor – the VRE Manassas Line. The 35-mile line operates on tracks owned by CSX Transportation and Norfolk Southern Railway. The line runs from just west of Manassas, in Bristow, to Union Station in Washington, D.C., generally paralleling I-66 to the south before turning north in the City of Alexandria and running through southern Arlington County into Washington. The line serves ten stations, including eight in Virginia. Most of these stations offer connections to other modes of transit, including WMATA's Metrorail, Amtrak, and various regional and local bus services.

VRE operates Monday through Friday, primarily traveling eastbound toward Washington, D.C. in the morning and westbound toward Manassas in the evening. There are eight trips total in each direction daily, with six being in the peak direction (six eastbound trips in the morning and six westbound trips in the evening, all operating at approximately 30-minute headways). Riders with valid tickets can also ride

[8] http://wmata.com/rail/safetrack.cfm
[9] https://www.mwcog.org/about-us/newsroom/2016/07/19/how-safetrack-has-impacted-traffic-on-area-roadways-so-far-metro-traffic-monitoring/

certain Amtrak trains which also serve the corridor along the same tracks and stop at the Manassas, Burke Centre, and Alexandria stations in Virginia.

Figure 17 shows a map of rail service in the study area, including Metrorail and VRE service.

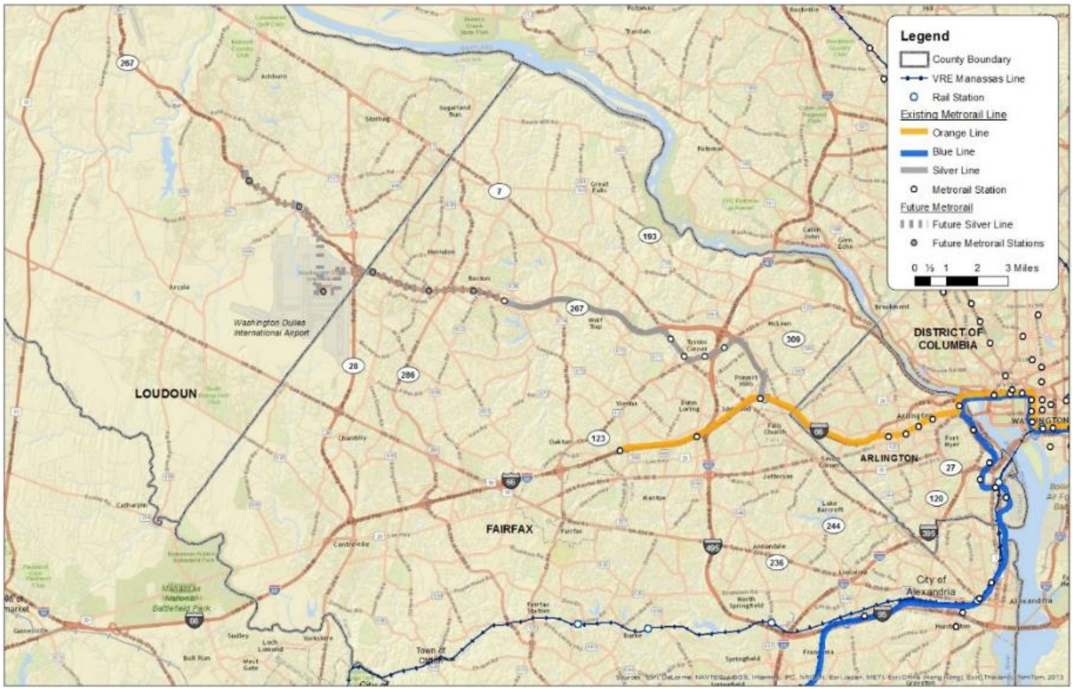

Figure 17: Rail Transit Service in Study Area.

Travel Patterns and Ridership

VRE provides current estimated midweek ridership for individual trains on its website.[10] This data is consistent with VRE's 2014 System Plan,[11] which notes that ridership along the Manassas Line grew at an average rate of approximately eight percent per year since 2007, before leveling off in 2013 as some trains approach capacity.

VRE's 2014 System Plan notes that VRE's major travel market is longer-distance commute trips from the middle and outer Virginia suburbs which are beyond the reach of the Metrorail system. VRE carries a significant share of total trips to the core activity centers of Washington, D.C., Arlington, and Alexandria from the catchment areas around VRE's stations. Figure 18 provides a map of VRE rider trip origins in 2012, while Figure 19 shows a map of VRE rider trip destinations. These figures show that much of VRE's Manassas Line ridership comes from the catchment areas near its stations, especially in the vicinity of Manassas in Prince William County and Burke in Fairfax County. While most riders originate from south of I-66, a non-trivial segment of the Manassas Line ridership originates from locations north of I-66 in the East-West study corridor, especially in Prince William County. Destinations are overwhelmingly concentrated in the activity centers of Alexandria, southern Arlington County near Crystal City, and Washington, D.C. VRE's 2014 System Plan notes that "the passenger-carrying capacity of VRE provides an important supplement to the regional highway network and helps mitigate traffic congestion by delivering a volume of travelers into the region's core every weekday equivalent to what can be carried on a lane of traffic on an interstate highway."

[10] http://www.vre.org/service/rider/consist/
[11] http://www.vre.org/vre/assets/File/2040%20Sys%20Plan%20VRE%20finaltech%20memo%20combined.pdf

During Metrorail's SafeTrack maintenance surge in 2016, VRE reported higher than usual ridership, including VRE's highest weekly ridership total ever.[12] VRE acknowledged on their website that the ridership increase was directly tied to SafeTrack work being conducted on parallel Metrorail lines. VRE offers guidance on their website on parallel service to Metrorail, including which stations riders should travel to and promotion of their mobile ticketing platform.

On-Time Performance

VRE provides daily information on delays within its system, as well as a historic archive of train delay information.[13] The information includes the total length of the delay and a brief description of the reason for the delay. VRE also provides an online interactive map for users to track train locations (via GPS) and on-time arrival status.[14] VRE compiles its daily delay figures into monthly averages. In July 2016, the VRE Manassas Line averaged an 86.56% on-time performance.

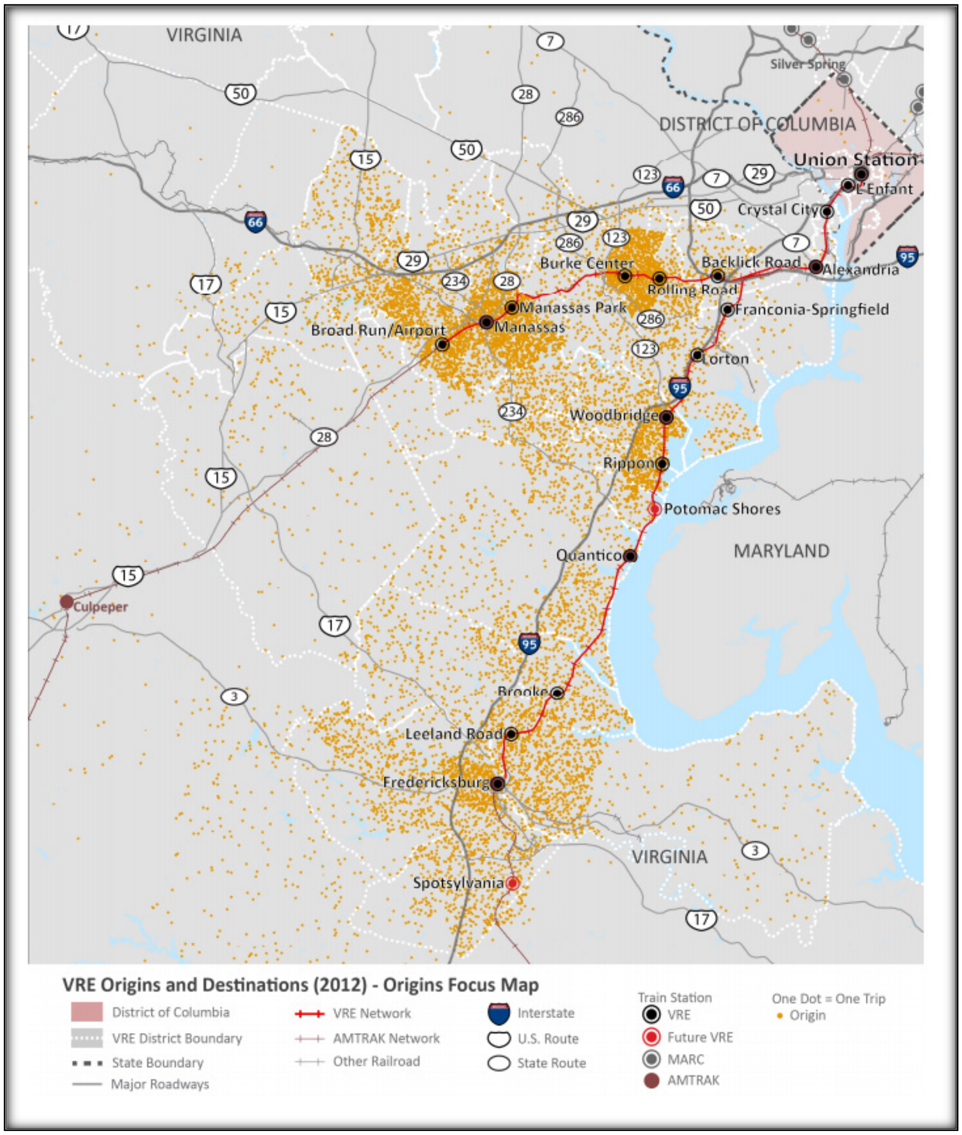

Figure 18: Origins of VRE Commuters, 2012 (Source: VRE 2040 System Plan)

12 http://www.vre.org/about/pr/vre-shatters-ridership-records-as-metro-riders-try-out-system-during-safetrack-work/
13 http://www.vre.org/service/daily-performance/
14 http://www.vre.org/service/status/

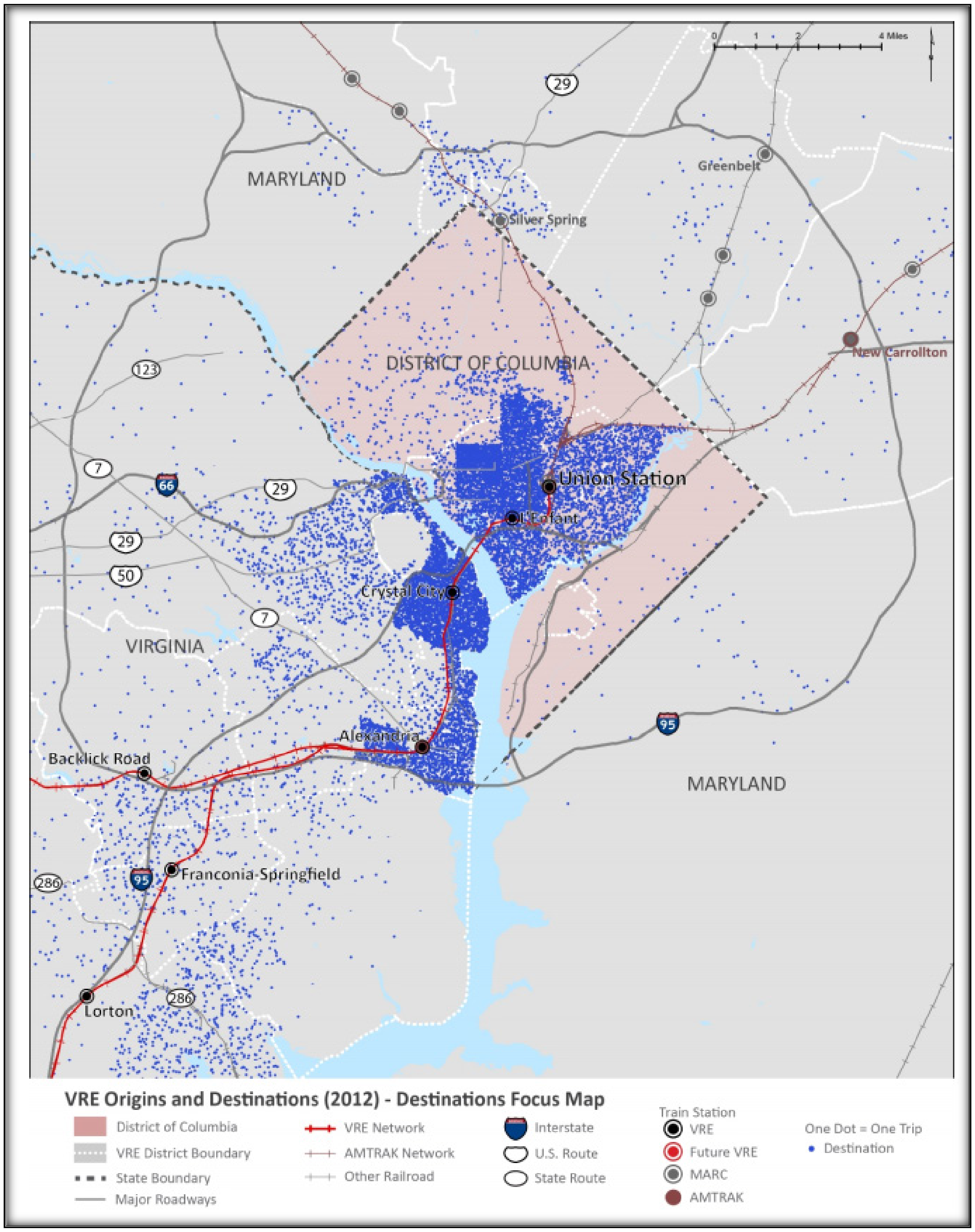

Figure 19: Destinations of VRE Commuters, 2012 (Source: VRE 2040 System Plan)

4.2.2.3. Commuter Bus

Several transit agencies provide bus service in the East-West ICM study corridor, including:

- **WMATA**, which provides regional Metrobus service to the Washington, D.C., area, including service in Virginia. Its Metrobus routes are generally targeted toward regional, inter-jurisdictional travel. WMATA Metrobus routes provide rapid and commuter service in the study area, including:
  - Major Routes 1A, 2A, 23A, 28A, and 38B
  - Extra Routes 16Y and 28X
- **Fairfax County DOT**, which provides Fairfax Connector local and express bus service in Fairfax County. As this study corridor profile focused on weekday, rush-hour service targeted toward commuters along the I-66 and SR 267 corridors, some key Fairfax Connector east-west commuter bus routes include:
  - Route 599 (Reston to Pentagon-Crystal City Express). See Figure 20.
  - Route 401 and 402 (Backlick - Gallows Northbound & Southbound). See Figure 21.
  - Route 306 (GMU – Pentagon)
- **Loudoun County Transit**, which operates morning and late-afternoon rush hour service from park-and-ride lots in the County to Metrorail stations and downtown Washington, D.C. Some of the key bus routes that provide east-west travel in the corridor include:
  - Route 87 X (Dulles Town Center to Wiehle-Reston Station)
  - Routes 402, 403, 405, 408, 410, 413, 414, 416, 417 and 420 (Leesburg to Rosslyn Station)
  - Routes 801, 803, 806, 808, 810, 811, 813, 815D, 819, 820, 821D, and 822D (Rosslyn Station to Leesburg)
- The **Potomac and Rappahannock Transportation Commission (PRTC**), which provides commuter bus service along the I-66 corridor known as OmniRide. The routes in the study corridor (See Figure 22) include:
  - Manassas OmniRide route (MN-R): Manassas–Pentagon-Crystal City-Washington D.C.
  - Gainesville OmniRide route (GV-R): Gainesville-Washington, D.C.
  - Linton Hall Metro Direct route (L-MD): Gainesville -Tysons Metrorail station
  - Manassas Metro Direct route (M-MD) City of Manassas-Tysons Metrorail station
- The **City of Fairfax City-University Energysaver (CUE)** bus system provides local bus transit service to the City of Fairfax, including George Mason University, as well as connections to the Vienna Metrorail station.

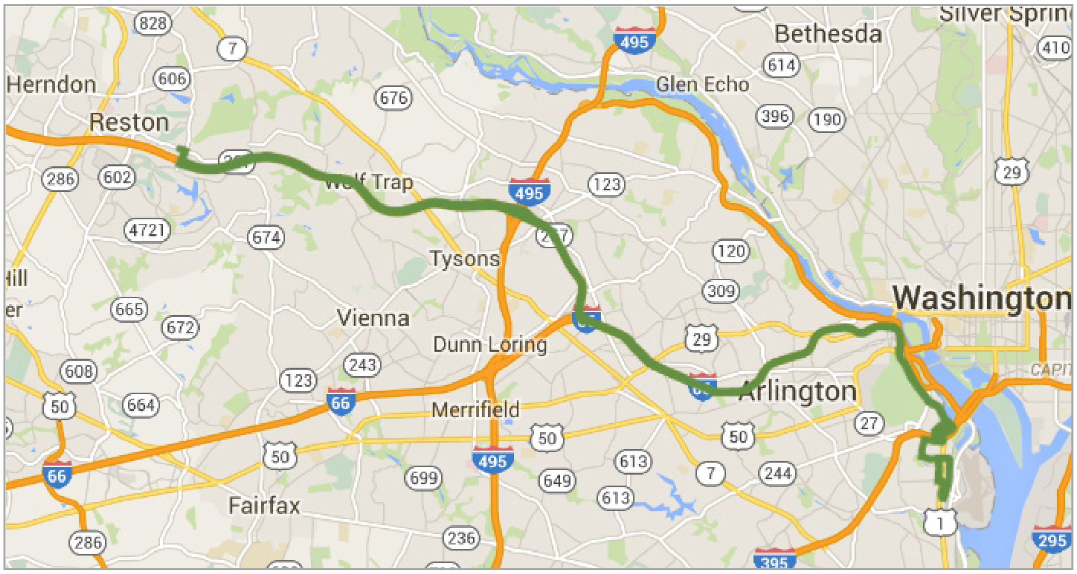

Figure 20: Fairfax Connector – Bus Route 599

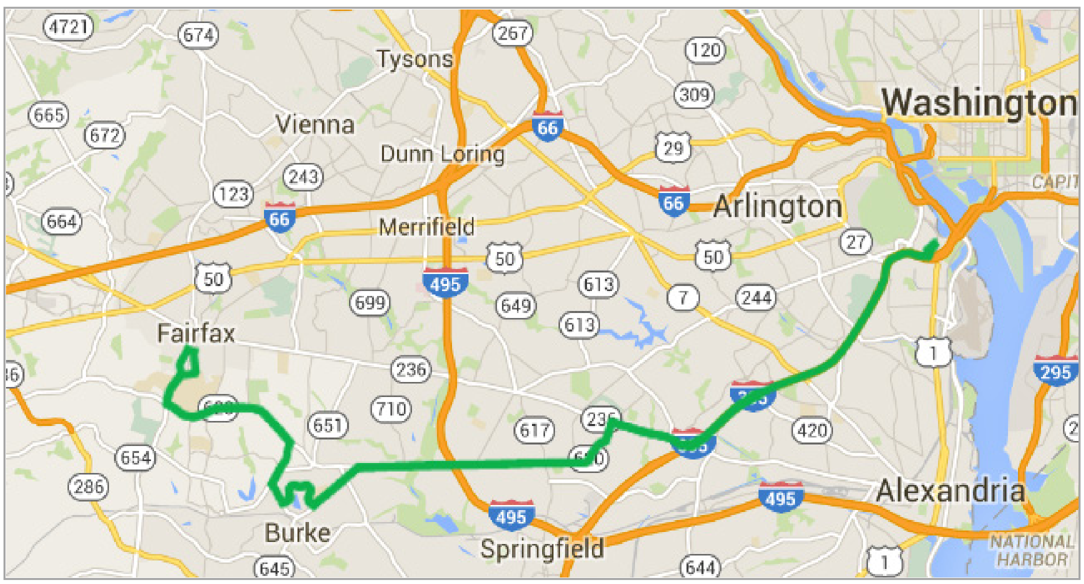

Figure 21: Fairfax Connector – Bus Route 401/402

The I-66 Transit/TDM Technical Report (2016) provides estimates of the current number of buses operating along various segments of I-66 during peak periods, as well as the overall bus ridership along the corridor. Figure 23 shows the estimated number of buses currently operating during peak periods, while Figure 24 shows the estimated bus ridership during the peak periods.

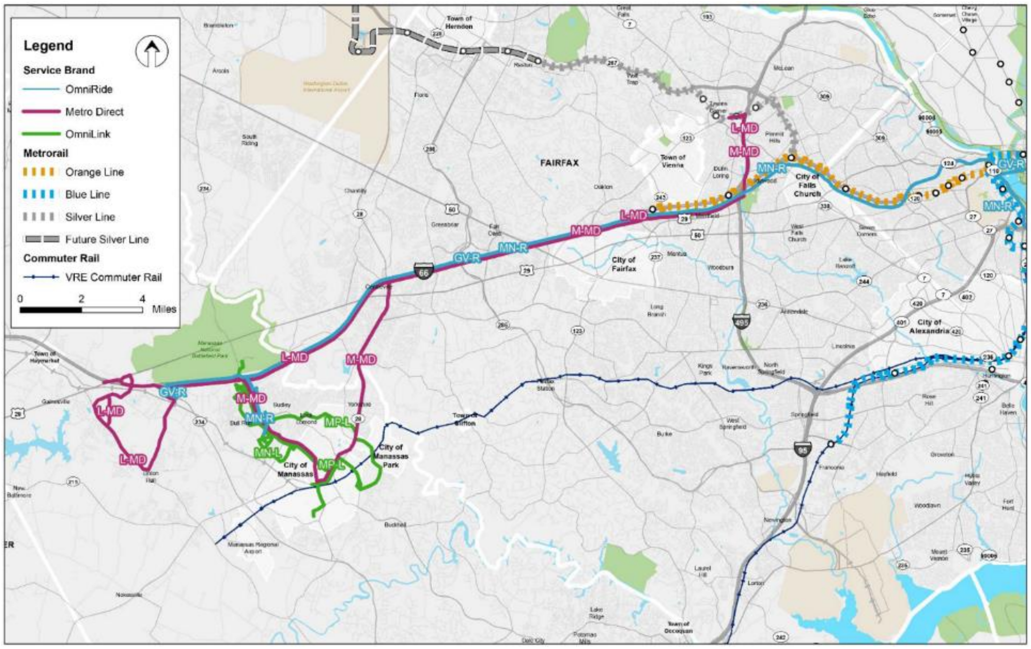

Figure 22: PRTC Major Commuter Bus Services in the Study Corridor

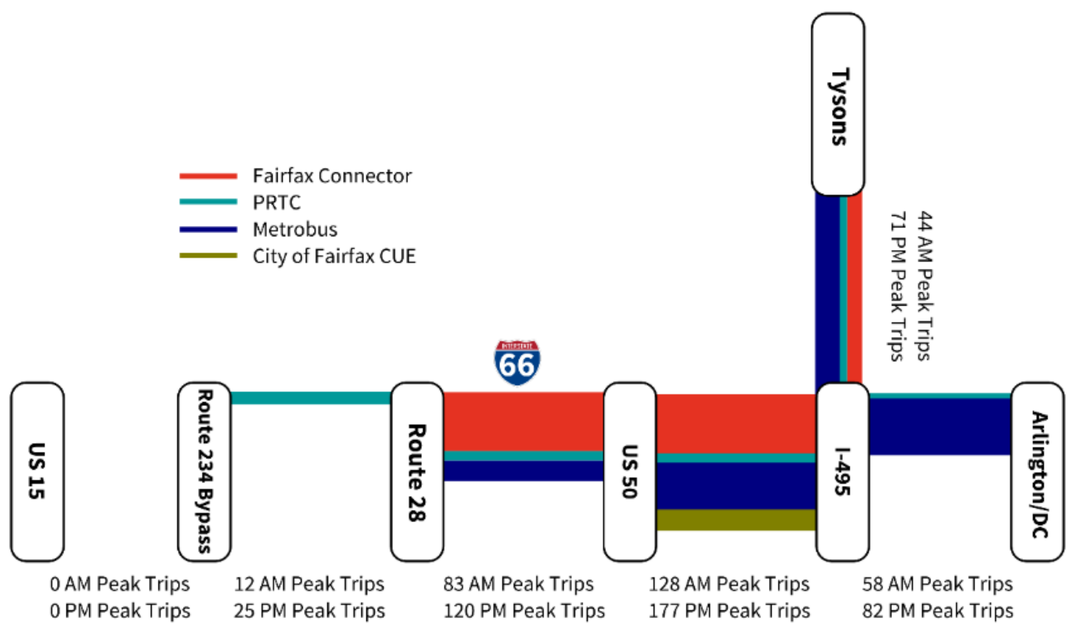

Figure 23: Peak-Period Bus Trip Volumes on the I-66 Corridor

Note: Trips include routes on parallel roadways within 1 mile of I-66. Bus volumes between corridors intersecting I-66 do not necessarily reflect travel for the entire distance between those corridors.

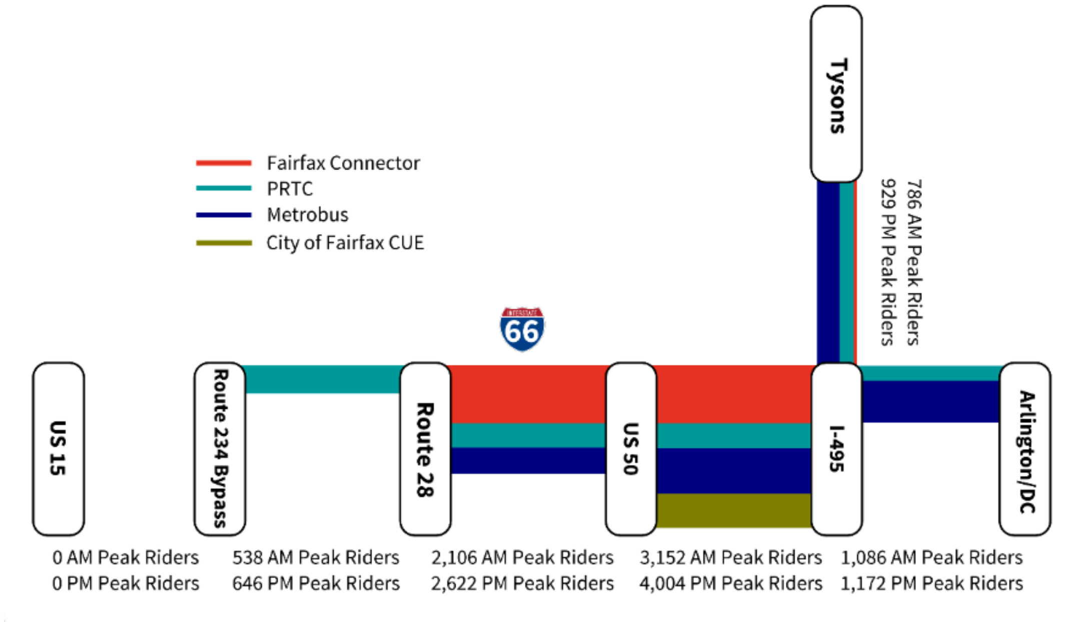

Figure 24: Peak-Period Bus Ridership on the I-66 Corridor

Note: Ridership includes routes on parallel roadways within 1 mile of I-66. Passenger volumes between corridors intersecting I-66 do not necessarily reflect travel for the entire distance between those routes.

4.2.2.4. Vanpool, Ridesharing, and Transportation Network Companies (TNCs)

Several other forms of non-single-occupancy-vehicle (non-SOV) travel are popular in the study area:

- **Vanpool.** The Vanpool Alliance program is a public-private partnership, created in 2013 to enhance commuter travel options through vanpooling. New and existing vanpools that originate or complete travel in the Northern Virginia region can enroll in Vanpool Alliance. Participating vanpool groups report travel and ridership information to Vanpool Alliance each month; in return, these groups receive support in marketing their program and maintaining drivers and ridership, including subsidies to reduce end-user costs for riders. Vanpool Alliance is administered by PRTC.
- **Ridesharing.** In the Washington, D.C. region, the growing HOV and Express Lanes network has made carpooling desirable for many commuters. The colloquial term “slugging” is often used to describe a unique form of “instant carpooling” in which strangers sharing similar destinations carpool from pre-determined park-and-ride locations in order to be able to utilize faster and more reliable HOV or Express lanes. Within each park-and-ride location, the pick-up and drop-off sites for particular destinations, such as the Pentagon or Capitol Hill, are either posted on private websites or known colloquially. More recently, mobile applications have been developed to assist new commuters in determining these points. While this form of ridesharing is currently most popular along the I-95 corridor in Northern Virginia, multiple slug lines currently exist from locations off I-66 and SR 267 for riders seeking to use I-66 east of I-495, which is restricted to HOV-only during peak commuting hours. As new park-and-ride lots and Express Lanes are constructed along I-66 over the next few years, it is anticipated that ridesharing will become more widespread along the corridor as travelers seek to take advantage of the enhanced reliability of this network (as seen currently on the I-95/I-395 Express Lanes network). The expansion of I-66 and construction of new park-and-ride lots is detailed further in Section 4.2.2.5.
- **Transportation Network Companies (TNCs).** Private-sector on-demand transportation providers, most notably Uber and Lyft, have become prominent in recent years in response to market demand and the rise of mobile phone apps and instantaneous payment platforms.

WMATA notes that these services often "fill the gaps" in the region's public transportation infrastructure when transit service to, for example, a transit station sporadic or non-existent.[15] WMATA is aware of opportunities to build on this model, including connections to Metro with first-mile/last-mile services, incident management support, paratransit, and development of shared products for fare payment and trip planning. Other TNC services in the Washington, D.C. area include car-sharing services, such as Car2Go and Zipcar, and shared-ride platforms, such as Split and Bridj.

4.2.2.5. Park-and-Ride Lots

Figure 25 depicts parking lot locations, ownership, and the estimated average weekday occupancy in the study area given parking counts or estimates between 2013 and 2015. The largest facilities, which tend to be garages at rail stations, are frequently approaching or are above capacity on an average weekday.

Along the I-66 corridor specifically, approximately 20 park-and-ride facilities are located between US 15 and I-495, with two additional lots at Metrorail stations east of I-495 offering capacity for approximately 12,000 vehicles. Of the approximately 9,000 spaces at Metrorail or VRE stations, nearly all are close to fully occupied during the average weekday.[16]

The park-and-ride system in the East-West corridor has continued to grow recently. In Gainesville, VDOT opened a new park-and-ride lot just off I-66 at Exit 44 (Prince William Parkway) in 2013. This lot provides a direct on-ramp connection to I-66 eastbound; the ramp is restricted to buses and vehicles with two or more people in them. PRTC runs non-stop bus service to the Tysons Corner Metrorail station from this lot. Nonstop service to downtown Washington was started in 2014. In Loudoun County, two new park-and-ride lots opened in 2016, both of which are served by Loudoun County Transit, with bus service to either the Wiehle-Reston East Metrorail station or downtown Washington. Finally, Fairfax County is renovating and expanding the Reston-Herndon garage, which will be located adjacent to the future Herndon Metrorail station as part of Phase II of the Silver Line.

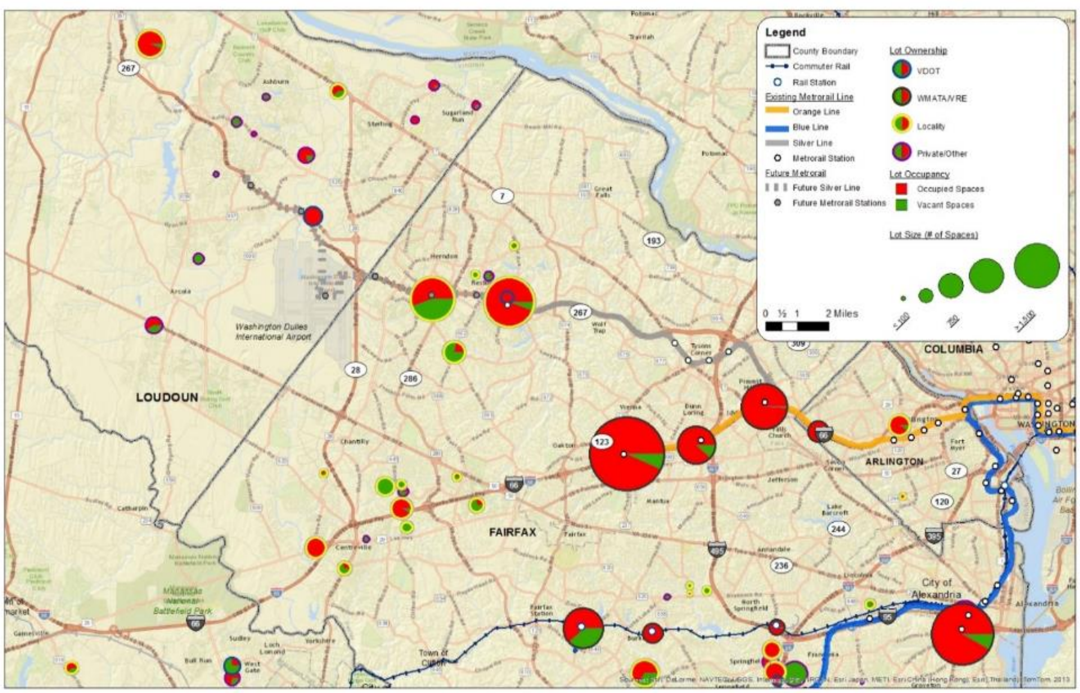

Figure 25: Parking Occupancy in the Study Corridor (2013 - 2015)

[15] http://planitmetro.com/wp-content/uploads/2016/06/DRAFT-WMATA-and-TNCs-Opportunities-and-Considerations.pdf
[16] *I-66 Transit/TDM Technical Report,* 2016.

Table 9 shows parking space occupancy at study area Metrorail stations after the opening of the Silver Line in 2014.

Table 10 shows parking space occupancy at VRE stations in the corridor. At other facilities, parking occupancy varies. The I-66 Transit/TDM Technical Report (2016) notes that park-and-ride facilities at Stringfellow Road, Stone Road, Vienna Metrorail station, Dunn Loring Metrorail station in Fairfax County, and the Limestone Drive facility in Prince William County are at capacity. It should be noted that WMATA does not provide park-and-ride facilities at the four Silver Line stations in Tysons.

Table 9: Parking Space Occupancy at Corridor WMATA Metro Stations (2014 Study)

Station	Line	Capacity	Occupancy
Vienna	Orange	5,169	93%
Dunn Loring	Orange	1,326	88%
West Falls Church	Orange	2,009	67%
Wiehle-Reston East	Silver	2,300	79%
East Falls Church	Orange/Silver	422	116%

Table 10: Parking Space Occupancy at Corridor VRE Rail Stations (2014 Study)

Station	Capacity	Occupancy
Backlick Road	217	95%
Broad Run/Airport	1,081	92%
Burke Center	1,504	39%
Manassas	696	83%
Manassas Park	616	94%
Rolling Road	377	95%

Park-and-ride lots in Arlington, Fairfax, and Prince William Counties have higher utilization rates than the statewide average in the study area.[17] Prior to the start of Metrorail's SafeTrack maintenance program, WMATA released a map of estimated parking availability in its park-and-ride lots on a typical weekday after the morning rush hour ends. Figure 26 shows this map; WMATA estimates that parking spaces are available at lots within the East-West ICM corridor, especially along the Orange Line at Vienna and West Falls Church.

[17] *VTrans 2040 Multimodal Transportation Plan CoSS Needs Assessment* – Northern Virginia Corridor.

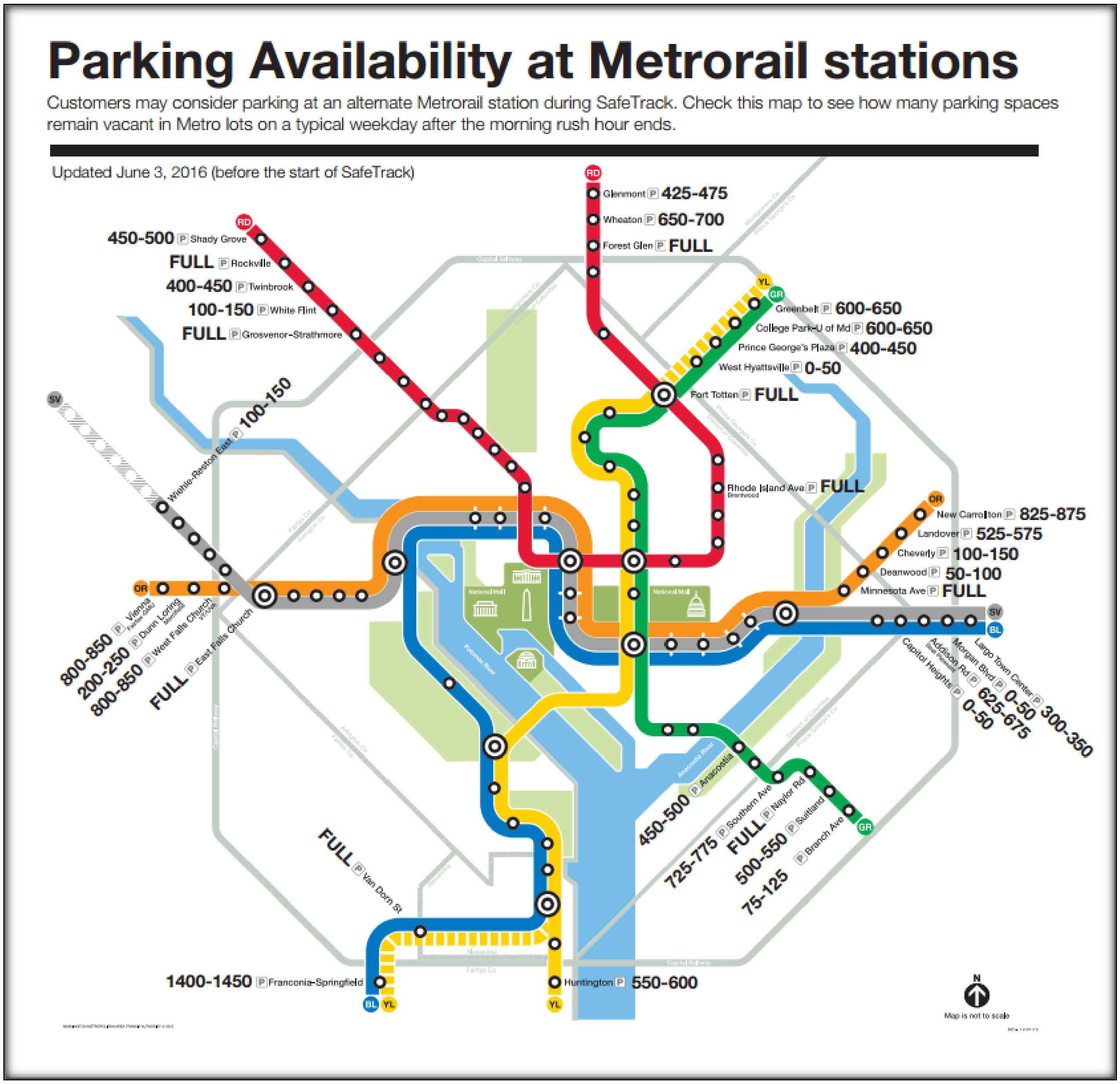

Figure 26: Parking Availability at Metrorail Stations (June 2016)[18]

4.2.3. Bicycle and Pedestrian Facilities in the Corridor

Biking and walking represents approximately 2 percent of commuter mode choice along the I-66 corridor[19]; these modes are more popular in more urban jurisdictions closer to Washington, D.C. In addition, biking and walking serves as a "last mile" mode for many transit trips in the corridor.

[18] http://planitmetro.com/wp-content/uploads/2016/06/parking-availability-system-map-2.pdf
[19] *I-66 Transit/TDM Technical Report*, May 2016.

The study corridor features many dedicated off-road multi-use biking trails, as shown in Figure 27. Some of the primary trails include:

1. Washington and Old Dominion Trail (45 miles)
2. Martha Custis Trail (4 miles)
3. Fairfax County Parkway Trail (28 miles)
4. Cross County Trail (40 miles)
5. Four Mile Run Trail (6.2 miles)

The primary bike trails are depicted in red in Figure 27 and are heavily used for commuter traffic in addition to recreational trips. The various jurisdictions each contain a network of smaller trails, on-road striped bike lanes, and bike-friendly roadways.

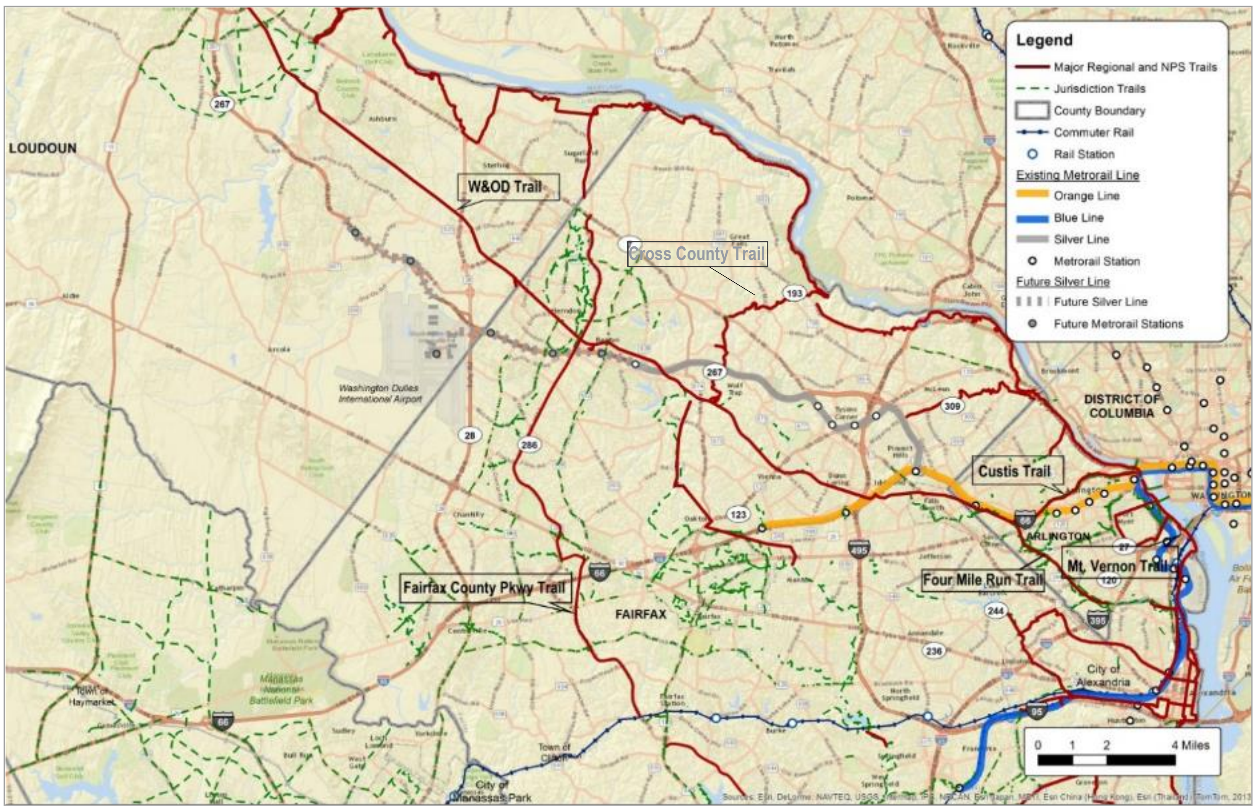

Figure 27: Major Regional Bike and Jurisdictional Trails

Capital Bikeshare (CaBi) is a bicycle-sharing system serving the Washington, D.C. region, with over 300 stations and 2,500 bicycles that riders can rent for short periods of time. This system launched in September 2010, and stations are owned by individual jurisdictions. Within the East-West study area, Arlington County continues to deploy CaBi stations, especially in locations close to transit facilities. Fairfax County deployed its first CaBi stations in the Reston Town Center and Tysons areas in Fall 2016. Figure 28 shows the number of CaBi trips taken each month in Arlington County since the service first launched in 2010; as shown, ridership has increased consistently each year as the service has expanded within the County and throughout the region. Ridership is much higher in the warmer months of the year. Notably, during the Summer 2016 Metrorail SafeTrack maintenance surge, Capital Bikeshare noted a spike in bike rentals, aided by a $2 single-trip-fare announced just before the surge began.[20] At the same time, in June 2016, Arlington County's automated bicycle counters along various trails recorded increases in bike traffic of up to 94 percent compared to June 2015.

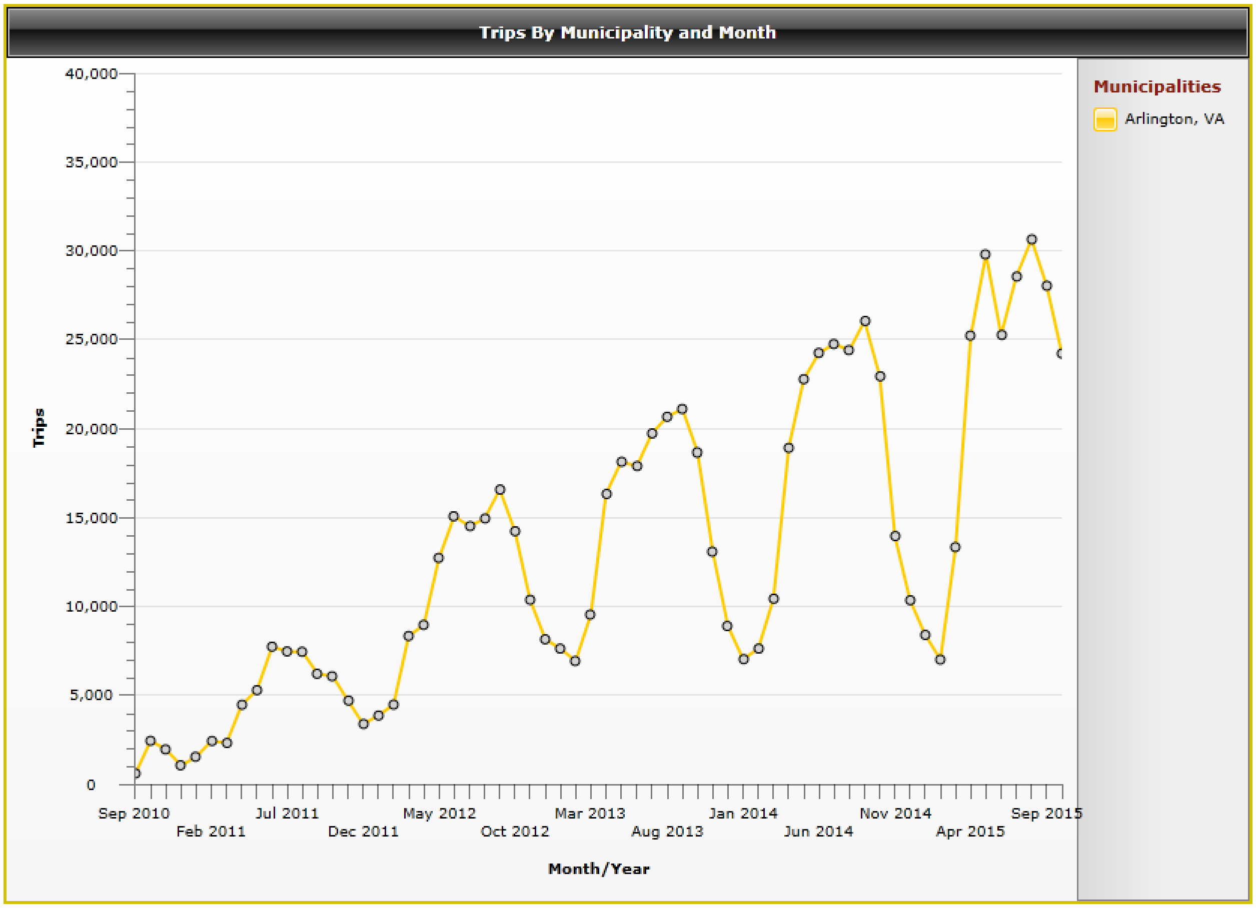

Figure 28: Capital Bikeshare Trips in Arlington County by Month (2010-2015)

4.2.3.1. Bicycle and Pedestrian Safety

Figure 29 shows locations of fatal and injury crashes in Northern Virginia that involved pedestrians and cyclists in the year 2014. Crash clusters indicate hotspots where significant numbers of crashes have previously occurred. There were 21 fatal crashes and 662 injury crashes involving cyclists and pedestrians in 2014, respectively.

[20] http://www.citylab.com/commute/2016/06/metro-safetrack-surges-cycling/486437/

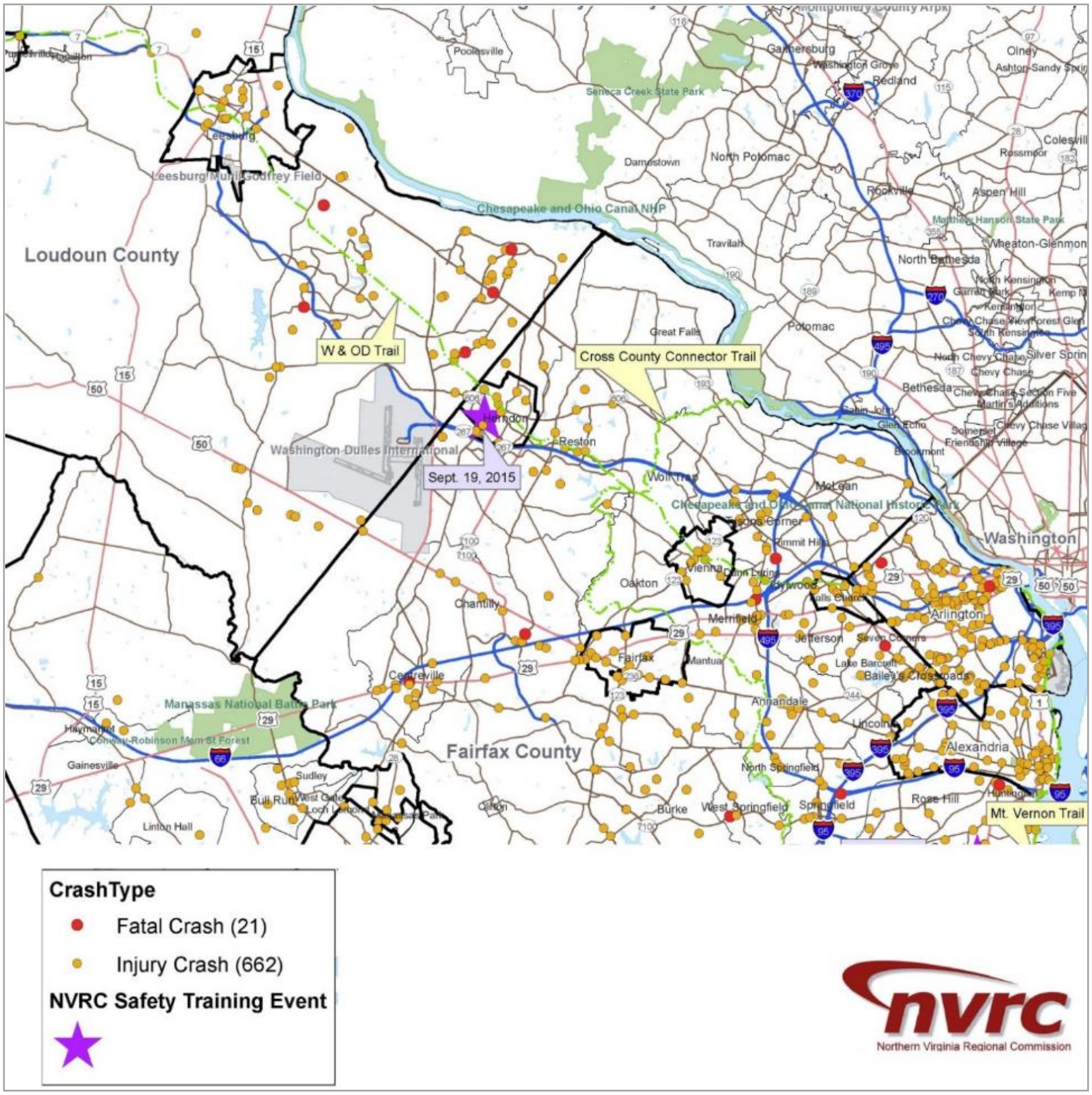

Figure 29: Bicycle and Pedestrian Crashes in Northern Virginia (2014)

Source: Northern Virginia Regional Commission. Map extents were modified to more closely fit the East-West ICM study corridor.

4.2.4. Freight Movements in the Corridor

The study corridor provides an important connection for truck and rail freight flows between Washington D.C. and the I-81 corridor. Freight facilities include:

- **Rail Facilities**: Norfolk Southern operates the Piedmont Division and Washington District rail lines along the Northern Virginia Corridor. These lines provide rail access north of Washington, D.C. to Baltimore and areas north along the east coast.[21]

[21] *VTrans 2040 Multimodal Transportation Plan CoSS Needs Assessment* – Northern Virginia Corridor.

- **Port Facilities**: No port facilities are located directly adjacent to the ICM study corridor, but it does provide direct access to the Virginia Inland Port just off I-66 near Front Royal west of the study area.[22]
- **Airport Facilities**: Dulles International Airport. Dulles International is the largest cargo airport in the Commonwealth.[23]

The following are some highlights of freight movements in the corridor obtained from recent studies:

- The *VTrans 2040 Multimodal Transportation Plan* analysis of the H2 segment including I-66, US 50, Dulles Airport, and Reagan National Airport estimates that 98 percent (19 million tons) of freight was moved by truck, while 478,000 tons of freight was moved by rail in 2012.
- According to the *National Capital Region Freight Plan*, trucking and rail tonnage in the NCR is expected to increase by 60 percent and 70 percent, respectively, by 2040.
- A study of freight bottlenecks for the Federal Highway Administration indicated that the I-66/I-495 interchange is the most congested interchange for truck freight haulers in Virginia.

4.3. Assets and ITS Infrastructure

This section provides an overview of the ITS infrastructure for the various modes of travel operating in the study corridor. This infrastructure includes devices deployed in the field along freeways and arterials, technology deployed on transit vehicles and at park-and-ride lots as well as backend supporting systems, and data feeds available for use by third parties and the general public.

4.3.1. Freeway and Arterial ITS Infrastructure

Various ITS devices have been deployed by VDOT and other jurisdictions along the corridor, including CCTV cameras, dynamic message signs (DMS), traffic sensors for counting and classifying vehicles, and roadside weather information system (RWIS) devices. Table 11 provides a high-level overview of counts of these ITS devices deployed along various freeways and arterials in the corridor by VDOT. Note that Arlington County also has CCTV deployed throughout the County, as well as DMS along major corridors which post travel times collected by Bluetooth sensors.

Table 11: Approximate Counts of VDOT ITS Devices in the Corridor

Route	CCTV Camera	Dynamic Message Signs (DMS)	Traffic Sensor System (TSS)	RWIS
I-495	40	15	24	1
I-66	64	78	141	0
US-15	1	1	0	1
US-29	5	4	0	1
US-50	6	2	0	0
SR 7	12	6	0	2
SR 267/Dulles Toll Road/ Dulles Greenway	2	0	1	1
SR 123	8	2	0	0
SR 286	2	4	1	1
SR 28	6	2	11	0

[22] *VTrans 2040 Multimodal Transportation Plan CoSS Needs Assessment* – Northern Virginia Corridor.
[23] *Virginia Statewide Multimodal Freight Study*, Final Report, 2010.

Figure 30 provides a map of CCTV deployments along freeways and arterials in the corridor. Figure 31 maps the DMS deployments in the corridor, and Figure 32 maps the traffic counting stations. Figure 33 provides a map of RWIS deployments in the corridor. Most VDOT deployments are heavily concentrated along the interstate facilities in the corridor (I-66 and I-495); separately, Arlington County owns and maintains its own network of CCTV and DMS, which are shown in the figures.

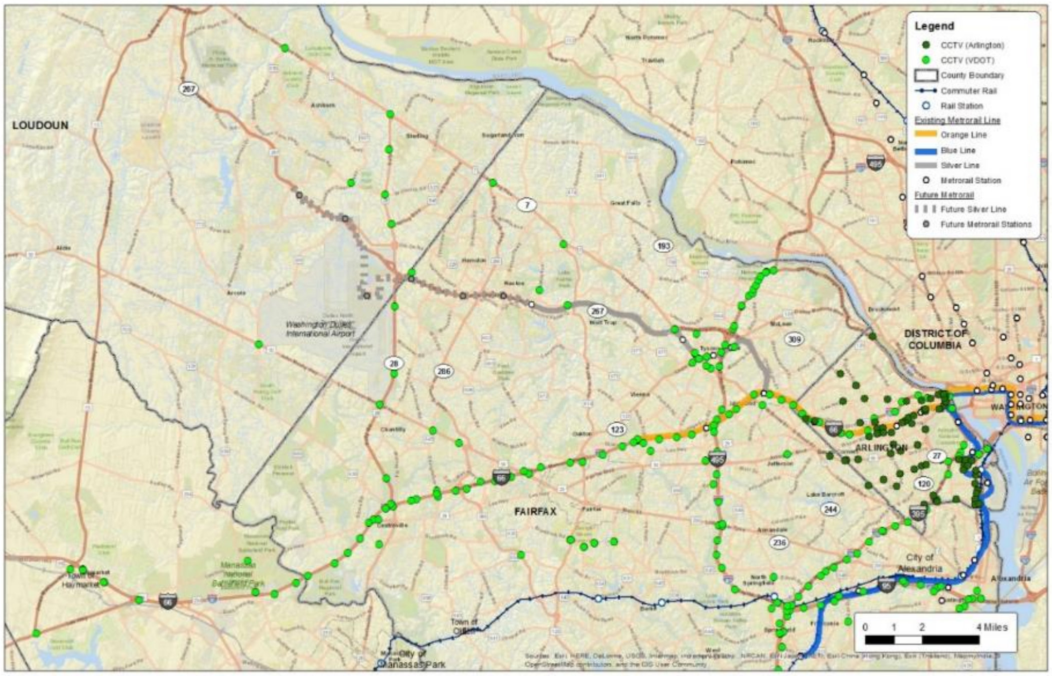

Figure 30: CCTV Camera Locations in the Study Area Corridor

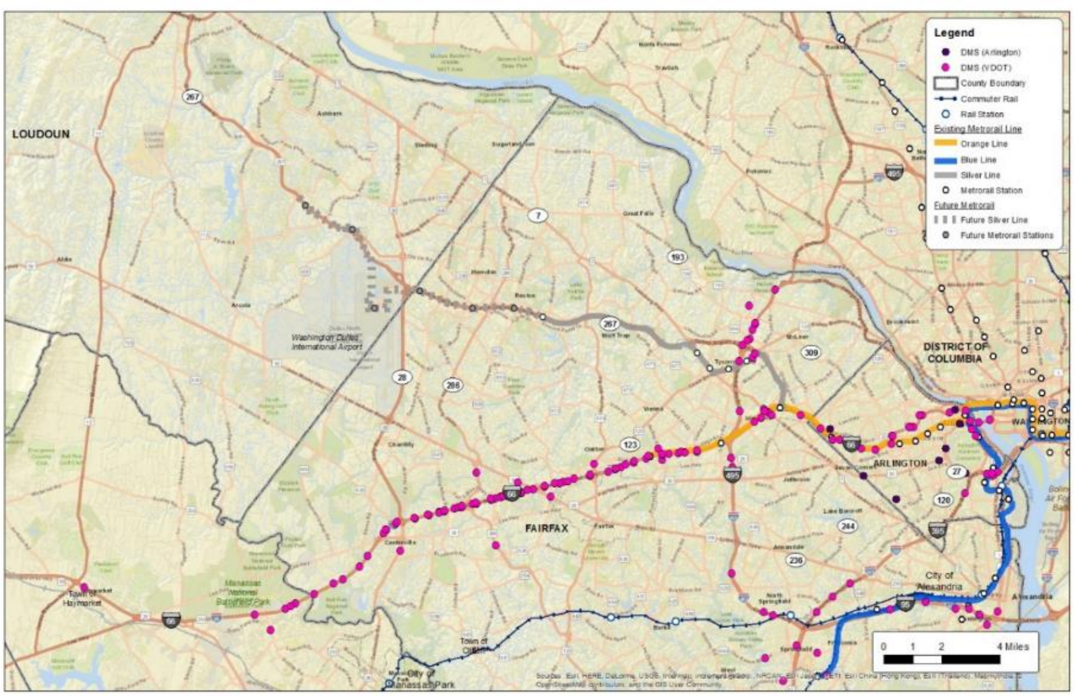

Figure 31: Dynamic Message Sign Locations in the Study Area Corridor

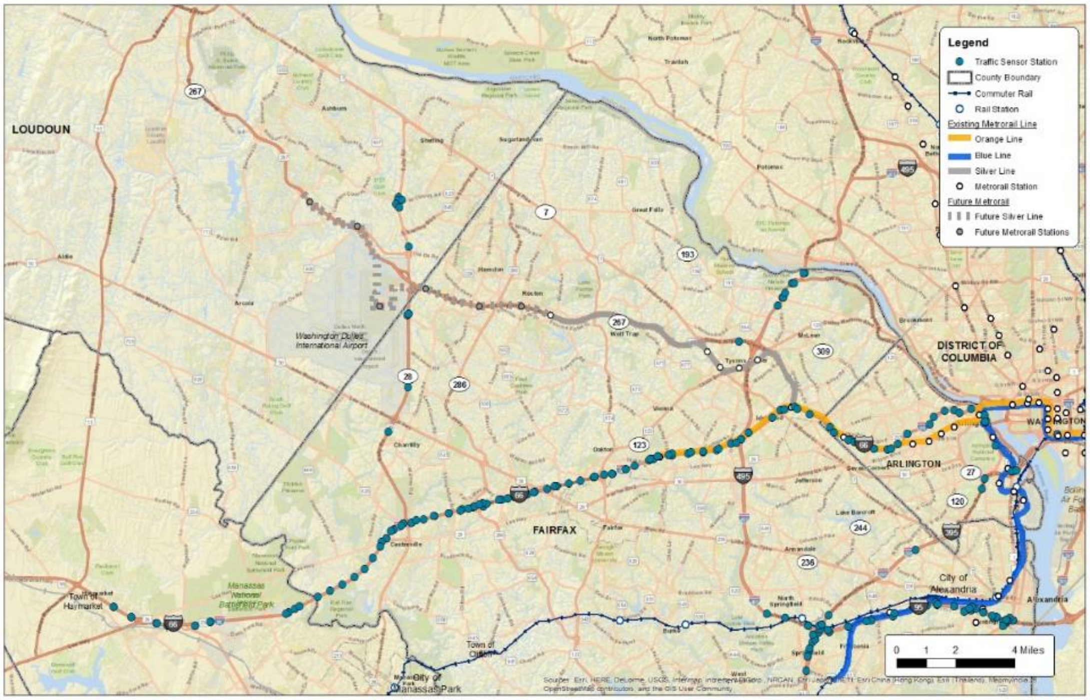

Figure 32: Traffic Counting Station Locations in the Study Area Corridor

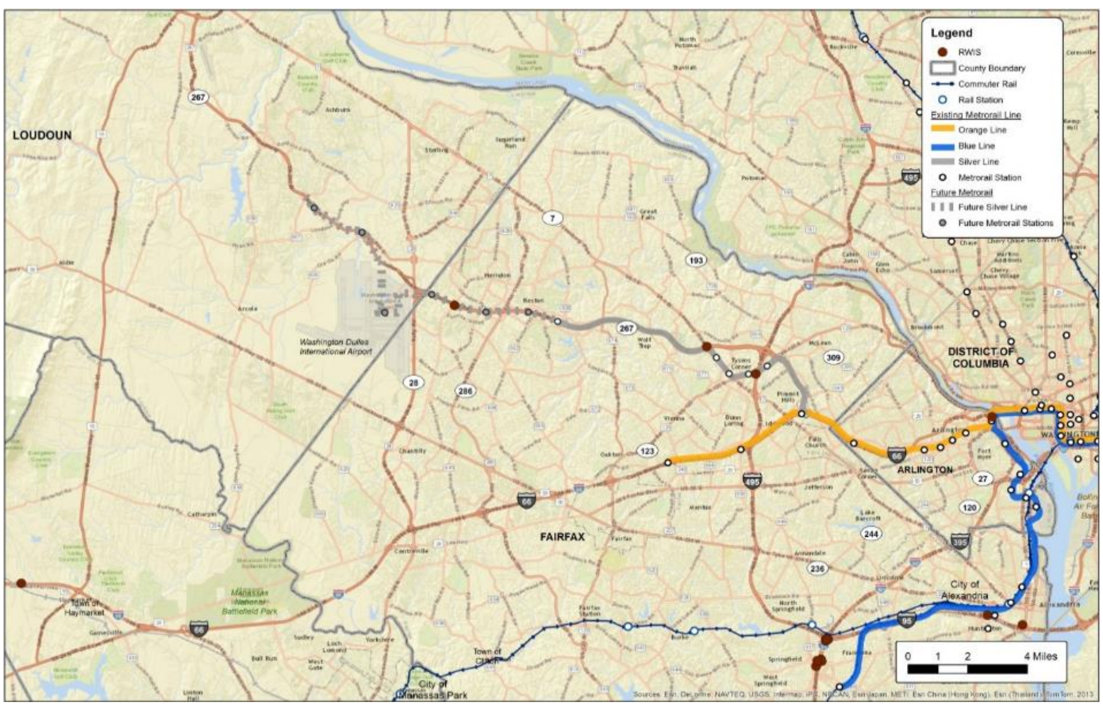

Figure 33: Road Weather Information System Locations in the Study Area Corridor

4.3.1.1. Hard Shoulder Running and Active Traffic Management (ATM)

As noted in Section 4.2.1, I-66 experiences frequent heavy congestion along nearly its entire length within the study area; between US 50 (Exit 57) and I-495 (Exit 64), a consistently congested segment in both directions and on weekends, VDOT utilizes lane control signals to designate whether the painted hard shoulder is open to vehicular traffic as an additional lane. Prior to 2015, the lane control signals for the hard shoulder were activated according to a fixed schedule only; the shoulder lane was opened eastbound during the weekday AM peak period and westbound during the weekday PM peak period.

In 2015, VDOT deployed lane control signals across all lanes between US 29 in Centreville (Exit 52) and I-495 (Exit 64) as part of a new Active Traffic Management (ATM) system. ATM components include:[24]

- Expanded use of the shoulder lanes between I-495 and US 50. These lanes are now open to traffic when congestion builds, regardless of the time of day or day-of-week.
- Lane control signals across all lanes between US 29 and I-495, which allow motorists to see which lanes are usable or blocked in advance of incidents. These gantries are also utilized for employing variable speed limits along segments of the corridor.
- Expanded camera and DMS coverage between US 29 in Gainesville (Exit 43) and the Washington, D.C. line.
- Upgrades to the ramp metering system east of I-495.

As of August 2016, the system is also being utilized to designate lanes as “Exit Only” via the overhead LED signs; one such application is along I-66 westbound approaching SR 28, where the right-most lane is designated as “Exit Only” only during the AM peak periods.[25] Figure 34 shows the ATM system in use near SR 28.

Figure 34: I-66 Active Traffic Management System Lane Control Signals in Use

As part of the planned expansion of I-66 Outside the Beltway (west of I-495), the lane control signals will be removed, as I-66 will have barrier-separated HOV/managed lane/transit facilities from the general-purpose mainline. More details on this project are described in Section 4.4.1.

[24] http://www.virginiadot.org/newsroom/northern_virginia/2015/i-66_active_traffic_management85954.asp
[25] http://www.virginiadot.org/newsroom/northern_virginia/2016/i-66_overhead_signs_create106530.asp

Hard Shoulder Running Outside of I-66

There are multiple other locations in the study area in which hard shoulder running is utilized. Along the SR 267 spur east of I-495 that connects to I-66, buses are permitted to run along the shoulder in the eastbound direction approaching the West Falls Church Metrorail station during peak periods, bypassing frequent queues. Along I-495 northbound, north of Tysons Corner approaching the American Legion Bridge into Maryland, hard shoulder running was recently deployed and is signed via lane-use gantries.

4.3.1.2. Infrastructure for Automated and Connected Vehicles

Connected vehicles (CV) are vehicles using various technologies to communicate with the driver, other cars on the road (vehicle-to-vehicle, or V2V), roadside infrastructure (vehicle-to-infrastructure, or V2I), and the cloud. This technology can be used to improve vehicle safety, improve traffic operations, and reduce greenhouse gas emissions. Separately, fully automated or "self-driving" vehicles (AV) are defined by the USDOT as "those in which operation of the vehicle occurs without direct driver input to control the steering, acceleration, and braking and are designed so that the driver is not expected to constantly monitor the roadway while operating in self-driving mode." USDOT has defined five "levels" of automation, with the higher levels of automation requiring decreasing driver control. Some lower-level technologies, such as vehicle-assisted braking or adaptive cruise control, are already available to the public, while high-level technologies are being researched and tested. To have a fully automated vehicle, the vehicle must also be a connected vehicle. Several states, including the Commonwealth of Virginia, have taken initiatives involving the real-world testing and deployment of CV and AV technologies.

The Virginia Tech Transportation Institute (VTTI), in partnership with VDOT and others, has undertaken two initiatives to study connected and automated vehicle technologies which are relevant to the East-West ICM Corridor Study area:

1. The Virginia Connected Corridors (VCC) initiative is facilitating the real-world development and deployment of connected-vehicle technology using roadside equipment units (RSUs) and highly instrumented vehicle fleets. This initiative includes the *Northern Virginia Connected Vehicle Test Bed*, which is located along I-66 and along US 29, US 50, and SR 7 in Fairfax County and is the largest infrastructure test bed in the nation. This test bed allows developers and researchers to test how connected vehicle technologies will perform under real-world operating conditions. The Northern Virginia test bed, which has over 50 RSUs, was selected because of its inherent transportation shortcomings: i.e., congestion, high crash rates, and air-quality non-attainment. Through this test bed, VTTI and its partners are studying how connected vehicle technologies can effectively address these deficiencies. Connected applications being studied so far include traveler information, enhanced transit operations, lane closure alerts, and work zone and incident management.

   The Northern Virginia Connected Vehicle Test Bed is shown in Figure 35 and features the following:

   - Four major merge/diverge locations
   - Two Metrorail stations
   - Public transport and commuter routes
   - HOT and HOV lanes
   - A large County hospital
   - A fire station
   - Multiple schools
   - Pedestrian trails
   - Mixed-use Commercial and residential areas
   - Major roadway construction

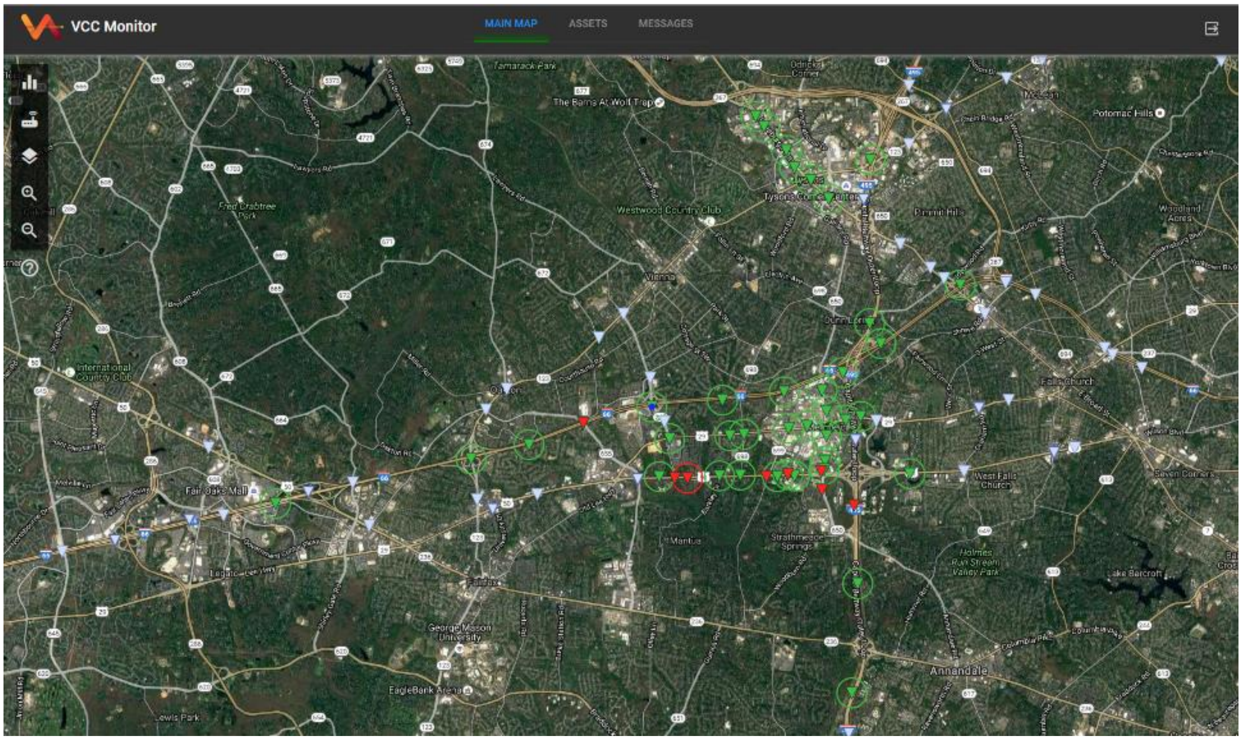

Figure 35: Northern Virginia Connected Vehicle Test Bed

2. The Virginia Automated Corridors (VAC) initiative, unveiled in summer 2015, aims to streamline the use of Virginia's roads and state-of-the-art test facilities for automated vehicle testing, certification, and migration toward deployment. The VAC initiative will offer automated vehicle developers the opportunity to test their technologies on Virginia roads covering more than 70 miles of interstates and arterials in Northern Virginia, including I-66, I-495, US 29, and US 50 in the ICM corridor study area. The VAC initiative will integrate multiple resources, including:

   - Access to dedicated HOT lanes managed by Transurban along I-495 and I-95.
   - High-definition mapping capabilities, real-time traffic and incidents, intelligent routing, and location cloud technology supported by HERE, which has worked with major automakers on previous automated-vehicle projects.
   - Pavement markings maintained by VDOT for completeness and retro-reflectivity.
   - Accurate localization via high-precision global navigation satellite systems (GNSS).
   - Connected-vehicle capabilities enabled by dedicated short-range communications (DSRC) and cellular technology and access to sophisticated, unobtrusive data acquisition systems.

Figure 36 and Figure 37 show the location of the Northern Virginia Automated Corridors along arterials and interstates, respectively.

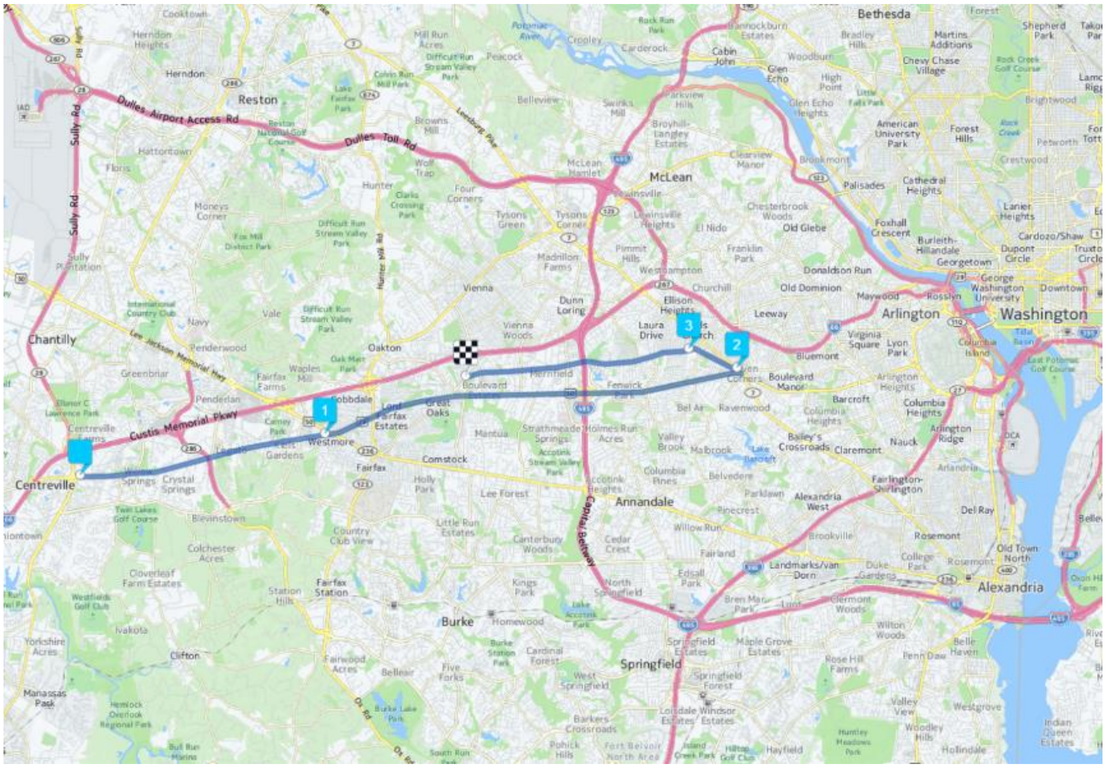

Figure 36: Northern Virginia Automated Corridors (Arterials)

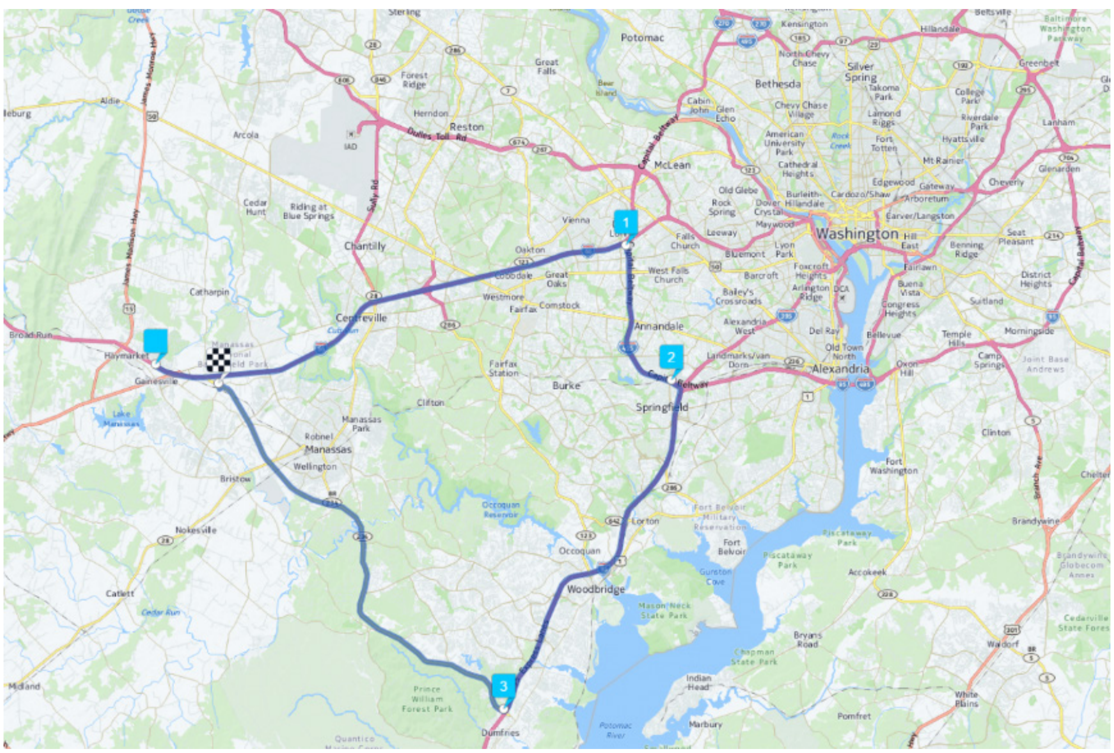

Figure 37: Northern Virginia Automated Corridors (Interstates)

To advance CV and AV technologies in Northern Virginia, VDOT is taking the initiative to broadcast signal phase and timing (SPaT) data and implement work zone safety and related traveler information message (TIM) applications. A contract has been issued with the developers of the firmware and the capability is expected within FY17. This capability will facilitate applications such as red-light violation warning and eco-driving and is a step towards additional applications such as emergency vehicle preemption and transit signal priority. In addition to broadcasting SPaT messages from equipped intersections, VDOT is also working to develop the capability to access this data directly from the central signal control system, MIST; MIST can then be incorporated into a future statewide central system platform. A prototype traveler information message (TIM) application has been developed as part of VDOT's ongoing work in the VCC. To be most effective, the app requires access to accurate and timely information. VDOT is working on identifying existing data sources, gaps in data availability, and a framework for data management to support the TIM app.

4.3.1.3. Arterial ITS Infrastructure

The following VDOT initiatives are ongoing with regards to ITS infrastructure along arterials in the East-West ICM corridor:

- **Signal controller and communications upgrade.** The type 170 controller was the most advanced controller available when installed in 1996; in the intervening 20 years, advances have been made in controllers that provide more features and ability to respond to traffic. To take advantage of all the features available, high-speed communication with the central system is essential. VDOT is upgrading all traffic signal controllers and communications to type 2070 ATC controllers and Ethernet broadband communication. As July 2016, out of 1,425 signals in the region, approximately 1,000 had been upgraded.
- **Transit Signal Priority (TSP).** VDOT and local jurisdictions have expressed strong interest in deploying Transit Signal Priority (TSP) in Northern Virginia; however, the type 170 controller limits the ability to quickly restore the programmed signal timing after TSP is triggered. With the new controller upgrade at all signals, VDOT has partnered with WMATA to deploy TSP along SR 7 as an operational strategy that facilitates the movement of in-service transit vehicles through traffic signals with modified green time. TSP has been implemented by WMATA at fifteen intersections along SR 7 between Fairfax Square in Tysons and Carling Springs Road in Bailey's Crossroads, where NRO set a high priority to upgrade controllers and communication at these intersections.
- **Adaptive Control Systems (ACS).** VDOT initiated a feasibility study to identify potential opportunities to improve traffic operations and reduce delays along key arterial roadways using Adaptive Control System technology. VDOT has piloted two ACS in the East-West corridor: one along Braddock Road and another along SR 236. While no two adaptive systems are the same and each handles traffic operations optimizations in a unique fashion, the review determined which systems are best suited for the operational traffic conditions on the project arterials. After extensive study on the key corridors' profiles (all ICM arterial corridors are on the list) and analysis of the potential benefits and impacts of available ACS in the market, the following East-West corridor segments were concluded to potentially benefit from implementing ACS:
    - SR 7 from Seven Corners to S. George Mason Drive – the recommended ACS could respond to and accommodate the rapid traffic growth in the AM peak period.
    - US 29 from Circle Woods Drive to Graham Road and from US 15 to Ridge Top Road - the recommended ACS could accommodate the rapid changes in traffic because this corridor has potential for freeway diversion traffic which creates abrupt shifts in traffic, as well as pronounced peak periods and drop-offs in traffic during peak periods.
    - SR 286 from Popes Head Road to US 1 – the recommended ACS could reduce the duration of oversaturated conditions.

VDOT has put a temporary hold on implementing the recommended ACS until the agency is fully migrated onto the new statewide central signal management system.

- **Proactive signal timing optimization and operations.** The VDOT Signal Operation team proactively monitors and adjusts signal timings in real-time using a central signal system; performs signal optimization by developing and implementing new timings; responds to internal and external customer concerns and requests; coordinates with local jurisdictions; and manages incidents and special events.
- **Arterial CCTV deployment.** While VDOT had deployed hundreds of CCTV cameras along interstate facilities for many years with nearly 100 percent viewing coverage, the camera deployment at signalized intersections to aid arterial operations only started in FY12. While approximately 80 intersections were identified as higher priority out of over 1,400 signalized intersections for the camera deployment, VDOT has been deploying these cameras with the target completion by the end of FY17 with available resources. These cameras not only are used for supporting signal/arterial traffic management and incident management, but also for aiding snow operations. These feeds are available for the general public's viewing via 511.
- **Uninterruptible Power Supply (UPS).** To preserve continuous signal operations during power outages, VDOT had been taking a phased approach to furnishing and installing a true-on-line, power conditioner and DSP processor-based uninterruptible power supply (UPS) system designed for transportation and traffic applications. The inverter will be in operation at all times and capable of supplying clean regulated power to all loads at critical intersections along these corridors. The phased approach is not only due to the limited resources, but also to prepare for a more manageable life-cycle replacement maintenance program.

Additionally, as noted previously, Arlington County, which manages and maintains its own roadway and signal network, has CCTV deployed along arterials throughout the County and is continuing to deploy more cameras. Arlington has been upgrading its communication backbone to fiber throughout the County to support its ITS deployments. Arlington has DMS deployed along US 29 and US 50 to show travel times within the County; these travel times are collected using Bluetooth sensors along the corridors.

4.3.1.4. Statewide Systems

Statewide Advanced Traffic Management System (ATMS)

VDOT is in the process of implementing a new common statewide ATMS operating platform to replace its current Virginia Traffic Information Management System (VaTraffic) and ATMS offerings, and to improve interoperability among the systems deployed across its Transportation Operations Centers (TOCs).[26] VDOT currently utilizes various ATMS platforms across its regional TOCs and is striving to improve interoperability of the processes across its TOCs through a common platform. By Spring 2018, all five regions across the state are expected to be on the same ATMS platform. This platform will allow for ITS device management, roadway network monitoring, interfacing with connected signals, CAD feeds from local police dispatch, and incident response plans that can be sent to operators based on the CAD feeds. While parking management is not a module that will be part of the new first-generation ATMS deployment, it is viewed as potential future module for the ATMS that could ingest information coming from parking facilities, such as park-and-ride facilities for transit or truck parking.

Performance Measurement System (iPeMS)

In 2015, VDOT implemented a statewide performance measurement system known as iPeMS. This system collects data from VDOT's Transportation and Video Data (TVD) feed, including information such as DMS messages as well as crashes. It serves as an archive to the statewide ATMS and allows for assessment of real-time conditions as well as extensive performance reporting on roadways throughout the state. VDOT staff have noted that, while iPeMS can be used to provide situational awareness in real-time, the system is generally not used in a real-time context and is most applicable for generating reports.

[26] http://www.virginiadot.org/vdot/newsroom/statewide/2012/asset_upload_file14_56036.pdf

4.3.2. Transit ITS Infrastructure

This section describes systems and technologies utilized by the transit providers in the study area that are applicable within an ICM context. These include fare payment systems, systems to track the locations of vehicles and count passengers, and systems to share data with developers and third parties.

4.3.2.1. Rail Transit ITS Systems

WMATA Metrorail

WMATA currently utilizes a smart-card fare payment system known as SmarTrip. SmarTrip cards are permanent, reloadable fare media that can be purchased and reloaded online, at any Metrorail station, and many other locations in the Washington, D.C. area. As of 2016, for riders on the Metrorail system, riders must use a SmarTrip card to enter the system. Riders scan their cards to enter a Metrorail station and must scan again to exit the station; fares are calculated on a station-to-station basis (as opposed to one system-wide fare or a zone fare structure). SmarTrip cards are also accepted by Metrobus and all other local bus transit providers in the study area, allowing riders to pay for multiple modes using the same media and, in some instances, obtain discounts for transfers. As discussed in Section 4.2.2, WMATA aggregates this fare payment data into origin-destination data that it occasionally releases to the public.

WMATA Metrorail riders can access real-time train arrival information and trip-planning information through tools on WMATA's website, as well as a variety of third-party mobile applications. WMATA's online Rider Tools platform also provides elevator/escalator status and service alerts. Riders can sign up for MetroAlerts, which notify subscribers of Metro service disruptions via email or text messages; if further information on the incident is available, a link to the website describing the information in more detail is sent as well.

WMATA provides a suite of developer resources for creating third-party applications on desktop, web, or mobile devices:

- The Metro Transparent Data Sets API includes the order and location of rail stations by line, train arrival predictions for each station, service alerts, and elevator/escalator status. As of Summer 2016, WMATA also included real-time train positions as part of this developer portal.
- The General Transit Feed Specification (GTFS) download provides the same official schedule data that supports Metro's online trip planner.
- RSS feeds provide subscriptions to Metro advisories and news releases and GTFS schedule releases.

Virginia Railway Express

VRE does not participate in the SmarTrip system, as its fare structure is aligned differently than that of Metrorail or the various local bus providers. VRE riders can purchase single-ride passes, day passes, five-day passes, ten-trip, and monthly passes; fare payment is inspected prior to boarding or on board trains. As of 2015, VRE offered a mobile ticketing platform in which riders could purchase fares and store them electronically on their mobile devices. VRE also provides an online interactive map for users to track train locations (via GPS) and on-time arrival status.[27]

4.3.2.2. Bus Transit ITS Systems

All bus transit providers in the East-West study corridor have their buses equipped with SmarTrip-compatible fare boxes. Riders can pay for trips with their SmarTrip card or cash. WMATA's online trip planning tool is integrated with the other transit providers' static schedules and can suggest bus transfers to and from the Metrobus and Metrorail systems. Most agencies allow bus riders to reload values onto their SmarTrip cards while on board the bus.

[27] http://www.vre.org/service/status/

WMATA Metrobus

WMATA has automated passenger counters (APCs) on all buses recording passenger boardings and alightings. APC can be coupled with its automatic vehicle location (AVL) system on all buses, which tracks the location of a bus along its route, to provide ad-hoc analysis of boardings and alightings by stop. WMATA does not currently able to monitor bus loads in real-time via a real-time integration of these systems. WMATA does not record crowding at bus stops at this time, but has noted anecdotally that bus stop crowding at locations outside the District of Columbia are “practically non-existent.”

Fairfax Connector

Fairfax Connector is in the process of upgrading to a new fully-integrated on-board ITS system to enhance operational performance. This system was piloted in 2015, and FCDOT expects a full deployment of the system by Summer 2016. As part of this system, automatic passenger counters (APCs) will be deployed on all buses and integrated with a new CAD/AVL system for tracking vehicle locations and monitoring vehicle loads in real-time. With this new ITS system, FCDOT will be able to track bus loads over time between stops, and be able to tie ridership data to individual stops and time-of-day.

Loudoun County Transit

Loudoun County Transit has AVL installed on nearly all buses, and all buses should have AVL equipped later in 2016. The County is hoping to make this data publicly available when this happens; even if the County is not able to acquire a real-time GTFS feed for its data, riders should be able to use the website from the transit agency’s AVL vendor to track its buses. Riders can also use WMATA’s trip planner, based on LC Transit’s static bus GTFS schedule, to plan trips.

LC Transit does not have APCs on buses; however, ridership is tracked using the fare box counts and manual count data which is used as a check on fare box counts. LC Transit releases 120-day summaries of ridership for commuter trips to the Wiehle-Reston East Metrorail station and to destinations in Arlington and Washington, D.C. This data is available for download from the Loudoun County government site and was provided to the project team for this corridor profile.

LC Transit is not able to monitor passenger loads in real-time or near-real-time currently, as this would require its passenger-counting system to be integrated with its AVL system in real-time. LC Transit does monitor passenger loads on all runs each day, enabling them to add buses in when and where needed (assuming that new equipment is available). They use fare box data along with GPS data from the AVL system to determine where the buses fill up and where passengers are ultimately destined.

LC Transit has two forms of message notification for its passengers:

- Bus Biz is an email notification system for sending information to riders about the service, such as surveys for holiday schedules to changes in parking at particular park-and-ride lots.
- LC Alert is a real-time text-messaging system used when service is disrupted based on unanticipated road closures, detours, or major traffic delays. The alerts are sent if a bus is anticipated to be more than 10 minutes late. These are powered by the AVL system.

Potomac and Rappahannock Transportation Commission (PRTC)

PRTC has implemented and is refining a CAD/AVL system, including APCs, which are currently in a testing and verification phase. PRTC does not currently track on-time performance as a performance measure, but will begin doing so once the CAD/AVL system has been accepted. Currently, ridership is derived from the electronic fare box data. For commuter routes defined by one major boarding and one major alighting location, monitoring passenger loads is fairly straightforward. PRTC is aware of one trip along the Gainesville OmniRide route that is regularly overcrowded, while, anecdotally, capacity exists on virtually all other trips. However, the recent increase in the transit benefit provided to commuters from the FAST Act could change this in the coming months.

In conjunction with the deployment of its CAD/AVL system, PRTC has a Beta version of a real-time passenger information notification system under development, with a text or email being sent to riders according to preferences. PRTC's website has a trip-planning tool and transit information is available on Google. Their static GTFS feed is available through PRTC's website for third-party development.

4.3.3. Park-and-Ride Lot ITS Infrastructure

No park-and-ride lots in the study area currently feature systems to share information in real-time on occupancy or areas of lots which are at capacity. WMATA has detectors at gates to its Metrorail station lots which allow the agency to perform ad-hoc analyses of lot occupancy; agency staff have noted issues with the reliability of the data in this system if the detectors become un-calibrated.

VDOT provides an interactive online tool in which users can search for park-and-ride lots by region, by city/zip code, or via an interactive map.[28] This mobile-friendly website provides information, such as the number of spaces including handicapped spaces, any associated fees, whether the lot is served by transit service, and amenities such as whether the lot is paved and has bicycle accommodations. WMATA also provides detailed information about the lots it operates on its website.[29] Currently, neither of these sources provide information on rea;-time parking availability or historic parking availability, such as the typical times at which a lot reaches capacity.

4.3.4. Bicycle Network ITS Infrastructure

The East-West ICM corridor study area, led by Arlington County, is a national leader in technology innovations for encouraging and facilitating bicycle use and sharing data on travel patterns to foster further innovation.

Arlington County provides a crowd-sourced "rack spotter" online tool[30] to allow riders to locate nearby bike racks. This tool provides an interactive map with addresses of bike racks, types of racks and number of spaces, and photos and descriptions when available. This tool has been expanded well beyond Arlington County and shows bike racks throughout the Washington, D.C. region, including many within the East-West ICM corridor.

Arlington County also provides an online and print "Level of Comfort" map[31] for riders showing which facilities in the County are recommended for various rider levels of experience, as well as locations of hills and Capital Bikeshare stations. This map is currently available in a static format.

Arlington County has deployed a network of bicycle and pedestrian counters.[32] As of January 2015, the County has 18 permanently-installed counters on shared-use trails, 10 permanent bicycle-only counters in on-street bike lanes, 6 mobile counters typically used for short-term sidewalk counts, and "the first real-time bicycle counter on the east coast" near the heavily-trafficked intersection of Lee Highway and N. Lynn Street in Rosslyn. The County provides an online dashboard[33] for users to view historic data from these counters, including associated historic weather data. Notably, in June 2016, during Metrorail's SafeTrack maintenance surge along the Orange and Silver lines, Arlington County's automated bicycle counters recorded increases in bike traffic of up to 94 percent compared to June 2015.

Capital Bikeshare provides a variety of publicly-available data to developers for real-time applications as well as transportation planning purposes.[34] It provides a live station status feed in XML and Generalized Bikeshare Feed Specification (GBFS) formats; this feed shows the number of bikes currently available at each station in the system. CaBi provides an archive of trip history data for download. CaBi also provides a dashboard for analyzing various performance metrics, including:

- Ridership by month,

[28] http://www.virginiadot.org/travel/parkride/home.asp
[29] http://www.wmata.com/rail/parking/
[30] http://www.rackspotter.com/
[31] http://www.bikearlington.com/tasks/sites/bike/assets/File/Bikemap_front.pdf
[32] http://www.bikearlington.com/pages/biking-in-arlington/counting-bikes-to-plan-for-bikes/
[33] http://www.bikearlington.com/pages/biking-in-arlington/counting-bikes-to-plan-for-bikes/counter-dashboard/
[34] https://www.capitalbikeshare.com/system-data

- Trip O-Ds by municipality and station,
- Trips per time interval and percentage of trips per time interval,
- Miles travelled per month,
- Fleet performance metrics, such as bicycles in service, number of bikes inspected/repaired per month, and bicycles damaged per month,
- Customer service metrics, such as the number of instances customers have reported stations full or empty, and
- Membership metrics, including the total number of users and new members.

4.4. Planned Projects and Improvements

4.4.1. I-66 Outside the Beltway

VDOT, as part of a private-public partnership initiative, plans to reconstruct I-66 between US 15 (Exit 40) in Haymarket and I-495 (Exit 64) in an effort to transform the corridor into a much more multi-modal corridor. The reconstruction and expansion will include the following elements:

- Two express lanes in each direction, initially from near US 29 in Gainesville (Exit 43) to I-495. These lanes, like the current express lanes on I-495, will be free to HOV3+ vehicles and tolled to all other traffic. Vehicles will be required to be equipped with an EZ Pass to use the lanes. The lanes will be required to maintain an average speed of at least 45 miles per hour and will thus provide reliable travel times to a corridor notorious for unreliable travel at many hours throughout the day and on weekends.
- At least three general purpose lanes in each direction, free to all drivers, with an additional auxiliary lane between most interchanges.
- Safety and operational improvements at key interchanges, including near-complete reconstruction of several interchanges. This includes the reconstruction of the SR 28 interchange and removal of traffic signals along SR 28 in the vicinity of I-66, which create lengthy queues along I-66 in the AM peak period and along SR 28 southbound during the PM peak period.
- New transit service along I-66, operating as a bus extension or complement to the Metrorail Orange Line. The I-66 Rapid Bus Service (RBS) will operate on several route patterns to offer frequent headways during weekday peak periods, as well as all-day and weekend service from park-and-ride facilities along the express lanes.
- Expansion of existing park-and-ride lots and construction of new park-and-ride lots with direct ramp connections to the express lanes to facilitate the enhanced transit service and carpooling. In total, these new or expanded facilities should provide approximately 4,000 new spaces as part of the initial construction effort and approximately 6,500 total spaces by the time the full construction is completed.
- Deployment of ITS devices along the corridor during and after construction, including the following subsystems:
  - *Data collection and monitoring subsystem,* including detection between interchanges and utilization of third-party probe data to obtain real-time speed, occupancy, and volume between interchanges.
  - *Incident management subsystem*, including cameras, advisory DMS between every interchange and prior to managed lanes access locations, traveler information systems such as 511, and RWIS.
  - *ICM subsystem*, including parking data-collection systems and CCTVs at park-and-ride lots with the goal of sharing relevant transit and parking information on DMS along the freeway and at parking facilities.

- *Tolling subsystem*, which is the responsibility of the project developer, but must be compatible equipment-wise with the managed lane facilities on I-495 and I-95.
- *Connected vehicle subsystem*, including relocation of DSRC devices placed between SR 123 and I-495.
- *Communications subsystem*, including separate fiber optic cables for the managed and general-purpose lanes spare fiber.

Construction is anticipated to begin in 2017. Locations for planned park-and-ride lot expansions and new construction are shown in Figure 38.

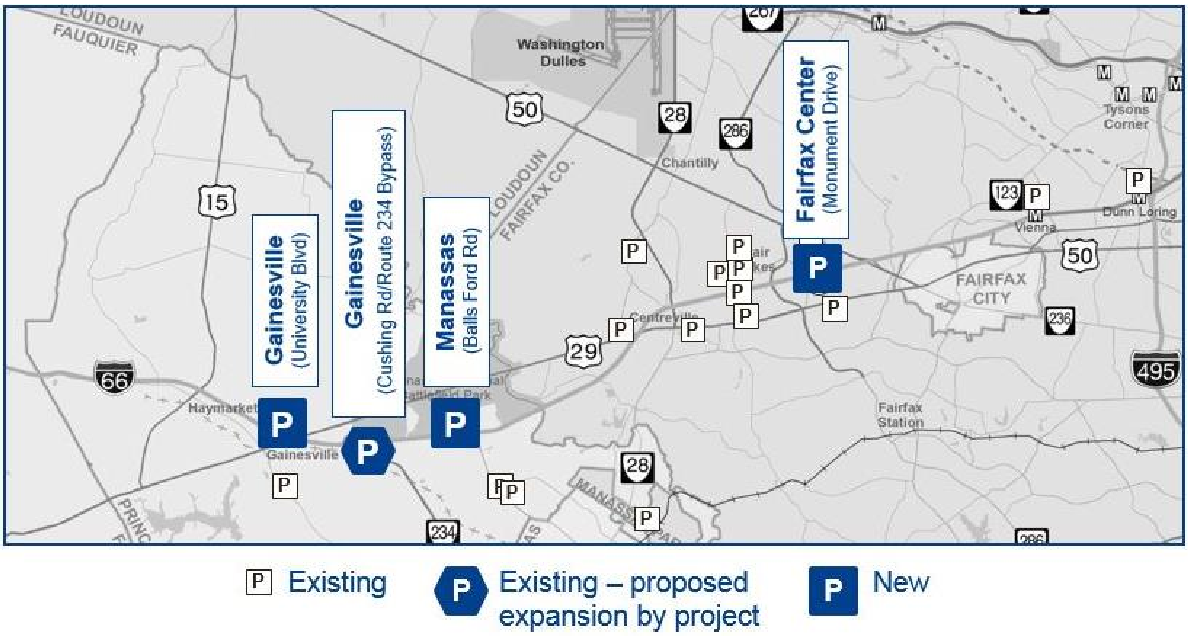

Figure 38: Planned Park-and-Ride Facilities Expansions and New Construction

4.4.2. I-66 Inside the Beltway

Separate from the expansion and reconstruction efforts taking place west of I-495, VDOT is planning for the first major improvements proposed for I-66 inside the Beltway in nearly 20 years as a result of a detailed multi-year study undertaken between 2011 and 2013. The *Transform I-66* Inside the Beltway project includes the following components:

- Converting I-66 east of I-495 to dynamically-priced toll lanes during rush hours in the peak directions (from 5:30AM until 9:30AM eastbound and from 3:00PM until 7:00PM westbound, Monday through Friday). HOV vehicles and buses will travel the lanes for free, while others will be required to pay a toll. This will remove the current ban on single-occupancy vehicles during restricted periods and instead charge them a demand- and distance-based toll. This will also relieve congestion before and after the HOV periods by lengthening the restricted periods. Vehicles will be required to have an EZ Pass transponder during the restricted periods, so the employment of dynamic tolling should theoretically reduce the number of single-occupancy violators during restricted period.
- An expansion of ITS devices to implement dynamic tolling, including overhead gantries and dynamic signage.
- Widening of I-66 eastbound from the Dulles Connector Road (SR 267, Exit 67) to Ballston (Exit 71) with lanes opening in early 2020.

4.4.2.1. NVTC Multi-Modal Improvements from I-66 Inside the Beltway Toll Revenues

Toll revenues from I-66 Inside the Beltway will be used to increase transit service benefiting the users of I-66 inside the Beltway as well as to enhance carpool and other TDM strategies throughout the corridor. This may include new park-and-ride lots, roadway improvements on parallel routes, transportation systems management, and other strategies. As of Summer 2016, the Northern Virginia Transportation Commission (NVTC) has recommended a total of $9.8 million in funding for ten multi-modal components which have been endorsed by the Commonwealth Transportation Board. These components are shown in Table 12.

Table 12: Selected FY17 Multi-Modal Components to be Implemented as Part of I-66 Inside the Beltway

Selected FY2017 Transform 66 Multimodal Components	Funding
Fairfax Connector Express Service from Government Center to Foggy Bottom	$3,336,836
Loudoun County Stone Ridge Enhanced Transit	$1,940,939
PRTC Gainesville to Pentagon Commuter Service	$887,900
Peak Period Service Expansion to Metrobus Route 2A, Washington Blvd – Dunn Loring	$1,000,000
Peak Period Service Expansion to ART Bus Route 55	$450,000
Bus Stop Consolidation and Accessibility Improvements	$462,000
Expanded Transit Access, Bike Share	$500,000
Multimodal Real-Time Transportation Information Screens	$250,000
Loudoun County Transportation Demand Management	$623,000
Expanded TDM Outreach to the I-66 Corridor	$350,000
Total Recommended FY2017 Transform 66 Multimodal Project	**$9,800,675**

4.4.3. WMATA Metrorail Silver Line Phase II

Phase II of the Metrorail Silver Line, which is currently under construction and projected to begin service in 2020, will continue west for approximately 11 miles from the current western terminus at the Wiehle-Reston East station and add six new stations to the line. There will be three stations in the center of SR 267 (Dulles Toll Road/Dulles Access Road portion) serving the growing Reston Town Center and Town of Herndon. The line will leave its alignment with SR 267 to serve an above-ground station at Dulles Airport before returning to an alignment along SR 267 (Dulles Greenway portion), connecting to two final stations in Loudoun County. New park-and-ride lots will be constructed adjacent to the new stations with the exception of the Reston Town Center station and Dulles Airport station. These stations will include pedestrian bridges across one or both sides of SR 267, bus drop-off and pickup locations, and bike racks and lockers.

4.4.4. VRE Gainesville/Haymarket Extension

The VRE Gainesville-Haymarket Extension (GHX) is a proposed 11-mile extension of the VRE Manassas Line commuter rail service via a Norfolk Southern Railway branch, extending from the City of Manassas through Gainesville to the Town of Haymarket near the intersection of US 15 and I-66. This segment of the VRE line would run adjacent to I-66; prior studies by VDOT and DRPT determined that a mixture of multi-modal improvements, including the I-66 Outside the Beltway improvements and the VRE GHX, would be necessary to address future demand, provide new travel options, and reduce congestion. In July 2015, VRE initiated an approximately two-year planning and design study for the GHX, including an alternatives analysis and a National Environmental Policy Act (NEPA) assessment. The study should identify a preferred alignment, number of stations and station locations, as well as preliminary engineering and cost estimates. Figure 39 shows the study area for the proposed GHX.

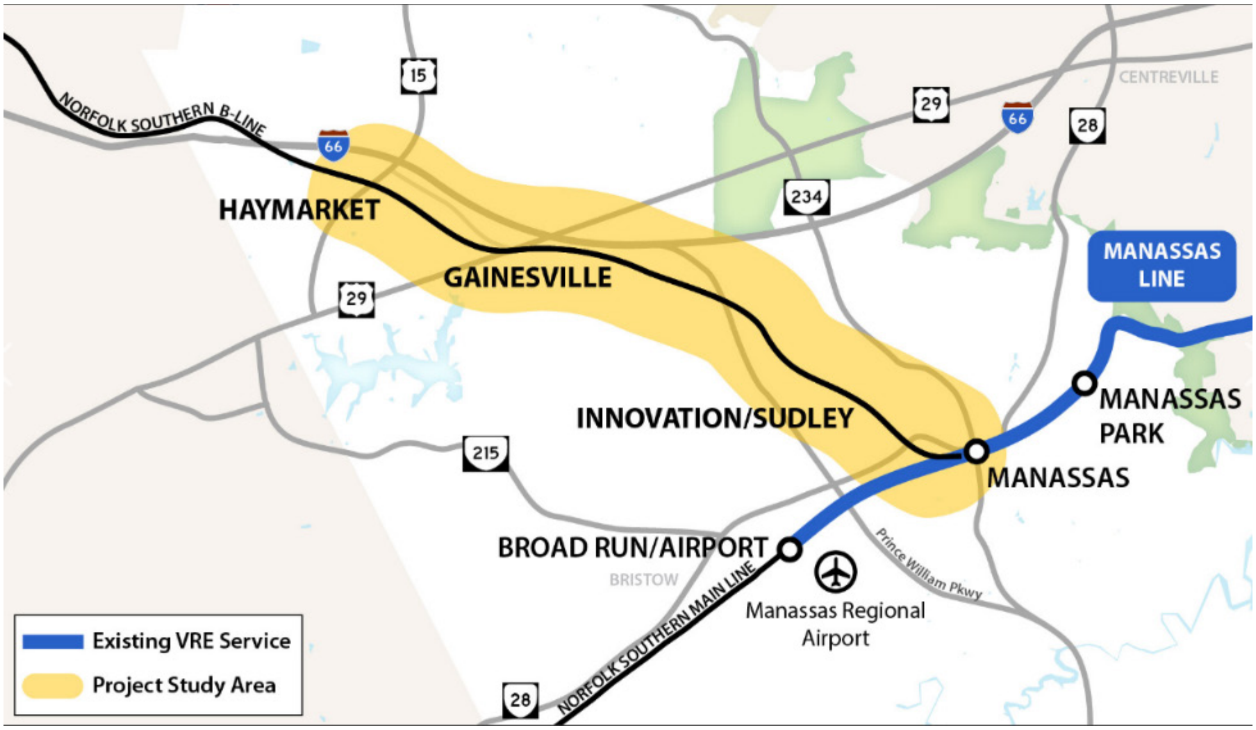

Figure 39: VRE Gainesville-Haymarket Extension Study Area.

4.4.5. Fairfax County Capital Bikeshare

Fairfax County will be deploying Capital Bikeshare stations at 29 locations in Tysons (14 locations) and Reston Town Center (15 locations) in 2016.[35] These represent the first Capital Bikeshare deployments west of I-495 in Virginia and the first deployments in the East-West study corridor outside of Arlington County. To enhance the Bikeshare service, FCDOT has been adding dedicated bike lanes and shared lane markings in Tysons and Reston.

4.5. Institutional Characteristics

4.5.1. Ownership, Operations and Maintenance of Facilities

The East-West ICM study corridor is a complex system of jurisdictions and transportation providers. This makes the study area somewhat unique in comparison to the suburbs of other major metropolitan areas. For example, VDOT owns and maintains most roadways and signals in the study area, except for those in Arlington County and the various independent cities and towns in the region (Fairfax, Falls Church, Manassas, Alexandria, etc.). Various jurisdictions run their own transit services as a supplement to service provided by WMATA, which is funded through a compact from agencies in Northern Virginia, Washington, and Maryland.

[35] http://www.fairfaxcounty.gov/news2/bikeshare-locations-selected-in-tysons-and-reston/

Table 13 provides a high-level overview of the ownership, operations, and maintenance obligations of various jurisdictions and agencies in the corridor.

Table 13: Ownership, Operations, and Maintenance of Corridor Transportation Assets

Jurisdiction/Agency	Roadways and Trails	Signals	Transit
VDOT	Owns and maintains interstate highways in the project limits and primary/secondary roadways in Fairfax, Prince William, and Loudoun Counties.	Owns and maintains most signals in study area outside of Arlington County and those in independent cities and towns.	-
Arlington County	Maintains primary roadways in County (VDOT owns). Owns and maintains secondary roadways in County.	Maintains signals in County (VDOT owns).	ART
Fairfax County	Owned and maintained by VDOT.	Owned and maintained by VDOT.	Fairfax Connector
Prince William County	Owned and maintained by VDOT.	Owned and maintained by VDOT.	PRTC
Loudoun County	Owned and maintained by VDOT.	Owned and maintained by VDOT.	Loudoun County Transit
Independent Cities – Fairfax, Falls Church, Manassas, Manassas Park, Alexandria	Owned and maintained by individual cities.	Owned and maintained by individual cities.	Fairfax CUE (City of Fairfax) DASH (City of Alexandria)
Independent Towns – Herndon, Vienna, Leesburg, Haymarket	Owned and maintained by individual towns.	Owned and maintained by VDOT.	-
MWAA	Dulles Toll Road and Dulles Airport Access Road.	-	-
Private Companies	Dulles Greenway, I-495 Express Lanes, Future I-66 Express Lanes Outside the Beltway.	-	-
WMATA	-	-	Metrobus and Metrorail
Northern Virginia Transportation Commission	-	-	VRE Commuter Rail (Operated by PRTC and NVTC)
Northern Virginia Regional Parks Authority	Own and maintain W&OD, Custis, and Four Mile Run Trails	-	-
US National Park Service	Own and maintain George Washington Parkway and Mount Vernon Trail	-	-

4.5.2. Existing System Integration Efforts

The following initiatives represent major ongoing efforts in the region to share information between agencies and coordinate in response to incidents and emergencies.

4.5.2.1. PSTOC[36]

The McConnell Public Safety and Transportation Operations Center (PSTOC) is a partnership between Fairfax County and the Commonwealth of Virginia that brings multiple agencies and functions together under one roof to enhance the effectiveness of public safety response, improve traffic congestion management, and better manage the response to, and recovery from, major emergencies. The PSTOC is located just south of I-66 in western Fairfax County, adjacent to VDOT's Northern Region headquarters. Within the PSTOC, the following agencies are housed:

[36] http://www.fairfaxcounty.gov/westox/mpstoc/

- VDOT's Northern Region Transportation Operations Center (TOC) and Signal Operation Center (SOC). The TOC monitors traffic and incidents (focused on interstates) by using cameras and other information-gathering mechanisms to better manage day-to-day traffic flow and large incidents. This includes dispatching Safety Service Patrols (SSP) and responding to incidents, as well as sharing information via DMS, 511, and social media. The SOC monitors secondary roadways and traffic signals, adjusting signal timing where needed.
- The Virginia Department of State Police (VSP) Division 7 communications center, which receives and dispatches all interstate-related calls for the Northern Virginia region.
- Fairfax County Department of Public Safety Communications, which receives and dispatches all 9-1-1 emergency and nonemergency police, fire, and rescue calls in the county.
- Fairfax County Office of Emergency Management (OEM), which oversees and activates the county's Emergency Operations Center during emergency incidents. OEM is equipped to receive and transmit Homeland Security and emergency information to state, regional, and federal partners.
- Fairfax County Fire and Rescue Department staff for assisting with specific dispatching.
- Fairfax County Police Department Forensics.

4.5.2.2. RITIS[37]

The Regional Integrated Transportation Information System (RITIS) is an automated data fusion and dissemination system that provides an enhanced macro-level view of the transportation network. Participating agencies are able to view transportation and related emergency management information through innovative visualizations and use it to improve their operations and emergency preparedness. RITIS also uses regional standardized data to provide information to third parties, the media, and other traveler information resources including, web sites, paging systems, and 511. There are three main RITIS components:

- Real-time data feeds, which provide direct access to real-time incident, event, detector, probe, weather, transit, and other data sources including ITS device status. The RITIS platform allows each agency to determine which data elements it wishes to provide in the data feed, and which elements it wishes to seclude from other agencies or the public.
- Real-time situational awareness tools, which allows users with appropriate credentials to view real-time RITIS data in a browser. This allows users to interact with the various real-time data feeds in maps, lists, and other graphics.
- Archived data analysis tools, which allow users to query, analyze, and derive performance measures. Users can use these tools for identifying incident hot-spots, analyzing queue length and bottlenecks, and evaluating the effectiveness of transportation operations strategies.

RITIS is used by decision-makers, researchers, planners, operations specialists, the military, and homeland security officials. RITIS is hosted at the University of Maryland's CATT Lab in College Park, MD, just northeast of Washington, D.C., on behalf of the region's major supporters, including VDOT, MDOT, DDOT, and WMATA.

[37] http://i95coalition.org/projects/regional-integrated-transportation-information-system-ritis/

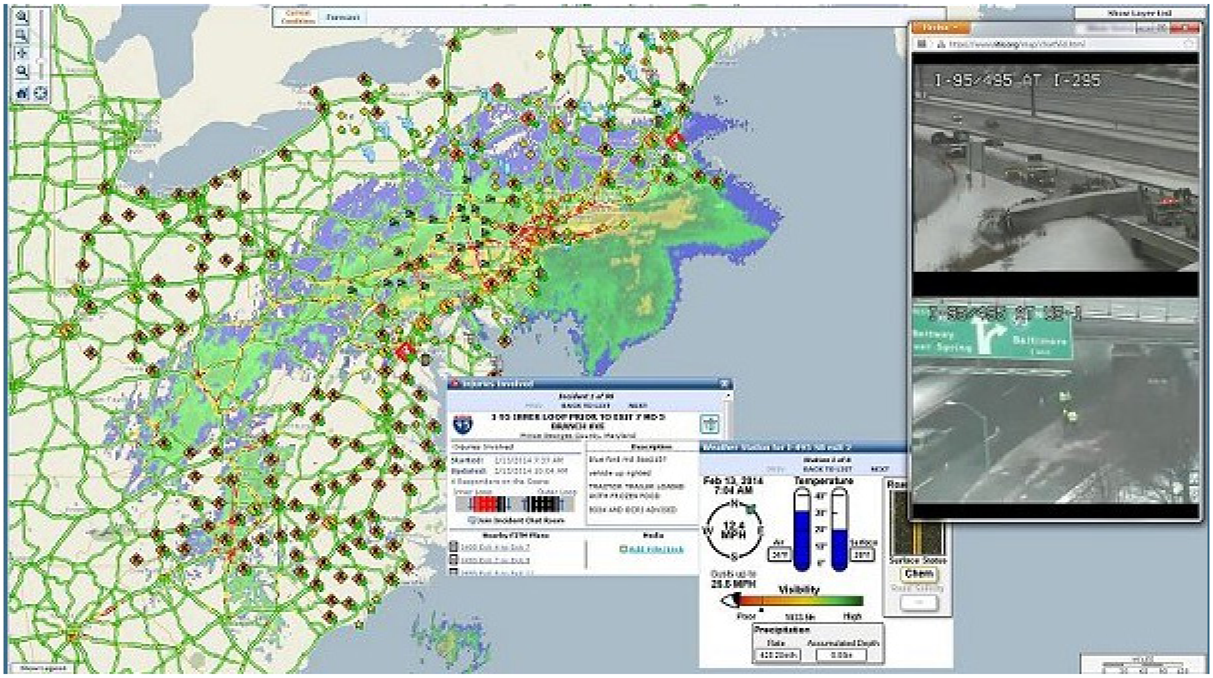

Figure 40: RITIS Real-Time Situational Awareness Tools.

4.5.2.3. MATOC[38]

The Metropolitan Area Transportation Operations Coordination (MATOC) program is a coordinated partnership between transportation agencies in D.C., Maryland, and Virginia that aims to improve safety and mobility in the region through information sharing, planning, and coordination. It is financially supported by MDOT, DDOT, and VDOT. WMATA is not a funding partner but serves on the steering committee; MWCOG also offers staff to support the steering committee. MATOC integrates traffic management systems to provide fast, accurate transportation information and situational awareness. MATOC aims to facilitate the exchange of transportation system information between operating agencies in the Washington, D.C. metropolitan area, helping agencies to more effectively and reliably coordinate with each other when major incidents or emergencies occur.

4.5.2.4. VDOT 511

VDOT's 511 system is a traveler information portal providing users with information about road conditions, traffic congestion, and highway construction throughout the Commonwealth. VDOT 511 can be access via a dedicated website, mobile app, or by calling 511 from a phone. The website also allows users to sign up to receive personalized information via text message or email for specific routes of interest. The system is fed by VDOT's Transportation Operations Centers (TOCs), who, in turn, are provided information from sources such as VDOT's safety service patrol crews, construction crews, traffic cameras, pavement sensors, the Virginia State Police, and citizens.

VDOT is developing several enhancements to its 511 system in 2017. It is being integrated with Waze to provide additional crowd-sourced travel information. For the I-66 TMP, multimodal information, such as transit availability and bicycle-related information, is being integrated into 511, which will feature a tab identifying regional partners. VDOT is also building out information on truck parking for the entire state to integrate into 511. VDOT ultimately wants to move users away from the phone system, which receives approximately 1.5 million calls per year, to its mobile app, which will provide push information and navigation.

[38] https://matoc.org/about-us/

4.5.3. Recent Trends in Regional Commuting

In 2016, MWCOG Commuter Connections staff released a *State of the Commute* survey looking at regional commuting behaviors such as usage of various transportation modes, distance traveled, and traveler sentiment with regards to their commutes. This 2016 report noted four major ways in which commuting in the Washington, D.C. region has changed since the last report in 2013:

- **Commuters are driving alone less.** The share of commuters who drive alone dropped from 65.8 percent in 2013 to 61 percent in 2016.
- **More commuters are teleworking and taking public transit.** In 2016, 32 percent of commuters reported working remotely or from home at least occasionally, which is up from 27 percent in 2013. About 20 percent of commuters reported taking a train or bus to get to work, up from about 17 percent three years previously.
- **Average commutes are longer**. In 2016, the average one-way commute distance was 17.3 miles and the average one-way commute time was 39 minutes. In 2013, the average one-way commute distance was 16 miles and the average one-way commute time was 36 minutes.
- **Metrorail riders are less satisfied with their commutes and bicyclists and walkers are more satisfied with their commutes.** Metrorail riders had the lowest satisfaction of any travel mode, with a 48 percent satisfaction rate in 2016, which was down from 67 percent three years before. People who walk or bike were the most satisfied with their commutes, with a satisfaction rate of 97 percent in 2016, up from 93 percent in 2013.[39]

These trends should be noted as an approach to Integrated Corridor Management is developed for the East-West Corridor.

4.5.3.1. Telework/Co-Work Centers

Teleworking, also known as telecommuting, means that an employee works from home or closer to home than his or her actual office, using information technology and telecommunications to replace work-related travel. MWCOG estimates that more than 600,000 workers in the metropolitan area telework, and that 25 percent of the area workforce teleworks at least 1.3 days per week on average.[40]

Commuter Connections, a regional network of transportation organizations coordinated by MWCOG, facilitates full-service teleworking and co-working facilities around the Washington, D.C., area which are open to both Federal and private-sector employers. These centers provide access to internet, phone, and other amenities.[41] Within the study area, Commuter Connections provides facilities in Fairfax, Leesburg, and Warrenton. DRPT also separately facilitates Telework!VA as a one-stop resource for businesses, individuals, and government agencies to learn more about telework or expand a telework program in the state.[42] Recently, privately owned and operating co-work centers have emerged as a growing trend in the region as well.

4.6. Suitability of Study Corridor for ICM

The Northern Virginia East-West corridor is well-suited to ICM efforts to optimize the capacity of the existing transportation network through mode, route, and temporal shifts. As detailed in the previous sections, the following characteristics of the study area make it especially suitable for ICM applications:

- **Multi-hour periods of recurring congestion throughout the system** on freeways and arterials, in both peak and “off-peak” directions and outside of peak periods, including weekends. While this congestion is recurrent, the duration and extent of this congestion is highly unpredictable in many locations and is frequently exacerbated by incidents and weather.

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[39] https://www.mwcog.org/documents/2016/09/21/state-of-the-commute-survey-report--carsharing-state-of-the-commute-travel-surveys/
[40] http://www.commuterconnections.org/commuters/teleworking/
[41] http://www.commuterconnections.org/commuters/teleworking/telework-centers/
[42] http://www.teleworkva.org/

- **The highly multi-modal nature of the corridor**, including heavy rail transit running in the median of the two major east-west freeways, a parallel commuter rail service, and various commuter bus services, as well as local bus service providing access to rail stations. These transit facilities operate at varying levels of capacity. Capacity is often available on transit facilities farther out from the Washington, D.C., core and in the off-peak direction along the Silver and Orange Metrorail lines.
- **High-occupancy vehicle (HOV) and express lane facilities on freeways in the corridor**, including existing managed express lanes on I-495 and future express lanes on I-66. The express lane facilities are required by law to maintain near-free-flow speeds and are ideal for carpools and transit.
- **Major park-and-ride lots adjacent to rail and bus transit facilities**, and future construction of new park-and-ride lots adjacent to the I-66 express lanes for rapid bus service and carpooling. Many existing park-and-ride lots operate at or near capacity based on historic counts and local knowledge, but no mechanisms currently exist for alerting commuters to parking space availability. In some locations, the capacity of transit service serving these park-and-ride lots may be constrained by the capacity (or users' perception of capacity) of the lots themselves.
- **Multi-jurisdictional ownership, operations, and maintenance** of freeways, managed lanes, arterials, transit service, park-and-ride lots, and even multi-use trails. Varying levels of coordination currently exist between the jurisdictions and agencies in this increasingly complex transportation network.
- **Growing concentration of jobs and residences around activity centers**, especially transit-oriented activity centers. These centers, such as Tysons, Reston, Herndon, and eastern Loudoun County, are forecasted to grow significantly over the next 25 years.
- **An effective but incomplete network of existing ITS infrastructure**, including deployments for connected vehicle and autonomous vehicle applications. Much of the ITS infrastructure is concentrated along interstate facilities in the region, or within Arlington County at the east end of the study corridor. The growing SR 267/Silver Line corridor is particularly lacking in ITS infrastructure and support despite being a major freeway and transit corridor.
- **A growing culture of "open data" and shared data** in which roadway operators share information such as incidents and congestion, transit operators share information such as vehicle locations and arrival estimates, private entities share information such as managed lane toll rates and bikeshare availability, and the general public shares information on amenities such as bike rack locations.

5. CORRIDOR ISSUES AND NEEDS

This section describes the key issues and needs of the NOVA East-West ICM corridor. These needs were gathered from stakeholders during workshops and follow-up discussions.

- Seven focus areas were identified in coordination with the Program Advisory Group (PAG):
  - Roadway Operations
  - Incident and emergency management
  - Transit and transportation demand management
  - Bicycles and pedestrians
  - Freight
  - Traveler information and communications
  - Innovation
- Stakeholder Champions and Co-Champions were identified for the focus areas.
- Discussions were conducted with the Champions at the first Stakeholder Coordinating Committee (SCC) meeting to scope the topic areas for each focus area.
- Two sets of resource forum workshops were conducted:
  - Workshop 1 – Identified pertinent issues and needs facilitated by the Champions (March 2016)
  - Workshop 2 – Brainstormed candidate solutions and strategies (May 2016)
- The issues, needs and strategies were compiled and organized in a structured manner by developing matrices for each of the seven Resource Forums. The matrices are included in the Appendix and represent a full documentation of stakeholder inputs and suggestions. Summaries of key issues and needs for each focus area are provided in Section 5.1.
- The SCC reviewed the matrices and revisions were made.
- For each of the seven focus areas, below, the key issues and needs are identified:
  - *Key Issues* describe specific problems within each given focus area. Background information is also included where appropriate.
  - *Needs Statements* are formal statements and commentary, predicated on the description of issues that identify the precise needs to be addressed.
- The recurring, top-level needs and candidate strategies across all seven focus areas are shown in Table 14 in Section 6.

5.1. Focus Areas

5.1.1. Roadway Operations

Key Issues:

- Transportation agencies and stakeholders need to collaborate, coordinate, and communicate across networks and modes.
- Data on arterial/non-interstate conditions in the study area are not uniformly available to continuously and accurately monitor traffic conditions.
- Operations organizations are often unaware of the data, video, etc. their partner agencies have.

- Rerouting of traffic in response to congestion or incidents needs to balance between connecting the roadway networks and modes, and preventing congestion on local roads and public transportation.
- Traffic signals along arterials in the corridor are not always optimized when traffic conditions change.

Needs:

1. **Need a comprehensive view of available capacity and demand throughout the corridor.** A comprehensive view of the available capacity and demand along each network and mode of travel in the corridor will allow transportation agencies to better manage the corridor, and balance supply and demand.
2. **Need broad-based coordination and sharing of information between public agencies, and between public agencies and private entities.** Data-sharing needs to be routine and ubiquitous among partner organizations. Need the MOU's and staff in place to support and coordinate the information-exchange. Also, when one entity gains access to new or third-party data, ideally need negotiated agreements, legal authority, and distribution mechanisms to share the data among partners.
3. **Need for accurate, reliable, real-time information on travel conditions along the pertinent arterials/non-interstates in the study area.** The information is needed both by operators (VDOT, localities, and other partners) and travelers.
4. **Need enhanced tools for decision support before rerouting traffic.** This includes the ability to predict conditions based on historic and real-time data before the traffic is rerouted, and knowledge of roadway conditions.
5. **Need to improve throughput at signalized intersections in response to changing traffic conditions.** The timing of traffic signals is a potentially important tool for managing the flow of traffic along arterials. Rather than always have signals cycle through preset timing sequences, traffic signal timings can be modified to respond to changes in travel conditions, give priority to transit vehicles and emergency vehicles, etc.

5.1.2. Incident and Emergency Management

Key Issues:

- Incidents impacting travel need to be cleared in a safe, efficient, and effective manner, across all modes, utilizing proper communications and collaboration with appropriate partner agencies.
- In emergency situations, agencies tend to focus on their own goals.
- Evacuation planning and real-time awareness among emergency operations personnel and the public is lacking.
- Radios from Virginia State Police (VSP) and localities, emergency personnel (police, fire, EMS, etc.) are not on the same platform. VSP uses Statewide Agencies Radio System (STARS) and the localities' emergency personnel use 800 MHz band (e.g., City of Alexandria).

Needs:

1. **Need a more robust information-exchange capability among emergency responders.** There is a need for an enhanced method of information-exchange among the fire, police, and transportation dispatchers at the state, city, and county levels. This exchange of information will help manage incident sites more effectively.
2. **Need interactive communications and clearly defined overarching goals among agencies in order to facilitate coordinated response.** Corridor agencies need to work together to plan for incident remediation and efficiently execute actions to clear incidents in a timely manner, in order to improve the response to incident events.

3. **Need to establish incident response plans among partner agencies (jurisdiction DOTs, transit, VDOT, law enforcement, etc.).** Corridor agencies need a means to collect and store pre-agreed response plans to enable agencies to understand collective roles and responsibilities, communicate effectively, and improve response times in responding to events.
4. **Need better and earlier messaging to inform drivers to move away from the blocked shoulders/lanes.** Drivers, depending on roadway and location, often first become aware of an incident location at close proximity to the incident, which does not allow adequate time to safely change lanes away from the blocked lane. This poses a safety risk for emergency responders and drivers.
5. **Need a consistent, standard platform for first responder agencies' communication radios.** Several incident responders are unable to communicate via radio en-route to an incident, and at the incident scene, to share pertinent information that could impact incident response and clearance times.

5.1.3. Transit and Transportation Demand Management

Key Issues:

- Transit and modal shifts need to be made more attractive and user-friendly for travelers.
- Data exchange standards and formats differ across jurisdictions and agencies.
- For transit and roadway operators, there is no central data source for obtaining real-time and historic information, including roadway conditions, incidents, transit vehicle locations, transit incidents/disruptions, and park-and-ride lot availability.
- For travelers, information on real-time locations of vehicles, incidents/disruptions, park-and-ride space availability, etc. is not always available or accurate.
- Travelers interested in ridesharing services do not have access to real-time data on seat availability.
- Travelers desire the ability to use one mechanism to pay for transit trips, bikeshare, and other non-automobile modes such as ridesharing.

Needs:

1. **Need a centralized mechanism to exchange data across modes, agencies, and jurisdictions, including real-time and static data.** For some agencies, this will first require deployment of technologies to collect data such as vehicle locations or parking space availability. This could include TDM data as well, such as vanpool monthly logs of trips.
2. **Need accurate, real-time *customer-facing* information systems for vehicle locations and predicted arrival times.** In order for travelers to adjust their trip modes and routes as they embark on their trips by bus, they need to be aware of not only bus arrival times at bus stops and terminals, but also bus departure times.
3. **Need for transit incentives.** Travelers are not fully utilizing transit because of perceptions or unfamiliarity. Appropriate incentives might sometimes be effective in moving single-occupant vehicle (SOV) commuters to use transit.
4. **Need for the establishment of common data formats and standards that allow data-exchange among jurisdictional DOTs, transit agencies, and other stakeholders**. In order to disseminate traveler information across routes and modes, data standards from partner agencies need to be congruent, allowing access to raw data for processing. Data feeds need to be organized in consistent formats to allow for aggregation and processing.
5. **Need access to space availability information for ridesharing services.** In order to spread demand across modes, travelers interested in exploring ridesharing services (vanpool, carpool, etc.) as alternative travel modes need to know, in real-time, that seats are available ahead of time.

6. **Need strategies to improve bus operations on arterial corridors to reduce delay and remain competitive with vehicular travel.** Transit signal priority (TSP) and queue jump systems can be set up to be activated when buses are running behind schedule, or if buses are carrying certain passenger loads. Off-vehicle fare collection or farecard loading can reduce delays at stops from passengers.
7. **Need an integrated payment system among transit, bikeshare, and other non-automobile modes that maintains a cash option.** WMATA and other transit agencies are currently in the process of revisiting planning for the New Electronic Payment Program (NEPP) as a replacement to the existing SmartTrip system, while Capital Bikeshare requires a credit card or key fob. It is important to keep in mind equity issues and maintain the option for transit riders to pay with cash.
8. **Need a real-time decision support system for routing buses via the Dulles Airport Access Road rather than the Dulles Toll Road.** Worsening congestion on the Dulles Toll Road creates a need for an on-the-fly algorithm to route buses via the Airport Access Road, rather than a time-of-day based schedule.

5.1.4. Bicycles and Pedestrians

Key Issues:

- Bicycle and walking trips are often part of the first mile or last mile to a non-automobile trip such as transit. Transit and modal shifts need to be made more accessible for bicyclists and pedestrians.
- Potential bicyclists are hesitant to take trips if they are unfamiliar with local roads, as many major arterials near activity centers may not be comfortable for biking.
- Bicyclists are often unaware of important information on major bike facilities, such as incidents, closures, or maintenance which could necessitate the need to divert to different facilities.
- Accommodating bicycles on Metro trains, buses and VRE is an issue due to existing policies.

Needs:

1. **Need a "level of comfort" map for unfamiliar riders.** Arlington County has a detailed "level of comfort" map for cyclists, and VDOT released a similar set of maps for Northern Virginia in a 2015 study. Ideally, these maps will be integrated into a mobile-friendly format and updated as new facilities are planned and constructed.
2. **Need real-time information for riders.** This includes crowd-sourced data such as incidents or closures.
3. **Need to revisit policy for accommodating bicycles during peak periods on Metrorail for "reverse commutes" and on VRE.** This should include an assessment of overall impacts at stations and platforms, as even if train cars in the reverse direction are not crowded, platforms may still be crowded. On VRE, ideally, policy needs to allow for bicycles and wheelchairs to be accommodated together on trains.
4. **Need to provide clear signage on VRE trains to identify railcars that allow bicycles.** Bicycles are currently allowed on VRE trains, but only on certain cars.
5. **Need improved bicycle storage facilities and information about these facilities at targeted Metrorail/VRE/park-and-ride stations.** This can include bike parking (long-term and short-term) and cages/lockers, as well as the ability to make short-term locker reservations at Metrorail and VRE stations.
6. **Need expansion of bikeshare locations in the study area.** These deployments are especially needed near outer jurisdiction Metrorail stations, including future Silver Line Phase II stations.

5.1.5. Freight

Key Issues:

- Freight operators in the study area grapple with roadway restrictions and lack of freight-specific traveler information.
- The delivery of in-vehicle traffic information is hindered due to lack of interoperability between truck systems and the infrastructure.

Needs:

1. **Need to collect and disseminate real-time freight-specific information.** Truckers need information regarding traffic conditions, incidents, roadway and infrastructure restrictions, and truck parking.
2. **Need to consolidate freight information for easier access.** Freight-specific information is spread across several online sources.
3. **Need for truck parking availability information.** Parking information is helpful to truckers during major incidents and traffic congestion. Truckers tend to park on ramps and shoulders if they cannot locate empty parking spaces. This information can be overlaid with queuing information at distribution terminals such as Dulles Airport.
4. **Need interoperability to facilitate in-vehicle communications between information dissemination and truck systems.** Interoperability between in-vehicle devices and infrastructure irrespective of the manufacturer, vendor, or service provider is essential for disseminating in-vehicle traffic information to truckers.

5.1.6. Traveler Information and Communications

Key Issues:

- Travelers need on-demand real-time and predictive, user-centric traveler information encompassing end-to-end trips.
- Travelers currently use multiple traveler information tools to plan trips which makes it tedious to find a consolidated sets of information about all modes; this difficulty discourages modal shifts.
- Travelers do not feel well-informed while en-route in each mode and route.

Needs:

1. **Need comprehensive corridor-wide traveler information across all modes.** In order for travelers to self-adjust their trips and potentially spread demand across available capacity in the corridor, travelers need to be presented with information to inform them on travel times, incidents, etc. along all modes and routes.
2. **Need historical/trend/behavior data to support predictive modeling.** Predictive modeling outputs based on real-time travel conditions will allow travelers to gain better understanding of potential future conditions on their commutes and whether particular travel modes, routes, or combinations thereof be used. These capabilities will better equip commuters to make informed decisions about their most suitable travel options.
3. **Need access to user-centric information en-route.** For travelers to potentially adjust their trips en-route, they need access to information at key locations per mode that can advise them on potential problem areas. By being provided access to en-route information, travelers will be able to select their best alternatives.
4. **Need a comprehensive end-to-end multi-modal trip planning system.** In order to influence travelers to confidently and routinely shift modes or routes, travelers need access to information on all potential modes and routes including first/last connectivity information Additionally, travelers need this information in a consolidated interactive format to more easily plan trips and modify en-route.

5. **Need real-time parking information and historical trend data on targeted park-and-ride lot utilization and availability for customers.** Travelers need to know if and when their desired park-and-ride lots reach capacity for planning in advance, as well as real-time space availability for potentially shifting modes. In conjunction with this, travelers would prefer to be presented with alternative solutions when their preferred lots are full.

5.1.7. Innovation

Key Issues:

- Innovative, multi-modal, outside-the-box solutions are needed to compensate for limited capacity and to optimize traveler choice.
- Over the next several years, significant changes in how information is delivered to travelers are anticipated.
- Travelers often do not know how to go about identifying and evaluating their transportation options.
- As part of the ICM program, mechanisms should be put into place to monitor and evaluate success.

Needs:

1. **Need for accurate, reliable, real-time information on travel conditions along the pertinent arterials in the study area.** The information is needed both by operators (VDOT, localities, and other partners) and travelers. By and large, the arterials are not instrumented. Third-party services report on arterial conditions, but have tended to be judged unreliable.
2. **Need to leverage and build on new, emerging technologies and mechanisms for delivering information to travelers in a user-centric fashion.** Even as the new technologies evolve, however, there will continue to be a need to accommodate and support information delivery using more traditional approaches. Need to evaluate relationships in information delivery between DMS, smart devices, and in-vehicle.
3. **Need to define the role of VDOT and its partner agencies in the collection, management, and delivery of traveler information.** This includes clarifying the roles of public agencies as data-collectors vs. data-providers vs. data-facilitators; and their roles in data-standardization, data-warehousing, etc. Also need to clarify the role of private entities in the traveler-information arena.
4. **Need to identify pertinent applications of connected and automated vehicles in the ICM plan.** In general, the ICM plan must be sufficiently fluid and flexible to accommodate future emerging technologies and innovations.
5. **Need to educate the general public on available transportation options, benefits/costs, etc. Need to encourage travelers to consider options that are not automobile-centric.** Initiatives are needed to promote activities with employers to encourage more telecommuting, flexible work schedules, etc. Shift the conversation from "moving vehicles" to "moving people."
6. **Need to define strategies to incentivize "smart traveler" choices.** A structured approach is needed to monetize benefits (e.g., reduced delay) in relation to investment. Ideally incentives should be in the form of investments back into the programs, rather than "external" rewards.
7. **Need to define and implement measures of effectiveness (MOEs) to assess performance.** Emphasize person-throughput rather than vehicle-throughput. Assess impacts on delay, travel-time reliability (over-the-road, transit, etc.), and energy consumption.

6. ICM OPERATIONAL CONCEPT

This section describes the goals and objectives, functional ICM concept, and architecture for the ICM plan. The overall concept views the individual transportation components (i.e., highways/roads, transit, parking lots, bicycle and pedestrian trails, etc.) as elements of an interrelated regional transportation network, whereby circumstances and conditions on one element of the network impact conditions on the other elements. The overarching ICM concept is to leverage technology, state-of-the-practice operating precepts, and institutional relationships to optimize performance of the transportation networks and modes. The concept aims to significantly improve decision support in the corridor by expanding the monitoring of conditions and data-exchange among agencies, making available personalized, real-time and predictive traffic information to travelers so they can better make informed choices, and incentivizing travel during non-peak periods. Optimizing transportation performance in the corridor involves, in part, effectively "balancing" – or redistributing – travel demand across roadways, modes, peak and non-peak periods, etc.

Development of the ICM schema included review of the general needs and strategies across the seven focus areas, specified previously, and identification of the recurring "top-level" needs and strategies, presented in Section 6.1. These top-level needs/strategies were then framed to identify overarching goals and objectives.

Key "foundational initiatives" to achieve the goals and objectives were subsequently identified; a planning horizon of five years was assumed. Also, a small number of "support initiatives" were identified to address additional needs and strategies under the individual focus areas that were not covered by the broader foundational initiatives. The ICM conceptual framework – notably the relationship between the goals and foundational initiatives – is illustrated in Figure 41. An ICM Conceptual Architecture is included in Section 6.6.

6.1. Top-Level Needs and Strategies

Recurrent themes voiced during the seven resource forums included the need for continuous, real-time access to multi-modal travel and status conditions across the study area, the ability to respond to those conditions through enhanced operational coordination/information-exchange, and the capability to communicate actionable information to customers.

The Issues, Needs, and Strategies Matrices produced during each pair of Resource Forum Workshops were reviewed and analyzed to identify the most important needs and strategies that cut across the different areas. These *Top-Level Needs and Strategies* are presented in Table 14.

Table 14: NOVA East-West ICM Travel Shed Top-Level Emerging Needs and Strategies

Needs	Candidate Strategies
Need accurate, reliable, real-time information on travel conditions along the key arterials in the study area.	■ Use 3rd-party data to identify real-time conditions on arterials.
Need accurate, reliable, real-time information on transit and commuter system status.	■ Use system data to identify real-time transit system status. ■ Implement and use technology to identify real-time parking lot availability status.

Needs	Candidate Strategies
Need expanded operational coordination and information-exchange across agencies, jurisdictions, and modes.	■ Execute agency-level MOU's governing operational coordination and information exchange. ■ Establish a data warehouse (or enhance existing systems, such as RITIS or iPeMs) for the aggregation of real-time travel conditions and status information across the study area. ■ Enhance incident response. ■ Optimize arterial signal management. ■ Define and implement decision-support processes and procedures.
Need on-demand, real-time, predictive user-centric traveler information encompassing end-to-end trips.	■ Establish a data warehouse for the aggregation of real-time travel conditions and status information across the study area. ■ Furnish regional inputs and guidance towards development of pertinent tools, including a data cloud for public-sector and 3rd-party app development. ■ Integrate conditions and trip planning functions, including first/last mile information. ■ Implement a point-to-point trip planning tool. ■ Implement functionality to predict emerging travel conditions, status, and traveler behavior; enhance travel time reliability. ■ Support flexible, on-demand clearinghouse access by users, including in-vehicle connectivity.
Need to promote and empower incentivized "smart" traveler choices.	■ Implement programs to incentivize reductions in travel using single-occupant vehicles, travel during peak periods, etc. ■ Adopt statewide policies and innovative strategies to incentivize travelers.

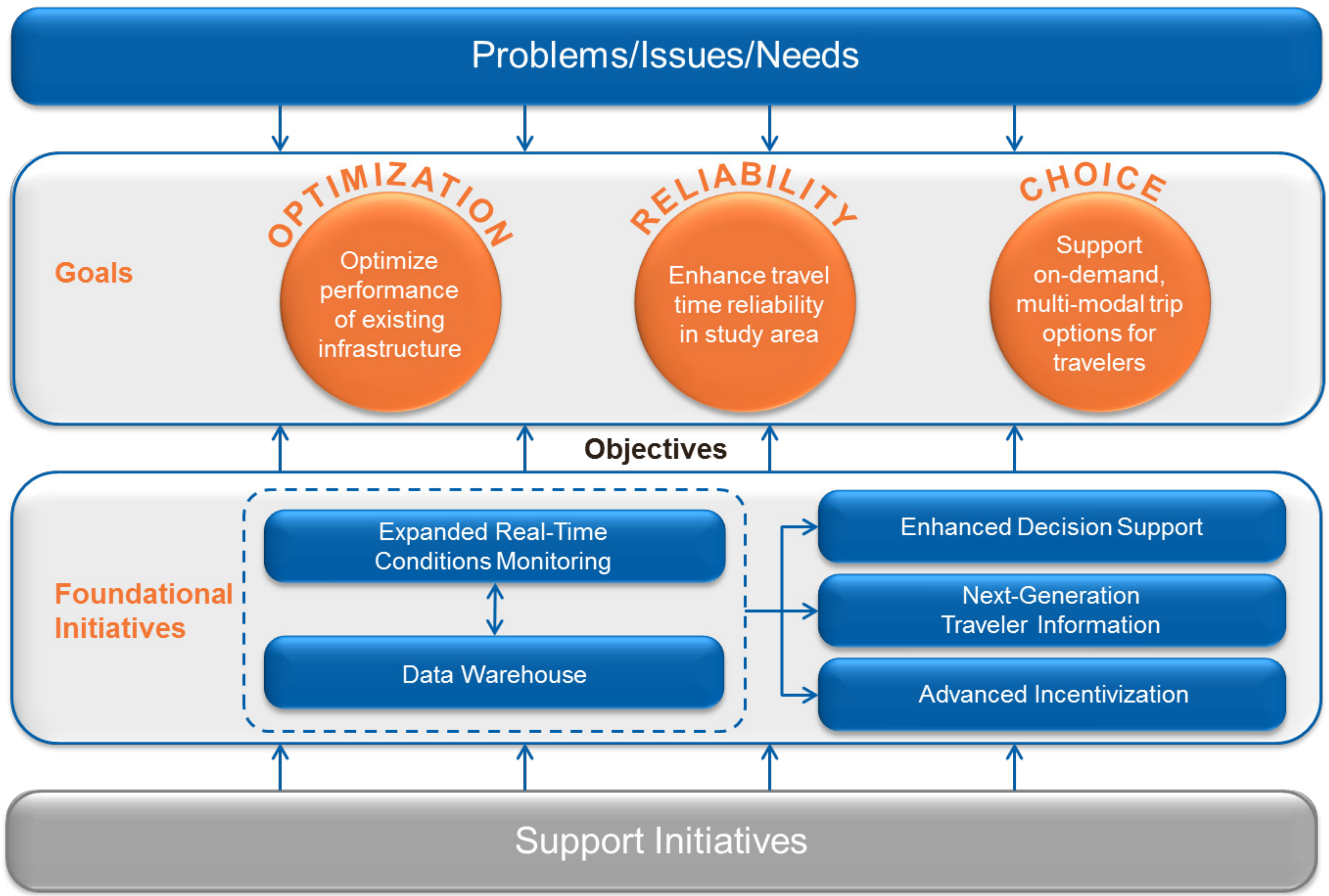

Figure 41: ICM Framework

6.2. ICM Goals and Objectives

Based on the top-level needs and strategies delineated above, three sets of goals for the ICM program were identified. Each goal is further divided into more specific objectives, as shown below.

Goal 1 – Optimization: Optimize performance of the existing infrastructure.

- Maximize utilization of all elements of the available infrastructure, including interstates, arterials, transit systems, ridesharing services, parking lots, bicycle and pedestrian paths, etc.
- Reduce overall travel demand.
- Load-balance travel demand from over- to under-utilized venues.
- Load-balance travel demand from peak to non-peak periods.
- Increase travel by non-traditional modes (walking, biking, car-sharing, increased mixed-use travel, etc.).
- Expand operational coordination and information-exchange capabilities across agencies, jurisdictions, and modes.
- Enhance decision support mechanisms/procedures for responding to adverse travel conditions, minimizing the delay from recurring and non-recurring congestion.

Goal 2 – Reliability: Enhance travel time reliability in the study area.

- Implement algorithms and procedures to improve the accuracy of travel time prediction in the study area.
- Apply travel time prediction initially to roads and transit.
- Extend travel time prediction to freight and bicycles.

Goal 3 – Choice: Support on-demand, multi-modal trip options for travelers.

- Furnish accurate, real-time, user-centric information on multi-modal traffic and travel conditions along travelers' routes of interest.
- Offer multi-modal, user-centric trip planning advice.
- Furnish comparative travel times and cost guidance by route and mode, including mixed-mode travel options.
- Predict impacts of anticipated conditions on comparative routing, comparative travel times, and "when best-to-travel" guidance.
- Expand the mechanisms and techniques for disseminating traveler information to customers.

6.3. ICM Foundational Initiatives

To achieve the goals and objectives, above, five foundational initiatives are proposed as part of the ICM concept:

- Expanded real-time conditions monitoring,
- Enhanced decision support,
- Next-generation traveler information,
- Data warehouse, and
- Advanced incentivization.

These initiatives are examined and enumerated below.

6.3.1. Expanded Real-Time Conditions Monitoring

Context:
To effectively respond to travel conditions in the study area, the operations team needs to be cognizant of real-time conditions. Currently conditions are generally well-monitored on the interstates, but much less so on arterials, transit systems, Dulles Toll Road, etc. Hence, this initiative will focus on filling in the "gaps" in coverage, relying predominantly on third-party data to address deficiencies.

Issues:

- VDOT and the local transportation agencies have infrastructure (cameras, detectors, etc.) and other information covering much of the study area's transportation network. Data are not always routinely shared across jurisdictions and agencies.
- To fill in the gaps in coverage, particularly off the interstates, it is unrealistic and impractical to undertake large-scale deployments of cameras, detectors, and communications infrastructure.
- One potential approach involves using *vehicle probe data* furnished by third-party providers, such as HERE, INRIX, and TomTom. Probe technology, which monitors the progress of designated "probe" vehicles through traffic, typically yields speed and travel time information along specified segments of roadway.
- Vehicle probe data on the interstates in the region have been found to be highly reliable. However, VDOT's assessment of the accuracy of probe data on arterials – though found to be improving – has been mixed.
- *Crowd-sourcing* services, such as Waze, have been found to offer reasonably reliable information on the occurrence and location of incidents. Crowd-sourcing relies on travelers to report incidents, typically over the Internet from their mobile phones; multiple travelers reporting similar details lends veracity to the reported incidents. Crowd-sourced information can often be effectively used to supplement incident data gleaned from independent sources, including cameras, police, service patrols, etc.
- Transit agencies and commuter bus services across the study area are at different stages in evolution re: their ability to report real-time schedule status, vehicle location, vehicle occupancy, etc. For example, WMATA is better equipped to gather these types of data than most jurisdictional transit agencies. Some local transit agencies have implemented or have plans to implement automatic vehicle location (AVL) systems, automatic passenger counters, etc. over the next several years. One challenge is that transit agencies often cannot or do not share real-time conditions and status information with parties external to the transit agencies. A second challenge is that there is relatively minimal consistency in the format of transit data across agencies.

Concept:
Ultimate Targeted Capability - Access to real-time and predictive data for all facilities and modes.

1. Define the data needed to monitor travel conditions across the study area along:
   - Interstates,
   - Toll roads,
   - Arterials,
   - Transit,
   - Commuter lots,
   - Bike paths,
   - Freight, and
   - Others.
2. Determine data needs that can be addressed using existing infrastructure. Emphasize utilization of available information at VDOT and municipal TOC's. Routinize the exchange of information among the operating jurisdictions, including municipal agency access to VDOT's Transportation Video and Data (TVD).
3. Use third-party data to fill in key gaps on roadways (e.g., speed, travel times, incidents). Test the accuracy of probe data and apply "adjustment factors" to the results, etc., as needed.

4. Build up the capability to monitor transit system conditions, including counts of available seats and parking places. Target selected routes and work with jurisdictions to accelerate the monitoring of conditions along those routes. Determine where third-party data can temporarily substitute for missing/unavailable transit data. Address data format and information-sharing issues.
5. Plan to expand VDOT technologies for monitoring parking space availability to commuter lots in the study area. VDOT is currently field-testing technologies to provide real-time information on the availability of parking spaces in commuter lots and commercial vehicle rest areas.
6. Plan to capture basic freight and bike trail data.
7. Design, develop, and implement the concepts for incremental rollout.

6.3.2. Data Warehouse

Context:
The Data Warehouse will function as a repository for a range of data, including roadway operations, signals, transit, parking, bike, freight, incident, probe, connected vehicles, etc. It will serve as the common repository for the sharing and exchange of information among the regional partners and third-party providers. Partners will be able to upload and download data to and from the warehouse, which will contain both real-time and archived data. The warehouse, which may build on complementary statewide, "cloud-computing" efforts, will support other foundational initiatives, including conditions monitoring, decision support, and traveler information. For example, a Virginia-wide cloud data portal is being developed to support connected and automated vehicle applications.

Issues:
- The warehouse will contain both real-time and archived data. It is expected to include video feeds, through the TVD program, though these will not be archived.
- Ideally, the data warehouse will be capable of accepting data in virtually any format supplied by a given party ("format agnostic"). Agencies will often have difficulty providing or converting their data to prescribed formats. This is a critical issue and will likely impact the ability of some stakeholders – notably transit agencies – to be contributing partners to the ICM program.
- The warehouse should be able to capture data entered into agencies' local systems. Operators should not have to reenter data into the warehouse.
- It is anticipated that the VDOT ATMS and the data warehouse will be separate entities. Ownership and maintenance of the data warehouse and its interfaces with the VDOT ATMS will need to be determined early-on in the development process. An institutional framework defining agency relationships to the warehouse will also be required.
- The warehouse can potentially be a new system built from the ground up or piggy-back on an existing VDOT repository, such as iPeMS. iPEMS is tailored to provide more data controls to VDOT and has potential add-on modules that could be used in an ICM context. At the same time, iPEMS is a new initiative that has some limitations, including the current inability to pull-in data from adjacent jurisdictions. iPEMS is not presently being used for real-time decision making.
- Alternatively, an existing regional system, such as the Regional Integrated Transportation Information System (RITIS) can be utilized. The advantage of RITIS is that it already supports many functions expected to be required by the Data Warehouse, contains a considerable volume of relevant study area data with advanced visualization tools, and is adept at utilizing data in a range of formats. Disadvantages are that the system is not physically located in Virginia, does not pull data from TVD, and that it serves a range of clients and interests.

Concept:
Ultimate Targeted Capability – Advanced dashboard supports real-time and archival reporting and query.

1. Determine the general approach to the Data Warehouse - will it be created from scratch, or utilize an existing system? Who will maintain the warehouse? What will be the relationship between the warehouse and the Commonwealth's cloud-based data portal?
2. Establish a Steering Committee to oversee and guide planning, development, and implementation of the warehouse.
3. Determine the general framework for the Data Warehouse, including data content, format issues, tools, access procedures, data quality assurance, etc.
4. Define roles and responsibilities of participating agencies in populating, operating, maintaining, and accessing the warehouse.
5. Design, develop, and implement the Data Warehouse.

6.3.3. Enhanced Decision Support

Context:
Decision support refers to a structured process for responding operationally to recurring and non-recurring congestion. Organized, pre-planned, structured responses to circumstances often result in more efficient outcomes than ad hoc responses. The concept here will be to begin with consistent, structured response plans that are multi-agency and multi-modal, and to expand the capability to increasingly sophisticated automated tools that evaluate conditions and generate real-time response alternatives. Response plans should be multi-agency and multi-modal, and responsive to recurring and non-recurring congestion conditions. Typically, the ICM decision support system (DSS) reviews and evaluates the various response plan options and recommends solutions/actions to the operating agencies. Normally TOC operations personnel make final decisions on which actions to implement.

There are two primary approaches to a DSS – utilize a pre-defined response plan framework, or analyze the data in real-time to define an appropriate response. A hybrid approach, combining these two approaches, is also a possibility.

Issues:

- Decision support can involve manual or automated processes. The principle focus here is on automated processes. Decision support may include automating existing written response plans.
- Decision support requires the establishment and coordination of communications channels between agencies.
- In order for the DSS to evaluate the corridor, input data will be required, including static, historical, and real-time data. Most of this data is expected to be generated by the Data Warehouse; some may come directly from the VDOT ATMS.
- The focus of this decision support activity will be on guidance to the operations teams. Naturally, information of consequence to travelers may also be generated by the DSS. Relevant DSS information will be ported to customers through the Next-Generation Traveler Information component.
- Several institutional issues concerning the DSS will need to be addressed, notably the relationship between the DSS and VDOT ATMS. For example:
  - Will the DSS be a component of the ATMS, or an independent stand-alone module?
  - How will ICM-participating agencies access the DSS?
  - What entity will have software and hosting responsibilities for the ATMS?
  - What should be the role of the Metropolitan Area Transportation Operations Coordination (MATOC) Program, if any, in operating the DSS?

Concept:
Ultimate Targeted Capability – Automated tool uses real-time conditions, models, and engineering rules to generate incident response plans.

1. Establish a Steering Committee to oversee and guide planning, development, and implementation of the DSS module.
2. Gather existing agencies' response plans and identify commonalities, touch points, and thresholds for development of multi-agency, multi-modal response plans.
3. Identify the general approach to DSS, including a pre-defined response plan vs. real-time analytics. Resolve basic relationship, ownership, hosting issues, etc. Typically, a DSS should have a plan-generation portion and an implementation portion. The plan-generation portion could be manual in the early stages of development (e.g., pre-defined incident response plans). The DSS could potentially simulate which of the pre-defined plans would be the most effective.
4. Determine the DSS interfaces with the VDOT ATMS. This could be a two-way interface where the ATMS is a highway-centric data source, but also can receive input from the DSS. The ATMS can generate its own incident-response plans but will need to be able to ingest data from other modes in order to recommend a mode shift.
5. Consider an incremental deployment of the system based on a continuous improvement approach.
6. Define roles and responsibilities of participating agencies for response plan development.
7. Establish communications channels between the operations groups within the participating agencies.
8. Prepare a response plan framework.
9. Identify agency responsibilities for funding, development, implementation, hosting, and maintenance of the DSS.
10. Design, develop, and implement the DSS module.

6.3.4. Next-Generation Traveler Information

Context:
This initiative will move beyond providing travelers with "fixed" information on travel conditions on specified roads and segments. It will furnish on-demand, real-time and predictive, multi-modal trip guidance personalized to the needs of travelers, including assistance on travel mode options and identification of the optimal times to travel. For example, conditions at points of origin/destination and along route, route alternatives, modal options, comparative travel times, comparative costs, etc.

The program will rely principally on private, third-party providers to deliver traveler information to customers; to be granted access to regional data generated by VDOT and its partners, providers will need to meet minimum program requirements and standards. VDOT may fill in traveler information "gaps" not addressed by the marketplace. It will support safe, flexible dissemination of information across a range of media, including dynamic message signs, GPS devices, smart phones, personal wearable devices (e.g., Fitbit, Apple Watch, etc.), broadcast media, windshield displays and other in-vehicle devices, etc.

Issues:
- VDOT is reevaluating its role in the traveler information arena. Currently VDOT is a purveyor of traveler information through its *511 Virginia* program. In the future, VDOT may rely on the competitive, private-enterprise marketplace to deliver traveler information to customers. VDOT will provide the data that private developers can convert to information for end-users. Often the marketplace is able to introduce innovation and respond to technology changes more rapidly than can government entities.

- Under a market-driven approach to traveler information, VDOT and its partner agencies will still have a vital role to play. They will need to set standards and furnish guidance to the traveler information community on what must be achieved if the ICM objectives are to be realized.
- VDOT might establish partnership arrangements with marketplace suppliers of traveler information services. There would be no limit on the number of potential providers. Providers whose apps or other products meet the project's program standards would be granted "VDOT certification."
- Even under this arrangement, VDOT and its agency partners will continue to gather and maintain important data relevant to traveler information. This data will be made available to marketplace partners through a Traveler Information Data Portal. The data portal will likely be part of the Data Warehouse.

Concept:
Ultimate Targeted Capability – New, predictive capabilities leveraged in forecasting personalized travel conditions and options.

1. Define the respective roles of VDOT, other regional public agencies, and third-party providers in the next-generation ICM traveler information program.
2. Define the scope of the ICM traveler information program, including expectation re: data content.
3. Prepare standards and guidance materials for the traveler information program.
4. Establish partnership arrangements with interested marketplace providers. Certify providers where appropriate.
5. Plan, design, and implement the Traveler Information Data Portal.
6. Oversee traveler information performance under the partnership agreements.

6.3.5. Advanced Incentivization

Context:
The other foundational initiatives are focused on managing congestion. Advanced incentivization emphasizes proactively managing demand, i.e., strategies to reduce the number of vehicles and people on the transportation grid during peak periods. It will include education and outreach activities to encourage commuters to adjust their patterns of travel, but will extend to out-of-the-box strategies that "reward" travelers for exemplary behaviors that ease congestion, for example, reducing single-occupant vehicle and peak-period travel.

Issues:

- Education and outreach activities could potentially have a positive impact on curbing demand. The notion here is that some commuters and travelers, once they are aware of the costs (in time, money and stress) of travel by time-of-day, route, mode, etc., will have sufficient flexibility in their lives and schedules to adjust their travel activities and travel demands.
- Other foundational initiatives under the ICM program – notably, Next-Generation Traveler Information – also have the potential to curb demand as:
  - Travelers are routinely presented with comparative travel times and costs (including traveling at a different time of day),
  - Travelers find that specified travel times are increasingly reliable and trustworthy, and
  - Travelers learn, with access to expanded real-time information, that ad-hoc modal shifts (to transit, ridesharing, bikes, etc.) are increasingly practical and doable.
- Additionally, demand curbing incentives could potentially take different forms in a variety of areas. For example:

- Employers – commuter benefits programs, dynamic office space or teleworking for planned events.
- Transit and parking – parking incentives, reserved parking space, bus-to-rail discounts, bike parking incentives.
- Traveler choice – on-demand ridesharing, bike sharing membership incentives, subsidized bike riding.
- Technology – traveler information apps that offer rewards and gamification for specified behaviors.
- Community – pooled rewards/incentives for travelers who change their travel habits.

Concept:
Ultimate Targeted Capability – Structured, coordinated public/private partnership programs to incentivize traveler behaviors that ease congestion.

1. Establish a Steering Committee to oversee and guide activities.
2. Work with existing regional TDM/TMP constructs. For example, review the initiatives under the I-66 TMP and to determine if all or selected initiatives can be continued to support advanced incentivization.
3. Define and implement an education and outreach campaign.
4. Assess the practicality of incentivizing changes in travel behaviors and proceed accordingly.
5. Identify funding opportunities for the incentives.

6.4. ICM Foundational Initiatives Deployment Approach

The five foundational initiatives will be deployed incrementally based on the Capability Maturity Model (CMM) approach. Each foundational initiative is visualized as advancing along a continuum of increasing "maturity." Five levels of maturity – from "least-advanced" to "most-advanced" – are associated with each initiative. For instance, the initiative, Real-Time Conditions Monitoring, progresses from "Access to conditions data on ad-hoc basis" (least-advanced) to "Access to real-time and predictive data on all facilities and modes" (most-advanced). The maturity model is intended to institutionalize a process of "continuous, incremental improvement," enabling stakeholder partners to get up to speed at a realistic pace and for the region to work together, systematically and structurally, toward a common vision.

Table 15 shows a strawman CMM matrix for the Foundational Initiatives. The Implementation Plan will include recommended strategies to achieve the targeted CMM levels.

Table 15: Capabilities Maturity Model (CMM) View of the Five Foundational Initiatives

Least Advanced → Most Advanced

CMM Level	Expanded Real-Time Conditions Monitoring	Data Warehouse	Enhanced Decision Support	Next-Generation Traveler Information	Advanced Incentivization
1	Access to conditions data on ad-hoc basis.	Partners exchange data on ad-hoc basis.	Partners coordinate incident/congestion response on ad-hoc basis.	Freeway-centered traveler information, emphasizing general road conditions, travel times to specified destinations, etc.	No incentivization in real-time.
2	Access to static and historical conditions data.	Partners query common database of static/historical data.	Partners coordinate incident/congestion response by selecting from pre-agreed plans.	Traveler information coverage extended to arterials, transit, other modal networks, etc.	Traditional TDM programs (e.g., nominal discounts, subsidies, tax incentives, etc.).
3	Access to real-time data on selected facilities.	Some partners provide real-time feeds to database in either “specified” or “format-agnostic” data layouts.	Automated tool selects incident/congestion response from pre-agreed plans based on real-time conditions.	Personalized, user-centric traveler information, incl. route planning across modes and real-time conditions updates.	Public education campaigns on the merits of curbing demand, coupled with high-profile activities, e.g., regionally-declared congestion days.
4	Access to real-time data on all facilities and modes.	All partners provide real-time feeds to database in “format-agnostic” data layouts.	Computerized models evaluate the traffic impacts of response plans in real-time.	Information delivery formats and mechanisms expanded, including in-vehicle delivery (e.g., heads-up displays) and integration of traveler information with vehicle systems and apps.	Public agencies respond to congested conditions by offering incentives in near real-time.
5	Access to real-time and predictive data on all facilities and modes.	Advanced dashboard supports real-time and archival reporting and query.	Automated tool uses real-time conditions, models, and engineering rules to generate incident response plans.	New, predictive capabilities leveraged in forecasting personalized travel conditions and options.	Structured, coordinated public/private partnership programs to incentivize traveler behaviors that ease congestion.

6.5. ICM Support Initiatives

In addition to the foundational initiatives, above, multiple “support initiatives” were identified under each of the seven focus areas during the Resource Forum workshops. The selected initiatives are expected to improve competencies in the corresponding focus areas and to contribute to the success of the overall ICM program.

The focus areas and their corresponding support initiatives are identified below:

Roadway Operations:

- Deploy adaptive signal control technology on key corridors in the study area.
- Deploy next-generation traffic signals systems, such as the Multi-Modal Intelligent Traffic Signal Systems (MMITSS) bundle to improve passenger vehicle, pedestrian, transit, freight, and emergency vehicle mobility through signalized corridors.
- Perform evaluation studies to assess the accuracy of different types of crowd-sourced data.

Incident and Emergency Management:

- Procure 800 MHz portable radios for VDOT personnel to enable communications with localities.
- Upgrade or replace the STARS system to allow communications between Virginia State Police (VSP) and localities.
- Provide training and refresher courses on incident management concepts to first responders, including cross-jurisdictional table-top exercises.
- Upgrade signal preemption systems, including on-board equipment and roadside equipment from infrared technology to a GPS-based preemption system.

Transit/Transportation Demand Management

- Institute off-vehicle card loading and fare-collection for local transit agencies.
- Deploy transit signal priority along targeted corridors or queue jumps at targeted intersections.
- Expand and promote accommodations for storing bikes at transit stations/park-and-ride lots and bringing bikes on board transit vehicles.
- Create a new routine “meet-up” initiative for brainstorming ideas on traveler information.

Bicycles and Pedestrians:

- Provide education and outreach on social media platforms and other forums to let riders know where they can find information about trail closures.
- Develop platform to allow riders to report maintenance and safety issues on trails. Furnish education and outreach (on-trail signage, etc.) on how to call/report issues.
- Integrate bike-sharing programs as part of a future transit payment technology.
- Work with WMATA to modify policies restricting bicycles on railcars; rather than base restrictions on crowd loads, apply them by time-of-day.

Freight:

- Develop truck routing plans similar to TIM plans.
- Conduct incident response training for incidents involving trucks.
- Create a specialized response team for smaller truck incidents.

Connected Vehicle/Automated Vehicle (CV/AV) Technology:

- Dedicate lanes or shoulders (or potentially managed lane systems) for CV/AV use, especially transit vehicles outfitted with CV/AV technologies, such as cooperative-adaptive cruise control.

- Deploy VDOT's multi-modal intelligent traffic signal system in targeted locations to facilitate CV/AV communications with signals.
- Develop partnerships with the private sector for applications using CV/AV corridors in the ICM study area.

6.6. Conceptual Architecture

Figure 42, on the following page, depicts the conceptual architecture diagram and identifies high-level components that will comprise the ICM system. Existing entities and interfaces are shown as clear boxes, while new entities and interfaces to be developed appear as orange boxes.

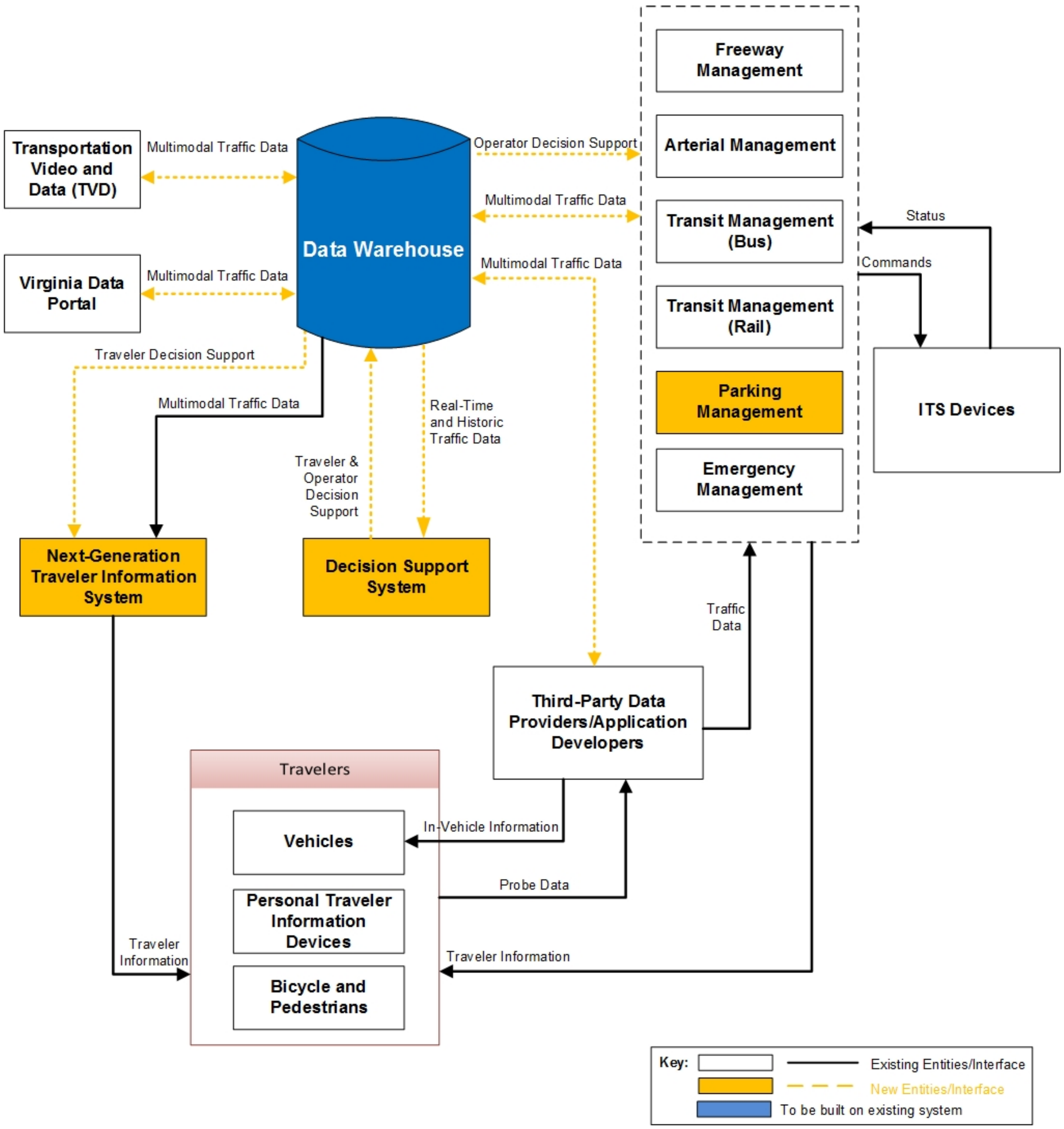

Figure 42: Conceptual Architecture Diagram

6.7. Alignment with Regional ITS Architecture

The ICM concept proposed for this project is consistent with the Northern Virginia ITS Architecture, 2011 Update. The foundational initiatives and some of the related information flows such as those covering connected vehicle-type applications may require nominal updates to the regional architecture. The recommended updates to the architecture will be submitted through the VDOT Systems Engineering and Architecture Compliance (Rule 940) Checklist process.

6.8. ICM Institutional Framework

In a dynamic and multi-jurisdictional study area, institutional support is an important element for the ICM program. There are several challenges associated with institutional integration in the study area:

- Ability and willingness to enter into common agreements for ICM collaboration.
- Compatibility between agencies in relation to systems and data formats.
- Ability and willingness to share data due to resource issues and contractual limitations with vendors.
- Clarity on agency roles and responsibilities in an ICM context.
- Difficulty in prioritizing between local issues and providing inputs for the ICM program.
- Turnover of elected officials and administration.
- Poor communication between agencies leading to different operational priorities that may not meet the ICM program goals.
- Potential impact of ICM and mode shifts on public and private agencies where ridership and volumes are tied to revenues.
- Perceived cyber-security issues related to sharing data through the cloud.
- Funding – Grant monies typically pay for the initial plans and implementation, but generally not for maintenance.

There are several candidate strategies to help overcome these institutional challenges:

- Deploy systems incrementally based on a capability maturity model (CMM) approach.
- Agree on common goals for the ICM projects that do not conflict with partner agency business plans.
- Minimize or eliminate restrictions on the sharing of data. For example, use of “open data” – in contracts with vendors, state upfront that all data used/collected belongs to the agency.
- Prioritize funding based on data-driven analysis of congestion hotspots.
- When implementing ICM strategies, be cognizant that some strategies could inadvertently discourage travel on modes where volumes/ridership are tied to revenues.
- Develop standard operating procedures that clearly articulate agency roles and responsibilities in an ICM context.

Overall management of the ICM program is expected to be provided by the Program Advisory Group (PAG) beyond the current planning stage of the project. The PAG will serve as the key oversight and decision-making body to ensure that the ICM projects meet the goals and objectives of the program. The group’s responsibilities will include the following:

- Plan and administer the overall program.
- Identify priorities.

- Identify funding opportunities for ICM projects.
- Ensure that transportation stakeholders across modes and networks are aware of project activity.
- Leverage synergies between transportation projects in the region for effective program management.
- Plan for and advance interoperability among technology applications.
- Perform outreach to stakeholders to gather inputs and update them on program status.
- Routinely measure performance to maintain high-quality ICM activity and continuously improve the program.

In general, the goal for institutionalizing the ICM framework will be to leverage established regional ITS, operations, and management frameworks instead of creating an entirely new structure. This makes sense from a resource perspective. It also helps integrate the ICM-related projects into existing planning and funding processes. It will ensure that the ICM projects align with the goals and initiatives of the various regional ITS, operations, and management stakeholders.

6.9. Performance Measures

6.9.1. Performance Measure Definitions

A preliminary list of performance measures for the ICM effort has been identified in coordination with the ICM Program Advisory Group and Stakeholder Coordinating Committee. These measures have been identified with the understanding that as the systems engineering process continues into requirements definition, project selection, and design, the preliminary performance measures will need to be re-evaluated. Figure 43 maps the preliminary performance measures against the ICM goals and foundational initiatives.

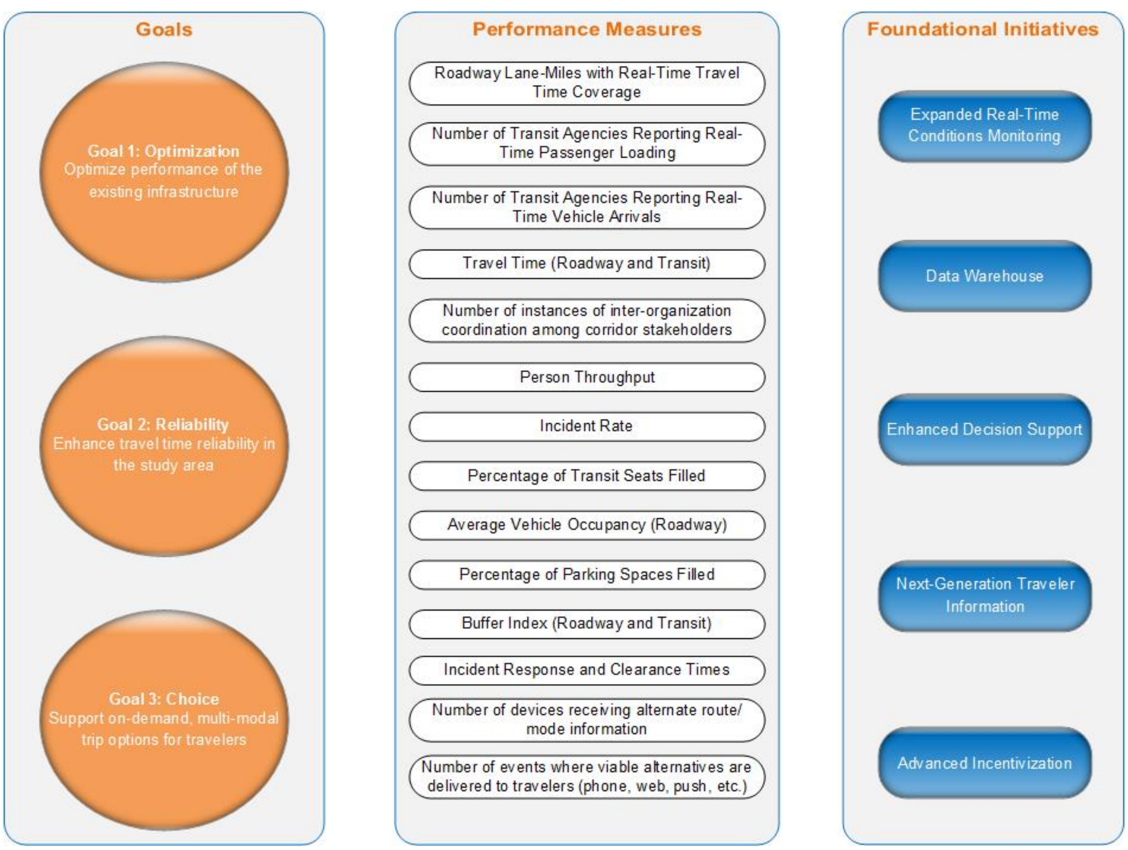

Figure 43: ICM Preliminary Performance Measures

The ICM Stakeholder Coordinating Committee recommended that performance measures be developed to provide *leading indicators* via an asset management framework to help foresee deficiencies and needs, in addition to the traditional lagging indicators that show performance already taking place. The stakeholder group emphasized the importance of safety measures, as incidents play a major role in non-recurring congestion on area roadways. It will be important to develop summary performance measures which can be aggregated to a *system* level to communicate overall benefit, such as system-wide park-and-ride utilization, transit ridership, and key roadway link measures of congestion. Table 16 presents a preliminary list of high-level performance measures and the major facility segments which should feed these measures.

Table 16: Proposed Data Collection Areas for System-Wide Performance Measurement

Performance Measure	Facility/Service	Segments
■ Average Travel Time (AM/PM Peak Hours) ■ Average Travel Time (Midday Off-Peak Hour) ■ Average Peak-Hour Increase in Travel Time from Off-Peak	I-66	■ US 15 to SR 28 ■ SR 28 to SR 123 ■ SR 123 to I-495 ■ I-495 to Glebe Road/Fairfax Drive
	SR 267	■ US 15 to SR 28 ■ SR 28 to Reston Parkway ■ Reston Parkway to SR 7 ■ SR 7 to I-66
	US 50	■ US 15 to SR 28 ■ SR 28 to I-66 ■ SR 123 to I-495
	SR 7	■ US 15 to SR 28 ■ SR 28 to Fairfax County Parkway ■ Fairfax County Parkway to SR 123 ■ SR 123 to I-66
	SR 123	■ I-66 to SR 7 ■ I-495 to George Washington Parkway
	SR 286 (Fairfax County Parkway)	■ I-66 to SR 267 ■ SR 267 to SR 7
	SR 28	■ I-66 to SR 267 ■ SR 267 to SR 7
	US 15	■ I-66 to US 50 ■ US 50 to SR 7
	Metrorail Silver Line	■ Ashburn to Reston Town Center ■ Reston Town Center to Tysons ■ Tysons to Rosslyn
	Metrorail Orange Line	■ Vienna to Rosslyn
	VRE Manassas Line	■ Manassas to Alexandria or Crystal City ■ Haymarket to Alexandria (future)
	Loudoun County Transit (Commuter Bus Service)	TBD
	PRTC (Commuter Bus Service)	TBD
	I-66 Outside the Beltway New Commuter Bus Service (Provider TBD)	TBD
■ Average Daily Transit Boarding's	Combined Rail (Metrorail Orange and Silver Line, VRE Manassas Line)	
	Major Commuter Bus Routes (Loudoun County Transit Commuter Bus Service, PRTC Commuter Bus Service, I-66 Rapid Bus Transit Service)	

Performance Measure	Facility/Service	Segments
■ Average Weekday Peak Parking Facility Utilization (%)	Major Select Park-and-Ride Lots	■ Metrorail Silver Line garages: Ashburn, Loudoun Gateway, Innovation Center, Herndon, Wiehle-Reston East ■ Metrorail Orange Line garages/lots: Vienna, Dunn Loring, West Falls Church, East Falls Church ■ I-66 Outside the Beltway garages/lots: Haymarket, SR 234 Bypass, Balls Ford Road, Stringfellow Road ■ Targeted lots in Loudoun County: Dulles North, Dulles South, Leesburg, Harmony

6.9.2. Performance Measure Targets

Performance measure targets will be developed to assess whether the goals and objectives of the ICM effort are being achieved. These targets will be both quantitative, such as a specific buffer index or percentage of park-and-ride spaces filled, and qualitative, such as seamless integration between data-collection systems from various agencies and the ICM Data Warehouse. Targets will be developed based on a synthesis of industry best practice, such as the soon-to-be-released benefit analysis of the San Diego and Dallas ICM deployments, as well as an assessment of existing (pre-ICM) performance of the East-West corridor. Trends will be used first to understand how various measures, such as park-and-ride lot utilization or travel time buffer index, have progressed over the past several years (or even to observe monthly/seasonal variation) before targets or benchmarks are developed. Targets will be developed with context in mind; for example, targets will consider the impact of other programs being implemented at the same time as this ICM project, such as the I-66 expansion and the Metrorail Silver Line. VDOT already has some targets developed, such as targeted incident recovery time. Targets will be developed in conjunction with the performance measures being finalized, as well as when relevant data become available.

6.9.3. Performance Measure Data-Collection and Reporting

The underlying data for the ICM performance measures will be provided by the individual participating agencies via their existing or planned data-collection systems. The ICM Data Warehouse will be an aggregator of the underlying data and a mechanism for calculating, storing, tracking, and reporting the performance measures. Given technological advancements, many performance measures can be analyzed and reported on a monthly basis, while others may be more appropriate for quarterly or yearly reporting given the cost burden. The most critical performance measures need to be reported regularly to help managers identify issues and prioritize resources.

7. OPERATIONAL SCENARIOS

The following section details operational scenarios that have been developed following significant stakeholder input regarding how the East-West ICM corridor should operate. These scenarios can help illustrate the impacts and benefits of ICM implementation. ICM deployment will help both operators and travelers become more aware of the available transportation supply (capacity across various modes) and demand (typical demand versus surges or changes due to closings, etc.). Operators will be able to develop better response actions, and travelers will be able to make better response decisions.

The operational scenarios emphasize operations along the **SR 267/Metrorail Silver Line corridor**:

- The I-66 / Metrorail Orange Line corridor will be undergoing major reconstruction and expansion over the next several years and has its own separate but coordinated set of ITS deployments and activities.
- SR 267 is an "interstate-quality" facility without an interstate designation and corresponding baseline level of ITS infrastructure one would expect from a major urban freeway. VDOT does not operate or maintain SR 267; rather, the segment east of Dulles Airport is operated and maintained by MWAA and the segment west of Dulles Airport is owned, operated, and maintained by a private company (TRIP II). Over the past several years, SR 267 has become prone to peak-period congestion between Tysons and Dulles Airport as major residential and employment growth continues to occur along the corridor.
- Within the median of SR 267, the Metrorail Silver Line will extend west of Dulles Airport to Ashburn in Loudoun County, providing a direct parallel transit option for commuters. New park-and-ride lots at nearly all stations in Loudoun County and western Fairfax County will be readily accessible via direct interchanges to SR 267, and these lots will also be served by local transit service. These park-and-ride lots will be owned and operated by the local jurisdictions or private companies, while transit service will be provided by WMATA (rail) and local jurisdictions (bus).
- SR 7, which runs parallel to SR 267 between Tysons and Leesburg, and SR 28, which runs north-south and connects SR 267 with I-66 to the south and SR 7 to the north, are also both "interstate-quality" facilities without federal interstate designations or corresponding baseline levels of ITS infrastructure that one would expect from major urban freeways. SR 28 will soon be fully grade-separated between I-66 and SR 7 (the only remaining signalized section is adjacent to I-66), and SR 7 will soon be fully grade-separated between SR 28 and US 15 in Leesburg. SR 28 and SR 7 will thus provide a parallel freeway to the Loudoun County portion of SR 267.

This section provides example user profiles of travelers along the corridor to demonstrate benefits and changes to travel behavior that ICM can help institute. Next, normal operations of the ICM system are described, including data collection and storage, the central ICM system and decision support, and outputs and information dissemination. Finally, a series of non-recurring congestion scenarios are presenting depicting how the implementation of ICM would enhance existing traffic operations by providing further information and tools to operators and travelers.

7.1. Example User Profiles

The following example user profiles have been developed to demonstrate benefits and changes to travel behavior that ICM can help institute:

- A traveler from Purcellville begins her typical daily commute to Tysons in the morning by checking for traffic information. While heading eastbound on Route 7 near Leesburg, she checks a message sign similar to the one shown in Figure 45. The sign informs her that the roadways near Dulles Airport are experiencing significant non-recurring congestion due to multiple crashes on the Dulles Toll Road eastbound and SR 28 southbound. Her commute time to Tysons is estimated to increase by at least one hour. Instead of continuing to drive into the congestion, she stops in Leesburg for coffee, gets on her laptop, and works remotely until traffic dissipates in order to complete the trip.

- A traveler from Ashburn has a midday meeting in Arlington that he is planning on driving to via his personal car. He checks the new Northern Virginia 511 trip planning tool, which informs him that due to an incident on I-66 eastbound near Falls Church, his travel time via automobile is estimated to take an hour and cost nearly $15 when combining tolls along the Dulles Greenway, Dulles Toll Road, and I-66. The app suggests taking Metro and parking at the Loudoun Gateway park-and-ride garage, which has nearly 100 spaces still available at 9 AM. The app tells him that his total cost between parking and riding Metro will be approximately $10 one-way, and that his travel time via transit would actually be less than driving if he left right now. Instead of driving all the way into Arlington, the traveler parks at Loudoun Gateway and takes Metro into Arlington. He uses a Capital Bikeshare bike to get the final two-thirds of a mile to his destination.
- A traveler from Manassas who commutes to Tysons generally avoids taking the new I-66 HOT lanes due to the toll and has generally avoided taking transit, as his previous experience of taking a bus using the old non-barrier-separated HOV lanes did not result in any travel time savings. One day, he is traveling along I-66 eastbound in the morning when his vehicle receives a DSRC message from a roadside equipment unit that has begun sharing traveler information alerts. The message is converted into an audio alert that informs him of an incident downstream on I-66 eastbound and suggests stopping at one of the new park-and-ride lots and trying transit or “slugging”. Already en route, the traveler decides to switch over to the I-66 HOT lanes and pay the toll this time, but he returns home later that day and researches the new park-and-ride lots, transit, and “slugging,” of which he was previous unaware. He discovers that one of the new park-and-ride lots associated with the I-66 Outside the Beltway expansion recently opened near his house; via an online trip planning tool, he is able to view typical parking availability and slug lines that operate from the lot. He discovers that parking is plentily available at his nearby lot at the time he typically leaves the house, and there is a strong slugging community between the lot and downtown Tysons. He begins parking and slugging via the HOT lanes daily, providing himself with a reliable and often-free trip to work.

7.2. Normal Operations (Recurring Congestion)

For the purposes of this report, normal operations will refer to times along a facility in which there are no planned events, major incidents, software or system failures, disasters, special events, or unusual conditions. This includes recurring congestion on over-capacity facilities and provides a baseline for daily multi-modal operations in the East-West corridor.

7.2.1. Data Collection and Storage

All ICM operations are dependent upon robust and reliable real-time data streams. The following data streams will be integrated and utilized as part of ICM implementation in the East-West corridor:

- **Roadway travel times –** VDOT will collect real-time freeway and arterial travel time data from approved third-party probe data providers such as INRIX. This information will be supplemented by existing field sensor data, such as loop detectors, side-fire radar, and Bluetooth deployments. Third-party travel time data will be used to cover roadway facilities and jurisdictions not owned or operated by VDOT as well, including both segments of SR 267, roadways in Arlington County and independent cities, and National Park Service roads. Connected vehicle applications along the Virginia Connected Corridors – I-66, US 50, and US 29 – will allow for vehicles to transmit speed and travel time data to DSRC devices and further supplement speed and travel time data. A subsystem within the ICM Data Warehouse will query this third-party travel time data every 30 seconds and maintain a database of historic and real-time travel times for individual segments along the corridor.
- **Roadway incidents and construction –** VDOT will enter into a data sharing agreement with Waze or another third-party data source to obtain crowdsourced incident information throughout the study area, including incidents along roadway facilities not owned or operated by VDOT. A

subsystem within the ICM Data Warehouse will query this third-party incident data every 30 seconds and maintain a database of historic and real-time incident information tied to individual segments along the corridor. Local incident response agencies, including the Virginia State Police and local police, will continue to supplement this by making their CAD feeds available to VDOT via the PSTOC.

- **Managed lanes pricing and travel times –** private companies own/will own and operate managed lanes along I-495, I-95, I-395, and I-66 (west of I-495); additionally, VDOT will own and operate managed lanes along I-66 east of I-495. The ICM Data Warehouse will query for managed lane pricing and travel times every minute for managed lane systems in which it can legally obtain the feeds. The Warehouse will maintain a database of historic and real-time managed lanes pricing and travel times.
- **Transit vehicle locations, travel times, and incidents –** Local transit providers, including WMATA, Fairfax Connector, PRTC, ART, and Loudoun County Transit, will individually collect data on vehicle locations via existing CAD/AVL systems and passenger loading (where available) via existing APC systems. These systems will report vehicle positions and passenger loads to a local server via radio or cellular at time intervals ranging from every 30 seconds to less than every 5 seconds. These providers will also maintain an electronic log of transit incidents via in-house CAD/AVL systems. The ICM Data Warehouse will maintain a database of historic and real-time transit travel times and passenger loading (where available) along the corridor. The ICM Data Warehouse will contain a downstream process to translate locational information into transit travel times; additionally, bus speeds may be used as a secondary data source for validating freeway and arterial network speeds.
- **Parking availability –** Park-and-ride garage/lot owners, including WMATA, VDOT, local transit agencies, and private companies, will individually collect data on parking space availability and, if possible, parking duration via in-house parking management systems. Relevant park-and-ride locations include all Metrorail Orange and Silver garages, VRE Manassas Line station lots, all park-and-ride lots associated with the Transform I-66 Outside the Beltway project, and park-and-ride lots in Fairfax, Loudoun, and Prince William County which historically have at least 100 spaces and an occupancy greater than 80 percent on an average weekday. The ICM Data Warehouse will query each garage's parking management system every 5 minutes and maintain a database of historic and real-time parking occupancies within the corridor.
- **Information for bicyclists –** Capital Bikeshare will continue to maintain publicly-available real-time and historic feed of bicycles available at each station in service, including future stations in the study corridor. Arlington County will continue to maintain a real-time and historic feed of bicycle counts at select locations in the Washington, D.C., metropolitan area, including those outside of Arlington County. Arlington County will continue to add to this database are more fixed and rotating bicycle counters are deployed on trails in the study area, including those outside of Arlington County. The ICM Data Warehouse will maintain a database of historic Capital Bikeshare station occupancy and bicycle counts at corridor locations; the ICM Data Warehouse will utilize Capital Bikeshare's and Arlington County's real-time feeds for any requests for real-time information.

Weather information – Weather information will remain available via existing VDOT RWIS deployments and from the National Weather Service. The ICM Data Warehouse will query available weather data sources every 5 minutes and maintain a database of historic weather information at select locations within the corridor.

Table 17 provides a listing of relevant ICM data streams, including listing of existing data feeds and potential new data feeds that could be featured in conjunction with ICM deployment in the corridor.

Table 17: ICM Data Streams

Data Stream	Existing Data Sources	Post-ICM Data Sources	Relationship to Data Warehouse	Query / Update Interval	Notes
Roadway Travel Times/Speeds	▪ Sensor data (loop detectors, side-fire radar) ▪ Targeted Bluetooth/WiFi deployments ▪ Private probe data vendors (freeways)	▪ Private probe data vendors (arterials) ▪ Connected vehicle communications (freeway and arterial)	Maintain database of historic travel times in 5-minute intervals.	30 seconds	Includes roadways not owned or maintained by VDOT
Roadway Incidents and Construction	▪ Police CAD feeds	▪ Third-party incident data (e.g. Waze)	Maintain database of historic incidents tied to individual segments along the corridor	30 seconds	Includes roadways not owned or maintained by VDOT
Managed lanes pricing and travel times	▪ None publicly available due to contractual agreements	▪ I-66 Outside the Beltway ▪ I-66 Inside the Beltway	Maintain database of historic pricing and travel times	60 seconds	Contractual and legal hurdles may inhibit obtaining pricing and travel time information for I-495 and I-95
Transit vehicle locations, travel times, and incidents	▪ CAD/AVL feeds for individual transit agencies	▪ Translation of CAD/AVL data and APC data into travel times and passenger loads via Data Warehouse	Maintain database of historic transit travel times and passenger loading (where available) along the corridor	5 to 30 seconds	Data streams to become available as various transit agencies upgrade ITS systems
Parking availability	▪ None other than historic count data conducted by garage/lot operators	▪ Parking garage occupancy data in real-time as collection systems are deployed	Maintain database of historic parking occupancies at garages along the corridor	5 minutes	
Information for bicyclists	▪ Capital Bikeshare ▪ Arlington County bicycle counters	▪ Expanded bicycle count data as collection systems are deployed	Maintain linkage to Capital Bikeshare historic station occupancy data and Arlington County bike count data	N/A	
Weather information	▪ VDOT ESS ▪ National Weather Service	▪ Connected vehicle applications	Maintain database of historic weather information at select locations along the corridor	5 minutes	

7.2.2. Central ICM System and Decision Support

The ICM Data Warehouse will process the collected data into information that can be used by both operators and travelers to meet the needs identified for the corridor. For example, the ICM Data Warehouse will calculate travel times for arterial and freeway routes given the raw probe data coming into the system. Additionally, the data warehouse will contain a downstream process to translate locational information into transit travel times; additionally, bus speeds may be used as a secondary data source for validating freeway and arterial network speeds. The information processed within the Data Warehouse will feed the Enhanced Decision-Support System.

The Enhanced Decision-Support System will monitor real-time data to assess current transportation network conditions and determine whether or not conditions and events in the network trigger an ICM-level response plan. At the same time, a dedicated ICM Coordinator on-site at the PSTOC/MATOC will be reviewing real-time information feeds and response plans suggested by the DSS. The Enhanced Decision-Support System will also contain processes to utilize the historic data in the Data Warehouse to track the impacts of incidents on specific roadway operations, feeding into a predictive model for speed and travel time impacts along facilities as downstream incidents occur.

During normal operations, however, the ICM focus will be on automated information sharing and distribution, especially at network “junctions” and interfaces. Data collected and stored in the ICM Data Warehouse will be accessible via one-way and two-way information flows with stakeholders. Stakeholders will be able to query for real-time and historic data for all of the data streams described in the previous section. Dashboards will be developed for client-side interaction with the ICM Data Warehouse to automate and facilitate these queries. Within these dashboards, operators will also be able to view high-level current system operations status, such as maps of congestion and incidents overlaid with layers of real-time transit vehicle locations and park-and-ride lot availability. There will be views showing alerts from various operators, such as lane blockages on roadways or transit incidents.

7.2.3. Outputs and Information Dissemination

Inter-agency coordination related to any local events, if needed, will occur per current procedures, as necessitated by the situation. However, monitoring and response to even routine, localized events will be enhanced by the streamlined access to third-party travel time and O-D data for freeways and arterials, parking information systems, and transit system feeds. The ICM Data Warehouse will make a wealth of information available to many parties which currently lack access to this information or require significant investment in coordination and data manipulation to obtain this information.

Under all scenarios, including normal operations, the following activities and information dissemination will be taking place with ICM being implemented:

- Next-generation traveler information sources will be utilized, including:
  - Proposed multi-modal travel information displays along freeways (as shown in Figure 45 to Figure 49). These information displays will provide comparative travel times and costs for major origin-destination pairs along the corridor, such as from Reston to Rosslyn. These displays could compare travel times for transit, freeways, and arterials and provide information about associated costs (such as tolls, transit fares, or parking) as well as information such as transit departure times. These displays will provide travelers with real-time choices and information but also will provide a mechanism to inform travelers of options that they may not be currently aware of to consider for future commutes.
  - Additional multi-modal information displays in urbanized areas such as Tysons and Reston Town Center and at transit stations. These displays will again provide travelers with real-time choices and information but also will provide a mechanism to inform travelers of options that they may not be currently aware of to consider for future commutes.
  - User-tailored trip planning tools developed by third parties in response to the expanded wealth of publicly-available data.
  - Connected vehicle applications will be developed in conjunction with these expanded data sources to provide tailored, in-vehicle messaging to drivers, beginning along Connected corridors with DSRC devices installed (I-66, US 50, and US 29).

- With the ICM Data Warehouse, operating agencies will be able to share incident and special event information via a common web interface and will be able to query real-time and historic data for operations or planning purposes.

Table 18 lists relevant agencies involved in ICM operations and their roles and responsibilities during normal operations.

Table 18: ICM Roles and Responsibilities, Normal Operations

Agency/Entity	Roles and Responsibilities
VDOT	■ Monitor conditions and operate traffic signals outside of Arlington County and independent cities/town ■ Operate VDOT-owned parking garages and transmit data on garage occupancy and space availability to VDOT/RITIS
RITIS	■ TBD
MATOC	■ TBD
WMATA	■ Operate Metrorail and Metrobus service ■ Transmit information on vehicle locations, travel times, and alerts to VDOT/RITIS
MWAA	■ Transmit information on incidents or closures to VDOT/RITIS ■ Post multi-modal travel times on select DMS along SR 267 (Dulles Toll Road) ■ Dispatch SSP for roadside assistance on SR 267 (Dulles Toll Road) ■ Operate toll plazas and gates on SR 267 (Dulles Toll Road)
Trip II	■ Transmit information on incidents or closures to VDOT/RITIS ■ Post multi-modal travel times on select DMS along SR 267 (Dulles Greenway) ■ Dispatch SSP for roadside assistance on SR 267 (Dulles Greenway) ■ Operate toll plazas and gates on SR 267 (Dulles Greenway)
Transurban / Managed Lanes Operators	■ Transmit speed, volume, and travel times to VDOT/RITIS ■ Monitor conditions on HOT lane facilities via CCTV and other ITS deployments ■ Set toll prices for HOT lane facilities ■ Provide information on toll prices and whether or not HOT lanes are in use via DMS and online ■ Dispatch SSP for roadside assistance on HOT lane facilities
Arlington County	■ Operate ART bus service ■ Transmit information on vehicle locations, travel times, and alerts to VDOT/RITIS ■ Monitor conditions and operate traffic signals within Arlington County ■ Maintain a real-time and historic feed of bicycle counts at select locations in the Washington, D.C., metropolitan area, including those outside of Arlington County
Fairfax County	■ Operate Fairfax Connector bus service ■ Transmit information on vehicle locations, travel times, and alerts to VDOT/RITIS ■ Operate County-owned parking garages for Metrorail Silver Line stations (and other transit hubs) and transmit data on garage occupancy and space availability to VDOT
Loudoun County	■ Operate Loudoun County Transit bus service ■ Transmit information on vehicle locations, travel times, and alerts to VDOT/RITIS ■ Operate County-owned parking garages for Metrorail Silver Line stations (and other transit hubs) and transmit data on garage occupancy and space availability to VDOT
Prince William County	■ TBD (Prince William County does not operate PRTC transit service directly or operate its own signals)
PRTC	■ Operate PRTC bus service ■ Transmit information on vehicle locations, travel times, and alerts to VDOT/RITIS ■ Operate VRE in conjunction with NVTC

Agency/Entity	Roles and Responsibilities
Northern Virginia Transportation Commission (NVTC)	■ Operate VRE in conjunction with PRTC ■ Transmit information on vehicle locations, travel times, and alerts to VDOT/RITIS
Independent Cities and Towns	■ Monitor conditions and operate traffic signals within Cities and Towns
Northern Virginia Regional Parks Authority	■ Transmit information on trail maintenance and closures to VDOT
US National Park Service	■ Transmit information on trail maintenance and closures to VDOT
Capital Bikeshare	■ Maintain a real-time and historic database of Capital Bikeshare station status and bike availability.

7.3. Non-Recurring Congestion

For the purposes of this report, non-recurring congestion will refer to periods when traffic abnormalities occur that cause a reduction in facility capacity or an abnormal increase in demand. These can include unplanned events such as traffic crashes or disabled vehicles (including transit vehicles), planned events such as highway or railway maintenance and reconstruction, special non-emergency events such as sporting events or concerts, and weather events.

The Enhanced Decision-Support System will monitor real-time data to assess current transportation network conditions; recommend pre-approved strategies and response plans when events occur that affect corridor operations; analyze and predict response plan benefits; and evaluate response plan results. Strategies could include:

- Updates to multi-modal information displays encouraging switching to transit.
- Coordinated incident response tactics from incident management response teams.
- Real-time adjustments to signal timing plans along parallel arterials; note that VDOT NRO has recommended Adaptive Signal Control systems along multiple arterial corridors in the study area.
- User-centric electronic alerts pushed to travelers suggesting alternate routes, modes, or times to embark on a specific commute.
- Additional rail vehicles along the Orange or Silver Lines (utilizing available railcar storage at the new Dulles Airport rail yard, which will be the largest in the WMATA system when the Silver Line Phase II opens).
- Transit bus bridges with agreements in place to operate within the managed lane systems and Dulles Airport Access Road, where appropriate.
- Dynamically waiving or reducing parking fees at targeted park-and-ride lots in order to encourage modal shifts to transit at specific locations.
- Partnerships with transportation network companies for subsidized trips within a certain geofence of transit stations to provide access to transit, especially if and when garages are full. Partnerships with Capital Bikeshare could also be implemented to provide reduced fares for trips between neighborhoods and nearby transit stations if a garage is full.

7.3.1. Non-Recurring Congestion Scenarios

Table 19 provides a breakdown of ICM applications during various non-recurring congestion scenarios (minor incident, major incident, etc.). It lists various processes, existing strategies, and enhancements that could be gleaned from ICM deployments. Example applications are provided for these various processes providing a concept for how ICM would function in the East-West Corridor.

Table 19: ICM Processes and Applications during Various Application Scenarios

ICM Foundational Initiative	Processes	Existing Conditions Strategies	Enhancement from ICM Strategies	EXAMPLE APPLICATIONS		
				Minor Traffic Incident: Incident on SR 267, No Lanes Blocked	Major Traffic Incident: Incident on SR 267, Multiple Lanes Blocked	Weather Event: Snow
Expanded Real-Time Conditions Monitoring	▪ Confirmation/validation of incident. ▪ Monitoring of speeds and travel times on upstream facilities, parallel arterials, and transit. ▪ Monitoring of incident response and clearance. ▪ Monitoring of park-and-ride lot space availability. ▪ Monitoring of passenger loading on transit facilities. ▪ Information-exchange between agencies.	▪ Confirmation from first responders or CCTV. ▪ CCTV allows for monitoring of upstream conditions if incident is on an interstate or facility with CCTV coverage (e.g. Arlington County primary roads). ▪ INRIX data provides real-time travel times for Interstate freeway segments. ▪ Individual transit agencies have CAD/AVL feeds monitoring vehicle locations. ▪ Agencies collect counts of parking space availability on an anecdotal basis; Metrorail tracks counts of trips in and out of garages. ▪ Some transit agencies have APC systems with real-time feeds of passenger counts by vehicle and route.	▪ Confirmation of incident via third-party incident data source (e.g., Waze). ▪ Third-party probe data source supplies speed and travel time information for upstream and parallel routes, including arterials and non-VDOT facilities. ▪ Transit speeds used as a supplemental data source to validate upstream congestion. ▪ Real-time parking availability at park-and-ride garages/lots are monitored via deployed data collection systems. ▪ Real-time passenger loading on transit vehicles is monitored as transit agencies upgrade their ITS systems. ▪ Various agency personnel are able to monitor conditions in real-time via dashboards created in the Data Warehouse and real-time querying functions.	▪ An incident reported by a cellular caller on SR 267 eastbound during the AM peak hour east of I-495 validated by third-party incident data source (e.g., Waze). ▪ Real-time speeds are monitored along SR 267 eastbound, SR 7, and I-495 using third-party probe data (e.g. INRIX). ▪ Transit AVL feeds are used to obtain real-time speeds for Loudoun County Transit commuter bus service and Metrorail Silver Line service. ▪ Real-time parking availability at Loudoun County Transit lots and Metrorail Silver Line garages in Loudoun and Fairfax Counties is monitored. ▪ Real-time passenger loading on Loudoun County Transit commuter buses and Metrorail Silver Line trains are monitored.	▪ An incident reported by a cellular caller on SR 267 eastbound during the AM peak hour east of I-495 validated by third-party incident data source (e.g., Waze). ▪ Real-time speeds are monitored along SR 267 eastbound, SR 7, and I-495 using third-party probe data (e.g., INRIX). ▪ Transit AVL feeds are used to obtain real-time speeds for Loudoun County Transit commuter bus service and Metrorail Silver Line service. ▪ Real-time parking availability at Loudoun County Transit lots and Metrorail Silver Line garages in Loudoun and Fairfax Counties is monitored. ▪ Real-time passenger loading on Loudoun County Transit commuter buses and Metrorail Silver Line trains are monitored.	▪ Real-time speeds are monitored along SR 267 eastbound, SR 7, and I-495 using third-party probe data (e.g., INRIX). ▪ Transit AVL feeds are used to obtain real-time speeds for Loudoun County Transit commuter bus service and Metrorail Silver Line service. ▪ Real-time parking availability at Loudoun County Transit lots and Metrorail Silver Line garages in Loudoun and Fairfax Counties is monitored. ▪ Real-time passenger loadings on Loudoun County Transit commuter buses and Metrorail Silver Line trains are monitored.
Data Warehouse	▪ Logging of incident. ▪ Maintaining database of incidents. ▪ Maintaining database of link segments speeds and travel times. ▪ Maintaining database of transit speeds and travel times. ▪ Maintaining database of park-and-ride lot space availability. ▪ Maintaining database of transit ridership by route and time period. ▪ Mapping relationships between incidents and facility speeds/travel times and park-and-ride lot usage/transit ridership. ▪ Information-exchange between agencies.	▪ Incident tracked in agency CAD systems. ▪ Historic sensor data at spot locations provides spot speed information. ▪ Historic vehicle probe data (INRIX) available in a searchable database and can be queried at an aggregated level (RITIS). ▪ Agencies maintain internal spreadsheets or databases on parking space availability at park-and-ride lots. ▪ Transit agencies maintain internal databases of per-vehicle passenger loading by route as ITS systems are upgraded.	▪ Incident record created in ICM Data Warehouse. ▪ Roadway speeds are stored in Data Warehouse in 5-minute intervals. ▪ Parking garage/lot occupancy data is stored in Data Warehouse in 5-minute intervals. ▪ Transit ridership data is stored in Data Warehouse at the trip and stop-pair level. ▪ Downstream process maps transit speed data into records of point-to-point travel times. ▪ Downstream process is used to assess relationships between incident occurrence and nearby traffic impacts, park-and-ride lot usage, and transit ridership. ▪ Various agency personnel are able to monitor conditions in real-time via dashboards created in the Data Warehouse and real-time querying functions.	▪ Incident is logged in Data Warehouse and tagged to SR 267. ▪ Speeds on segments of SR 267, Route 7, and I-495 are stored at 5-minute intervals in the Data Warehouse (as are speeds for other facilities). ▪ End-of-day machine learning process analyzes relationship between all segment speeds and incidents and maps SR 267 incident to only a short-duration reduction of speeds along SR 267. No impacts to Route 7, I-495, or transit are tagged to this incident.	▪ Incident is logged in Data Warehouse and tagged to SR 267. ▪ Speeds on segments of SR 267, Route 7, and I-495 are stored at 5-minute intervals in the Data Warehouse (as are speeds for other facilities). ▪ End-of-day machine learning process analyzes relationship between all segment speeds and incidents. Impacts to Route 7 eastbound, I-495 northbound and southbound, and Loudoun County Transit service travel times are tagged to this incident. Ridership impacts to Loudoun County Transit and Metrorail Silver Line are tagged to this incident.	▪ Data Warehouse aggregates weather data, including historic, current, and forecasted weather conditions, in 5-minute intervals from available data sources. ▪ End-of-day machine learning process analyzes relationship between all segment speeds, transit travel times, park-and-ride utilization, transit utilization, and nearby weather conditions.

ICM Foundational Initiative	Processes	Existing Conditions Strategies	Enhancement from ICM Strategies	EXAMPLE APPLICATIONS		
				Minor Traffic Incident: Incident on SR 267, No Lanes Blocked	Major Traffic Incident: Incident on SR 267, Multiple Lanes Blocked	Weather Event: Snow
Enhanced Decision Support	▪ Predicting incident duration. ▪ Recommending response strategies and traveler information updates. ▪ Information-exchange between agencies.	▪ Trained incident management teams assess incident severity and predict duration. ▪ TOC operators recommend response strategies including updates to traveler information.	▪ Predictive component of DSS assesses which facilities, including transit facilities, may be affected, as well as estimated duration of incident. ▪ DSS recommends strategies for action. ▪ Pre-planned/pre-agreed-upon traffic management scenarios. ▪ DSS recommendations confirmed by in-house ICM Coordinator and shared automatically with relevant agencies.	▪ DSS predicts that incident will be cleared to shoulder in less than 30 minutes. ▪ DSS recommends sharing of incident via relevant traveler information channels to drivers as well as with Loudoun County Transit. ▪ DSS does not recommend changes to transit service, promoting alternate routes, or updates to signal timing. ▪ Low-level alert of incident shared with MWAA, Trip II, Metrorail, Loudoun County, and Fairfax County informing agencies of incident, estimated duration, and severity.	▪ DSS predicts that incident will block two lanes and that incident will not be cleared for at least two hours. ▪ DSS predicts significantly increased travel times for SR 267 between Reston Town Center and I-495. ▪ DSS recommends sharing of incident via relevant traveler information channels to drivers as well as with Loudoun County Transit and Metrorail. DSS recommends promotion of utilizing transit (Loudoun County Transit or Silver Line). ▪ DSS recommends increasing Metrorail Silver Line headways to 3 minutes via spare railcar capacity available at Dulles Airport fleet yard. The supplemental trains will operate only between Ashburn and McLean. ▪ DSS recommends Loudoun County Transit buses reroute through Dulles Airport Access Road to bypass incident on SR 267. ▪ DSS tracks park-and-ride lot usage and transit ridership to verify that capacity is still available within each of these systems. ▪ DSS recommends implementing new signal timing plan for SR 7 eastbound for handling diverted auto traffic. ▪ High-level alert of incident shared with MWAA, Trip II, Metrorail, Loudoun County, and Fairfax County informing agencies of incident, estimated duration, and severity. Recommendations for actions are also shared.	▪ DSS predicts that travel speeds on SR 267 will decrease even during off-peak hours to 45 mph given historic segment speeds in response to the forecasted conditions. ▪ DSS recommends promoting the utilization of rail transit (Metrorail Silver Line) to get travelers off of roadways where possible. ▪ DSS recommends increasing Metrorail Silver Line headways to 3 minutes via spare railcar capacity available at Dulles Airport fleet yard. The supplemental trains will operate only between Ashburn and McLean. ▪ DSS tracks park-and-ride lot usage and transit ridership to verify that capacity is still available within each of these systems. ▪ DSS recommends alerting travelers to forecasted conditions via DMS and connected vehicle messages. ▪ DSS recommends promoting "dynamic telecommuting" to area residents or commuters to the area.

ICM Foundational Initiative	Processes	Existing Conditions Strategies	Enhancement from ICM Strategies	EXAMPLE APPLICATIONS		
				Minor Traffic Incident: Incident on SR 267, No Lanes Blocked	Major Traffic Incident: Incident on SR 267, Multiple Lanes Blocked	Weather Event: Snow
Next-Generation Traveler Information	▪ Messaging about incident to travelers.	▪ Brief information about incident shared via upstream DMS (if available). ▪ Incident information shown on 511 map. ▪ Third-party mobile applications show incident on map.	▪ Connected vehicle applications along major facilities allow targeted in-vehicle messaging via DSRC. ▪ Third-party mobile applications are aware of DSS recommendations. ▪ Upstream DMS show predicted multi-modal travel time in conjunction with messaging about incident.	▪ Low-level alert of incident shared via in-vehicle application to connected travelers along SR 267 eastbound and Route 7 eastbound. ▪ Comparative travel times and costs of taking Metro to Tysons and Rosslyn versus SR 267/I-66 are displayed on upstream message boards on SR 267 eastbound upstream of various Metrorail stations. Message boards provide transit departure times, but do not directly advocate seeking alternate routes.	▪ High-level alert of incident shared via in-vehicle application to connected travelers along SR 267 eastbound and Route 7 eastbound, as well as travelers on I-495. ▪ Comparative travel times and costs of taking Metro to Tysons and Rosslyn versus SR 267/I-66 are displayed on upstream message boards on SR 267 eastbound upstream of various Metrorail stations. Message boards provide transit departure times and directly advocate seeking alternate routes. Messages are developed informing transit riders of supplemental Metrorail service and Loudoun County Transit bypass of SR 267 using Dulles Airport Access Road. ▪ Parking availability information for Loudoun County Transit lots or Metrorail garages is shared at locations adjacent to SR 267 upstream of incident.	▪ In-vehicle messages and mobile alerts sent to travelers informing them of snow event and recommending non-vehicular travel, such as walking or rail transit, where possible. ▪ Comparative travel times and costs of taking Metro to Tysons and Rosslyn versus SR 267/I-66 are displayed on upstream message boards on SR 267 eastbound upstream of various Metrorail stations. Message boards provide transit departure times and directly advocate utilizing rail transit and staying off roadways. Messages are developed informing transit riders of supplement Metrorail service. ▪ Parking availability information for Metrorail garages is shared at locations adjacent to Silver Line stations.
Advanced Incentivization	▪ Alerting travelers to costs of various transportation options. ▪ Promoting transit usage (where available).	▪ Limited third-party trip planning tools provide users with information-related to costs.	▪ Expanded traveler information providing estimated comparative costs for trips.	▪ Comparative travel times and costs of taking Metro to Tysons and Rosslyn versus SR 267/I-66 are displayed on upstream message boards on SR 267 eastbound upstream of various Metrorail stations.	▪ Comparative travel times and costs of taking Metro to Tysons and Rosslyn versus SR 267/I-66 are displayed on upstream message boards on SR 267 eastbound upstream of various Metrorail stations. ▪ Messages are developed informing transit riders of supplemental Metrorail service and Loudoun County Transit bypass of SR 267 using Dulles Airport Access Road.	▪ Comparative travel times and costs of taking Metro to Tysons and Rosslyn versus SR 267/I-66 are displayed on upstream message boards on SR 267 eastbound upstream of various Metrorail stations. ▪ Messages are developed informing transit riders of supplemental Metrorail service. ▪ Messages are developed promoting “dynamic telecommuting” and shared via mobile applications and social media.

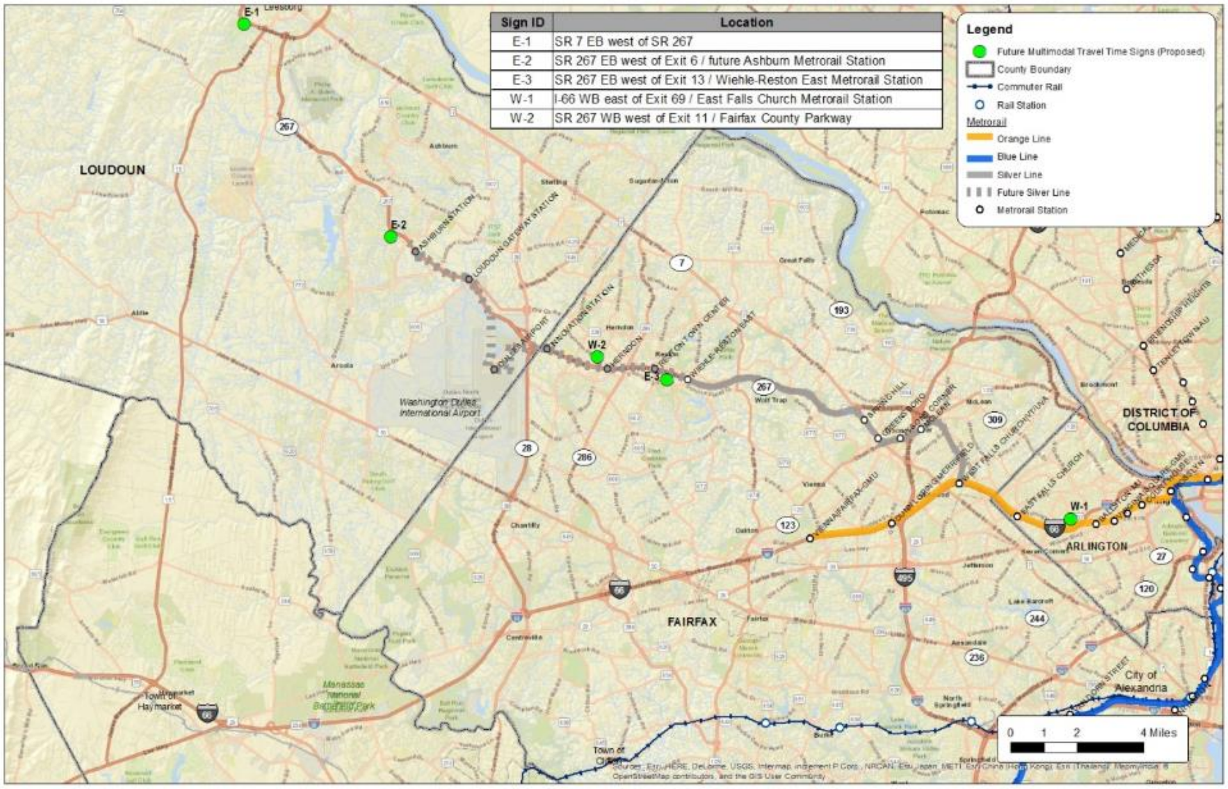

Figure 44: Locations for Proposed Multi-Modal Traveler Information Displays

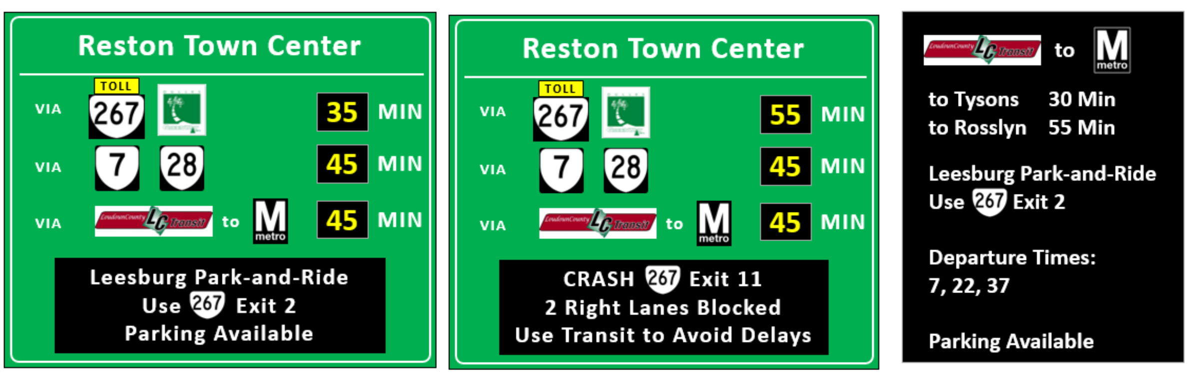

Figure 45: Proposed Signage at Location E-1: SR 7 eastbound west of SR 267

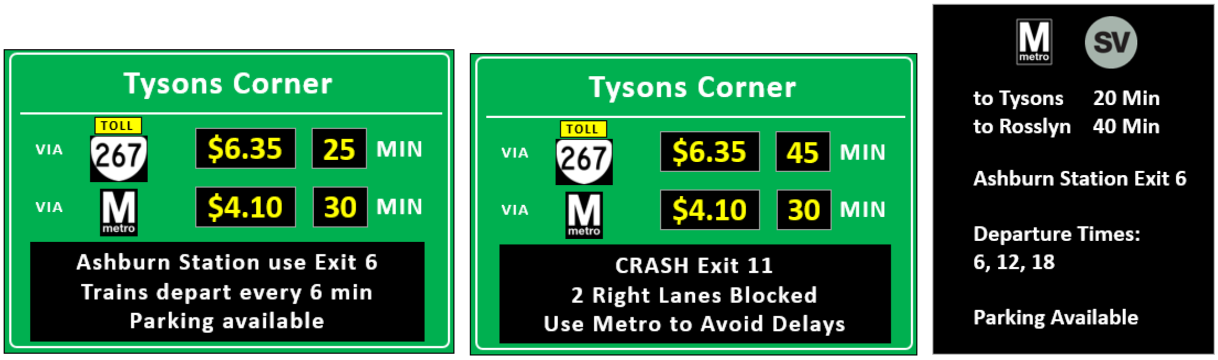

Figure 46: Proposed Signage at Location E-2: SR 267 Eastbound, West of Exit 6 / Ashburn Metrorail Station

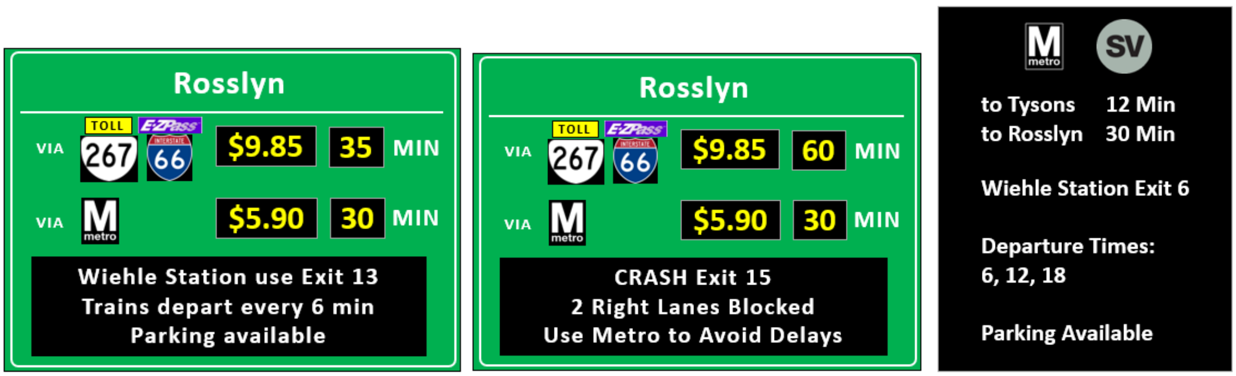

Figure 47: Proposed Signage at Location E-3: SR 267 Eastbound, West of Exit 13 / Wiehle-Reston East Metrorail Station

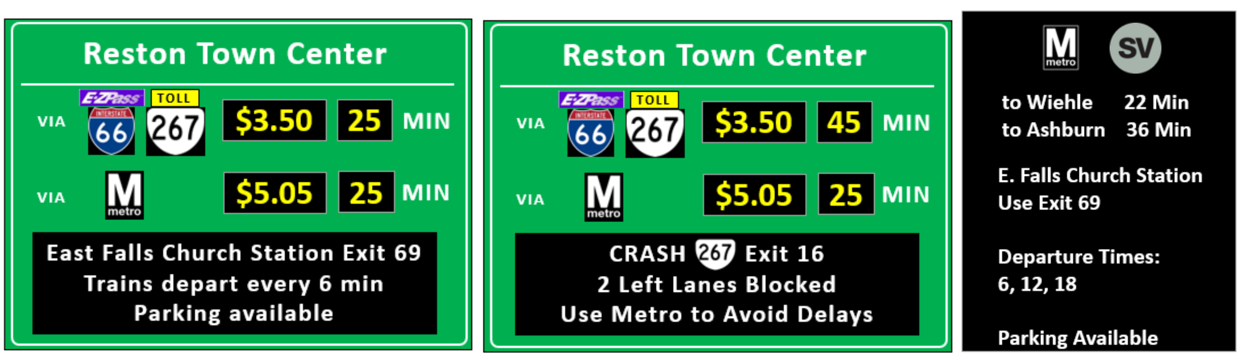

Figure 48: Proposed Signage at Location W-1: I-66 Westbound, East of Exit 69 / East Falls Church Metrorail Station

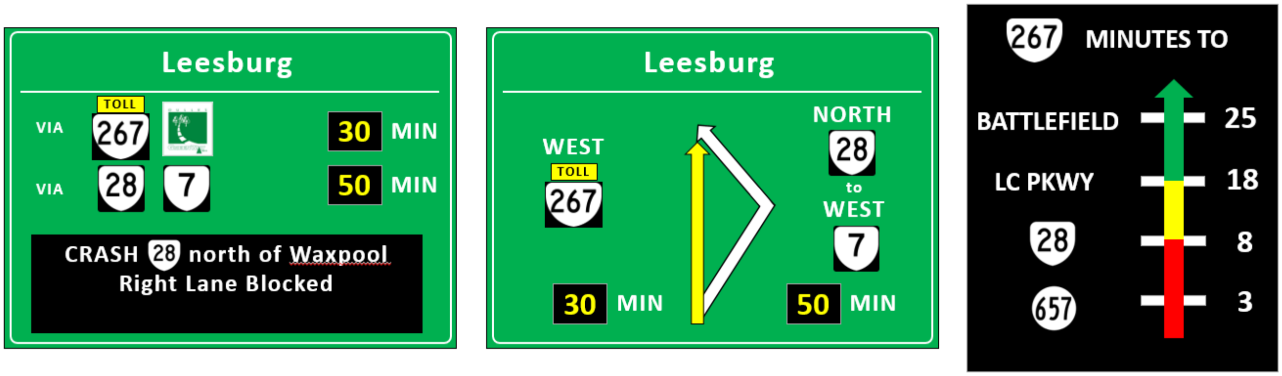

Figure 49: Proposed Signage at Location W-2: SR 267 Westbound, West of Exit 11 / Fairfax County Parkway

8. QUICK WINS

This section highlights actions that have been identified by stakeholders as “quick wins” in moving this ICM concept forward. Some efforts could be facilitated within existing institutional frameworks and funding, while others have been identified as ongoing projects related to the ICM concept.

8.1. Baseline ITS Deployments

Several gaps in baseline ITS infrastructure exist throughout the ICM study area due to the fragmented ownership and oversight of various facilities and services. Table 20 proposes a series of baseline ITS deployments needed in the study area and targeted locations or facilities. These gaps have been identified based on stakeholder input and the findings in Chapter 4 on the existing state-of-play in the study area.

Table 20: Identified Baseline ITS Deployments Needed

Deployment Needed	Facilities/Locations
Wi-Fi or Bluetooth Sensor Deployment	■ SR 267 between SR 7 (Leesburg) and SR 28, between SR 28 and Reston Parkway, between Reston Parkway and SR 7 (Tysons), and between SR 7 (Tysons) and I-66. ■ SR 7 between SR 267 (Tysons) and SR 28 and between SR 28 and US 15. ■ SR 28 between I-66 and SR 267 and between SR 267 and SR 7. ■ US 50 between US 15 and SR 28 and between SR 28 and I-66. ■ US 15 between SR 7 and I-66. ■ SR 123 between I-66 and SR 7 and between I-495 and George Washington Parkway.
Dynamic Message Signs	Segments along SR 267, SR 7, SR 28, US 50, US 15, and SR 123 upstream of the locations described above.
Parking Data-Collection Systems	■ Metrorail Silver Line garages: Ashburn, Loudoun Gateway, Innovation Center, Herndon, Wiehle-Reston East. ■ Metrorail Orange Line garages/lots: Vienna, Dunn Loring, West Falls Church, East Falls Church. ■ I-66 Outside the Beltway garages/lots: Haymarket, SR 234 Bypass, Balls Ford Road, Stringfellow Road. ■ Targeted lots in Loudoun County: Dulles North, Dulles South, Leesburg, Harmony.
Real-Time Transit Arrival Times (Public Feed)	Real-time vehicle location information is currently already available to developers via a public API for WMATA Metrobus, Metrorail (except end-of-line stations departure times), and ART. All participating transit agencies in the ICM study area currently have AVL systems to track bus locations. The following services are not yet available: ■ Metrorail end-of-line stations: departure times. ■ Fairfax Connector and PRTC: real-time bus locations, arrival predictions, and a public API. ■ Loudoun County Transit: no public API currently available for integrating with other trip planning tools, but LCT does have a tool for estimating bus arrivals and showing a map of bus locations.

Deployment Needed	Facilities/Locations
Real-Time Transit Passenger Loading (Agency Feed)	Fairfax Connector currently has deployed a fully-integrated on-board ITS system in which APCs transmit passenger counts in real-time to a central server, which has the ability to integrate with its AVL feed to calculate real-time passenger loads on buses. This feature is currently for internal use only and still undergoing testing. At this time, other transit agencies are at the following levels of deployment for APCs: ■ WMATA Metrobus – APCs on 100% of bus fleet; unclear if real-time passenger loads are being calculated. ■ Loudoun County Transit – plans to deploy APCs in the next 1-2 year; unclear if calculating real-time passenger loads is a near-term desire. ■ PRTC – APCs on 100% of bus fleet and currently undergoing testing. Same vendor (Trapeze) provides their AVL feed, but it is unclear if calculating real-time passenger loads is a near-term desire. ■ ART – APCs on 100% of bus fleet but not transmitting data in real-time (download at end of day).

8.2. Identified Efforts

The following tasks have been identified based on stakeholder input as tasks which could proceed forward with limited up-front capital costs and within the existing organizational frameworks available:

- Start to establish relationships with third-party data providers, such as Waze and probe travel time/origin-destination data providers.
- Define communication channels between agencies and points-of-contact for operations. Potentially establish an Operations Steering Committee.
- Form an Incident Response steering committee to begin developing pre-programmed incident response plans in anticipation of a DSS being developed.
- Integrate CAD feeds from various law-enforcement agencies to allow these to be shared with each other. A current ongoing project is the integration of the Loudoun County and Prince William County CAD feeds.
- Continue to promote and encourage other agencies to utilize VDOT's Transportation Video & Data Distribution (TV&D) feeds, as well as RITIS for real-time information, operational analyses, and planning purposes.
- Continue to enhance 511, including adding multimodal information. A potential addition to 511's multimodal information could include "typical usage" and "typical filled times" at park-and-ride lots along the corridor.
- Deploy message signs on freeways alerting users to parking space availability at select transit stations. These signs could contain static messages, such as "parking available" based on historic counts for lots or garages that are not at capacity. An example first deployment is along I-66 eastbound approaching the Vienna Metrorail Orange Line station, which has been operating below capacity since the opening of the parallel Silver Line. These signs can help alert commuters to transit options and alleviate the potential barrier of uncertainty about finding parking.
- Transit agencies should work with their ITS vendors and internal legal counsel to ensure the ability to share AVL and APC data with an external entity, such as an ICM Data Warehouse, and ultimately to public-facing applications developed outside of those agencies. As transit agencies'

ITS systems near retirement and replacement, they should plan for integration of AVL and APC systems to enable the ability to monitor passenger loads in real-time.

- Deploy additional multimodal information displays at key trip generation points along the corridor, similar to those featured in Tysons Corner and major transit hubs in Arlington County. These displays can alert potential users to the availability of transit services of which they may not be aware or simply to promote usage of transit in general.
- Include information about truck restrictions in RITIS and ATMS incident response plans.
- WMATA and VRE should explore partnerships with transportation network companies (TNCs) and local jurisdictions to potentially promote subsidized first-mile/last-mile rides within a certain geo-fence of major transit stations.
- Leverage insights and experiences from other ICM sites and demonstrations, notably about decision support systems.

8.3. Parallel Ongoing Efforts

The following tasks have been identified based on stakeholder input and the information contained in Chapter 4 as major separate, but parallel, ongoing efforts to the ICM project which could be potentially leveraged as part of the ICM deployment:

- VDOT is migrating to a new statewide ATMS operating platform to manage traffic congestion, incidents, events, and work zones via sensing, communications, and data-processing technologies. These technologies include modules for video, message signs, weather detection, traffic data-collection, travel time dissemination, lane control signals, ramp metering, gate controls, highway advisory radio, and more.
- VDOT has various ongoing arterial ITS deployments underway or in study, as mentioned in Section 4.3.1.3. These include upgrades to all signal controllers and communications in the region, transit signal priority deployments, potential adaptive signal control system deployments, and further CCTV deployments.
- The major projects along I-66 (both Inside and Outside the Beltway) will feature deployment of additional ITS devices, as described in Section 4.4.1 and Section 4.4.2. Toll revenues from I-66 Inside the Beltway will be used to increase transit service benefiting the users of I-66 inside the Beltway as well as enhance carpool and other TDM strategies throughout the corridor. This could include new park-and-ride lots, roadway improvements on parallel routes, transportation systems management, and other strategies. Outside the Beltway, the new park-and-ride facilities being constructed will have data-collection systems to monitor occupancy and space availability.
    - The Transportation Management Plan (TMP) for the I-66 projects provides funding for a variety of ICM-related initiatives, including supplemental state police patrols and VDOT Safety Service Patrol; funding for updating incident response plans; additional traffic monitoring and communications equipment; incentives for vanpool, carpool, and telework, and integrating Arlington CarFree A to Z trip-planning tool with real-time travel information from 511VA.
- VDOT has partnered with universities and others to deploy infrastructure for connected vehicle and autonomous vehicle research and applications in the ICM study corridor, as mentioned in Section 4.3.1.2.
- New park-and-ride garages being constructed by Fairfax County, Loudoun County, and private developers adjacent to future Metrorail Silver Line Phase II stations provide opportunities for deploying parking data-collection systems.
- MWAA has prepared plans to deploy CCTV and DMS along SR 267 between Dulles Airport and I-66 in the next two to five years.

- Loudoun County is currently developing a Transportation Technology Plan defining a program of projects with transportation-related technology applications, including applications in the areas of roadway infrastructure, incident management, safety and security, and transit.
- WMATA has expressed plans for implementation of an algorithm to predict parking availability at its park-and-ride garages using previously collected data.
- Several transit agencies are in the midst of ongoing transit ITS deployment efforts (as mentioned in Section 4.3.2), including:
  - WMATA is now providing a public feed of real-time rail vehicle locations.
  - Fairfax Connector is implementing a fully-integrated on-board bus ITS system, including the ability to monitor vehicle passenger loads in real-time.
  - Loudoun County Transit and PRTC both intend to make publicly-available feeds of bus arrival predictions based on real-time vehicle locations within the next one to two years. LCT furnishes a bus tracking tool that includes real-time arrival predictions as of September 2016, but does not yet have a public-facing API.
- WMATA and the local bus transit providers continue to be involved in ongoing discussions regarding upgrades to the SmarTrip card system, including upgrades to farebox hardware and software.

9. DOCUMENTS AND REFERENCES

- I-66 Operations Concept Technical Report.
- ICM Concept of Operations for the US-75 Corridor in Dallas, TX.
- ICM Concept of Operations for the I-270 Corridor in Montgomery County, MD.
- ICM Concept of Operations for the I-394 Corridor in Minneapolis, MN.
- ICM Concept of Operations for the I-15 Corridor in San Diego, CA.

APPENDIX

ISSUES, NEEDS AND STRATEGIES INPUTS FROM THE RESOURCE FORUMS

ICM Resource Forums #2; Focus Area: Roadway Operations

Summary of Candidate Strategies

Data Exchange:

- Establish a clearinghouse for the aggregation of real-time travel conditions and status information across the study area.
- Encourage agencies to sign-up for Traffic Video and Data (TVD) to view VDOT cameras and data.
- Build historic data to assess origin-destination patterns.

Throughput Optimization:

- Deploy adaptive signal control technology on key corridors in the study area.
- Deploy next generation traffic signals systems such as the Multi-Modal Intelligent Traffic Signal Systems (MMITSS) bundle to improve passenger vehicle, pedestrian, transit, freight and emergency vehicle mobility through signalized corridors.
- Develop a decision support system with predictive modeling capabilities.

Traffic Monitoring:

- Use 3rd-party data to identify real-time conditions on non-interstate roadways that have gaps in monitoring infrastructure.
- Stakeholder Roles and Responsibilities:
- Develop standard operating procedures that clearly outline stakeholder roles and responsibilities when responding to incidents.
- Develop inter-jurisdictional agreements.
- Conduct table-top exercises.

Problem Statement

Transportation agencies and stakeholders need to collaborate, coordinate and communicate across networks and modes.

Issues	Needs	Candidate Strategies	Notes
Topic: Data Exchange			
Transportation agencies operating in the study area do not have a comprehensive real-time view of the traffic demand in the different networks and capacity limitations.	1. **Need a comprehensive view of available capacity and demand throughout the corridor.** A comprehensive view of the available capacity and demand along each network and mode of travel in the corridor will allow transportation agencies to better manage the corridor, and balance supply and demand.	i. Establish a clearinghouse for the aggregation of real-time travel conditions and status information across the study area. ii. Encourage agencies to sign-up for Traffic Video and Data (TVD) to view VDOT cameras and data.	• RITIS may be used as the data aggregator and clearinghouse. • The clearinghouse should support open data formats. • Data sources include VDOT, local agencies and Dulles Toll Road (DTR). • There are no sensors or CCTVs on DTR. CCTVs will be deployed in the next 2-5 years. • VDOT can provide traveler information on roadways approaching the DTR. • TVD data can be accessed by signing an agreement with VDOT's probe data provider. • Visual monitoring of the roadways is important. • There are 10 CCTVs deployed in Alexandria and 30 more CCTVs will be added in the next 3-5 years.
Data exchange across modes and jurisdictions is lacking including knowledge of, and secure access to, existing data systems such as RITIS and video sharing.	2. **Need information exchange across all agencies, jurisdictions and modes in the study area.** Transportation agencies in the study area need to exchange data on current conditions within their network to improve situational awareness, optimize traffic across networks and modes, and enhance decision support.	i. Encourage agencies to sign-up for Traffic Video and Data (TVD) to view VDOT cameras and data.	• TVD data can be accessed by signing an agreement with VDOT's probe data provider. • VDOT used wi-fi and Bluetooth technology to collect travel time data. • Arlington used Bluetooth technology to collect travel time data on US-29 and US-50. • VDOT video is also available through NCRNet. • Accessing the data is the first step. It is important to be able to convert the data to usable information.
	3. **Need to archive data.** The data elements needed to support after action reviews and developing predictive analysis and decision support tools need to be identified and archived. This data can also support the performance measurement program.	i. Build historic data to assess origin-destination patterns.	• This strategy will also support the prediction engine proposed in need 6, strategy (i).
The transportation agencies in the study area including state, city, county, and transit agencies do not have information about what the other organizations are doing to respond to recurring congestion, incidents or special events.	4. **Need improved and timely information sharing between transportation agencies in the study area about how other agencies are responding to recurring congestion, incidents or special events.** Transportation agencies need pertinent information about the response activities of the other stakeholder agencies in the study area.	i. Establish a clearinghouse for the aggregation of real-time travel conditions and status information across the study area. ii. Develop inter-jurisdictional agreements. iii. Conduct table-top training exercises.	• The table-top training exercises can be conducted for a central location such as Crystal City.
Topic: Throughput Optimization			

Issues	Needs	Candidate Strategies	Notes
The traffic signals along arterials in the corridor are not optimized based on traffic conditions.	**5. Need to improve throughput at signalized intersections in response to changing traffic conditions.**	i. Deploy adaptive signal control technology on key corridors in the study area. ii. Deploy next generation traffic signals systems such as the Multi-Modal Intelligent Traffic Signal Systems (MMITSS) bundle to improve passenger vehicle, pedestrian, transit, freight and emergency vehicle mobility through signalized corridors.	
Rerouting of traffic in response to congestion or incidents needs to balance between connecting the roadway networks and modes, and protecting cut through traffic congestion and bottlenecks in the local areas. For example, Town of Vienna estimated 54% of traffic on Rt. 123 is cut-through and City of Fairfax estimated 60% of traffic on Rt. 50 within the city boundary is through traffic.	**6. Need enhanced tools for decision support before rerouting traffic.** This includes ability to predict conditions based on historic and real-time data before the traffic is rerouted and knowledge of roadway conditions.	i. Develop a decision support system with predictive modeling capabilities.	• This strategy will be a combination of need 1, strategy (i), need 3 strategy (i), and operator experience. • Various plans and scenarios can be pre-populated in the decision support system. • Operators usually have less than 15 minutes to implement a strategy after an incident during peak periods so the system should be able to provide quick and accurate outputs. • The system can be used for day-to-day operations as well major emergencies. • The TMPs developed for I-66 can be a test case for the system. • The prediction system can be tested using existing data.
Topic: Traffic Monitoring			
There is insufficient data, particularly on non-interstate routes to be able to continuously monitor traffic conditions.	**7. Need to continuously monitor traffic conditions in the study area.** The operators need the ability to monitor the roadway networks within the study area to quickly detect, verify and respond to issues. Infrastructure deployment to support this need requires investment and time, and should be minimized.	i. Use 3rd-party data to identify real-time conditions on non-interstate roadways that have gaps in monitoring infrastructure.	• Define data needed. • Identify pertinent technology assets already on the roadway (e.g., detection, cameras, fiber). • Outfitting “gaps” on the roadways with technology is likely to be short-sighted and prohibitively expensive. • Identify potential 3rd-party sources of data. • Define plan to overcome deficiencies (e.g., accuracy) of current 3rd-party data. • Address other practical/institutional challenges.
Topic: Stakeholder Roles and Responsibilities			
The roles and responsibilities of stakeholder agencies in the study area when responding to congestion, incidents and special events are mostly not outlined or documented. In cases where agreements exist, improved coordination is needed between the agencies to implement the agreement. For example, responsibilities between VDOT and Express/Toll Lanes Operators should be shared as outlined in the Amended and Restated Comprehensive Agreement (ARCA)/Compressive Agreement (CA) for the overall operation & maintenance of the HOT & adjacent facilities.	**8. Need to document roles and responsibilities of stakeholder agencies in the study area.**	i. Develop standard operating procedures that clearly outline stakeholder roles and responsibilities when responding to incidents. ii. Develop inter-jurisdictional agreements. iii. Conduct table-top exercises.	• Collaboration between the different incident response agencies in the corridor will be required to develop the standard operating procedures.

ICM Candidate Strategies; Focus Area: Transit/TDM

Summary of Candidate Strategies

Data / Traveler Information Needs:

- Develop a centralized data warehouse with transit/TDM and parking data, including real-time and static data.
  - Define data standards and formats.
  - Assess gaps in data and establish what steps need to be taken to fill in gaps.
  - Define an implementation plan to allow transit provides to join in as new on-board technologies such as AVL and APCs are deployed.
- Develop a one-stop-shop tool for multi-modal trip planning.
- Provide real-time train location data and end-of-line departure data to app developers.
- Deploy parking data collection systems that record in/out/total at Virginia Orange and Silver Line Metrorail lots and major park-and-ride lots.
  - Develop a real-time parking space availability map.
  - Communicate information on underutilized lots.
- Deploy real-time information displays at targeted major activity centers. Integrate displays with all local transit providers, bikeshare, and ridesharing services.

Transit Service Reliability:

- Develop a real-time decision support system for routing buses via the Dulles Airport Access Road rather than the Dulles Toll Road during congested periods.
- Institute off-vehicle card loading and/or fare collection for local transit agencies.
- Allow vehicles with CV/AV technology to utilize dedicated lanes such as the future I-66 Express Lanes.
- Deploy transit signal priority along targeted corridors or queue jumps at targeted intersections.

First-Mile / Last-Mile Access to Transit:

- Establish public-private partnerships for park-and-ride lots to expand connectivity beyond the transit line. One solution is a partnership with ridesharing providers to provide discounted rides within a certain radius of a transit lot.
- Integrate transit, bikeshare, ridesharing, etc., into any regional payment system technology that will be developed in the future.
- Expand and promote accommodations for storing bikes at transit stations/park-and-ride lots and bringing bikes on board transit.

Problem Statement

Strategies are needed to make transit and modal shifts more attractive and user-friendly to travelers.

Issues	Needs	Candidate Strategies	Notes
Topic: Data and Traveler Information Needs			
Data exchange standards and formats differ across jurisdictions and agencies, making it very difficult to integrate traveler information data into a common format for aggregation, processing, and dissemination.	**1. Need for the establishment of common data formats and standards that allow data exchange among jurisdictional DOTs, transit agencies, and other stakeholders**. In order to disseminate traveler information across routes and modes, data standards from partner agencies need to be congruent, allowing access to raw data for processing. Data feeds need to be organized in a consistent format to allow for aggregation and processing.	i. Provide a regional/state mandate or incentive to get local providers to install or provide necessary technology and data by a certain date. Sign an MOU if possible. ii. Establish an ITS architecture within Virginia (or Northern Virginia) for on-board bus systems such as AVL and APCs	• Issues with integration of on-board systems – no standards currently exist, and several vendors have unique standards and formats. • As agencies put out RFPs for on-board systems, they should require open data standards. • Platforms do exist to fuse information together even if gaps exist in data formats (for example, RITIS). • WMATA recently switched to BusETA (more "open-source" than NextBus). Is this expandable to the region? • Need to agree on regional data needs – for example, granularity and time intervals.
For transit and roadway operators, there is no central data source for obtaining real-time and historic information such as transit vehicle locations, transit service disruptions/delays, and park-and-ride lot availability. This makes it challenging to recommend alternatives to travelers or plan for solutions.	**2. Need a centralized data warehouse for Transit/TDM data, including real-time and static data**. For some agencies, this will first require deployments of technologies to collect data such as vehicle locations or parking space availability. Once agencies are able to collect this information, they need the ability to share this information (1) among each other and (2) with customers. This could include TDM data as well, such as vanpool monthly logs of trips.	i. Assess gaps in data and establish what steps need to be taken to fill in gaps. ii. Define an implementation plan to allow transit providers to join-in as information becomes available.	
Travelers are unable to obtain the real-time location of their bus/train (for transit providers); for those transit providers who do provide this information, the real-time arrival predictions are not always accurate, frustrating travelers. At terminals, travelers are not always aware of bus arrival and departure times while en route.	**3. Need accurate, real-time *customer-facing* information systems for vehicle locations and predicted arrival times.** In order for travelers to adjust their trip modes and routes as they embark on their trips by bus, they need to be aware of not only bus arrival times at bus stops and terminals but also bus departure times. Buses, sometimes, hold for longer than expected periods at transit terminals before leaving which delays travelers and lowers trip reliability. Travelers should be provided with bus arrival and departure times in order for them to choose their "best" alternative and thus spread demand across modes.	i. Provide real-time train location data to app developers. ii. Provide real-time departure estimates for end-of-line WMATA stations.	• WMATA is planning to provide real-time train location data to app developers by Summer 2016, as opposed to the existing legacy system that predicts arrivals based on a train passing timepoints in the system. • For bus departure times, the strategy will involve integrating real-time data (for arrival predictions) with static data (for scheduled departures if a vehicle is at a timepoint). Otherwise it may be difficult to include transit departure times in trip planning tools.
Travelers are unable to access information about park-and-ride space availability at lots and hence cannot tell if transit is a viable option because they don't know if they can park in a nearby lot.	**4. Need real-time parking information and historical trend data on targeted park-and-ride lot utilization and availability for customers.** Travelers need to know if and when their desired park-and-ride lot reaches capacity for planning in advance as well as real-time space availability for potentially shifting modes. In conjunction with this, travelers would like to be recommended with alternative solutions if their preferred lot is full.	i. Communicate information on underutilized lots or parking spaces which are only available at certain times of the day, such as after 9:00 AM. ii. Develop a real-time space availability map similar to the Capital Bikeshare "bike availability" maps for park-and-ride lot availability. iii. Expand knowledge/information on transit services which may be available at different lots.	• Consider commuters who work atypical schedules, especially those who work later in the day after some lots fill up. • Solutions should point riders to underutilized lots or areas within a lot. • RideFlag is working on a program with Florida International University in which an area of a parking lot is restricted unless riders who are carpooling via an app activate the gate. • Lots specifically mentioned for consideration at the forum include Dulles North and South in Loudoun County; Herndon-Monroe in Fairfax County; and the new I-66 Outside the Beltway lots in Fairfax and Prince William Counties. • VDOT is conducting a pilot deployment at Dale City.

Issues	Needs	Candidate Strategies	Notes
Travelers are often unaware of incidents in transit service, such as delays or schedule alterations.	5. **Need real-time incident information and the ability to seamlessly alert the public on transit incidents.** Travelers need to be aware of delays or incidents for a particular transit system to plan accordingly to shift to another transit system or mode.	TBD	• Utilize the capabilities of Twitter and Waze. • Issues with filtering out alerts to users – should alerts be within a geotagged buffer? Should they be personalized or corridor-specific?
Travelers interested in ridesharing services do not have access to real-time data on seat availability.	6. **Need for access to space availability information for ridesharing services**. In order to spread demand across modes, travelers interested in exploring ridesharing services (vanpool, carpool, etc.) as an alternative travel mode need to know in real-time if seats are available.	i. Develop partnerships with dynamic ridesharing services such as Via or Bridj to expand service coverage into the ICM study area.	
Travelers have tools to assist with multi-modal trip planning, but there is still no "one-stop-shop tool" that allows one to plan to drive or bike to access transit, such as via a park-and-ride lot. Travelers currently use multiple traveler information tools to plan trips which make it tedious to find a consolidated set of information about all modes and hence impede modal shifts.	7. **Need a one-stop-shop tool for multi-modal trip planning.** This would present travelers with options for driving, biking, walking, or using another form of transportation such as ridesharing, to access high-capacity transit.	i. Leverage existing capabilities of an established provider, such as Google Maps. ii. Build on new capabilities, such as Arlington's CarFreeAToZ tool.	• Google Maps already provides schedule-based information, and predictive or real-time transit information may be available within a year. • VDOT is working with Arlington County Commuter Services to integrate 511 with CarFree A to Z as part of the I-66 TMP.
Topic: Capital/Technology Deployment Needs			
Some transit agencies do not have the ability to track the location of their vehicles or passenger loads in real-time. Other agencies have the ability to track.	8. **Need on-board technologies such as Automatic Vehicle Location (AVL), Automatic Passenger Counters (APCs), and Automated Farebox Collection (AFCs) on all transit vehicles**. These systems allow transit agencies to monitor the real-time status of their transit fleet and, where appropriate, disseminate this information (via a website, mobile app, API, etc.). This need includes backend systems for analyzing this data and distributing this data to traveler information systems and/or a centralized data warehouse.	i. Develop matrix of local transit providers and various on-board technologies (AVL, APCs, etc.), and where each agency stands in terms of deployment. Identify the technology vendor where possible. ii. Provide a regional/state mandate or incentive to get local providers to install or provide necessary technology and data by a certain date. Sign an MOU if possible.	• All agencies in the study corridor (WMATA, ART, Fairfax Connector, Loudoun County Transit, PRTC, VRE, Amtrak) are at various states-of-play for on-board technology deployments.
Travelers are unable to access information about park-and-ride space availability at lots and hence cannot tell if transit is a viable option because they don't know if they can park in a nearby lot. No systems are currently deployed to collect this information.	9. **Need parking data collection systems deployed at major identified park-and-ride lots.** These systems should collect information on space occupancy, duration of space occupancy, and time-of-day. This will allow for potential traveler information systems to be set up to show travelers real-time parking space occupancy at lots and historical trend data. This data will also be useful to agencies as they plan for expansion or special events.	i. Deploy parking data collection systems that record in/out/total at Virginia Orange and Silver Line Metrorail lots and major park-and-ride lots such as Dulles North. ii. Reach out to Vanpool Alliance for locations at which it may be desirable to have dedicated spaces for vanpool.	• Stakeholders expressed concern over the high cost of parking data collection systems (especially ones that involve wayfinding). Lower-cost solutions count trips in and out of lots but do are not space-by-space counters. • Park-and-ride lot data collection is included as part of the Draft Technical Requirements for the design and construction of the new lots being provided as part of the Transform I-66 Outside the Beltway project.
Bus riders are frustrated and less incentivized to ride transit when buses are constrained by arterial congestion or delays at stops, especially when this causes schedule delays and reduces on-time performance of buses.	10. **Need strategies to improve bus operations on arterial corridors to reduce delay and remain competitive with vehicular travel**. TSP and queue jump systems can be set up to be activated if a bus is running behind schedule or if a bus is carrying a certain passenger load. Off-vehicle fare collection or farecard loading can reduce delays at stops from passengers adding value to farecards when they board the bus.	i. VDOT or municipal DOTs operating their own signals (Arlington, City of Fairfax, etc.) should work with local transit agencies to implement transit signal priority or queue jumps at targeted intersections. ii. Local transit agencies should institute off-vehicle fare collection or off-vehicle card loading.	• Stakeholders suggested several locations for TSP or queue jumps: US 50 in Loudoun County and Fairfax County, Braddock Road in Fairfax County, and SR 28 near I-66. • Off-vehicle fare collection/card loading could potentially present equity issues, as low-income riders often do not load much value at one time. A potential workaround would be to deploy more kiosks at bus stations or in retail/convenience stores for farecard loading. • DASH has banned card loading on its buses in Alexandria. • Follow up with VDOT regarding advanced signal research involving

Issues	Needs	Candidate Strategies	Notes
			CVs/AVs. Should we be thinking about "smart" transit vehicles that are communicating with adaptive signal systems?
Travelers desire the ability to use one mechanism to pay for transit trips, bikeshare, and other non-automobile modes such as ridesharing. However, it is important to keep in mind equity issues and maintain the option for transit riders to pay with cash.	**11. Need an integrated payment system among transit, bikeshare, and other non-automobile modes that maintains a cash option.** WMATA and other transit agencies are currently in the process of revisiting planning for the New Electronic Payment Program (NEPP) as a replacement to the existing SmartTrip system, while Capital Bikeshare requires a credit card or key fob.	i. Integrate transit, bikeshare, ridesharing, etc., into any regional payment system technology that will be developed in the future.	• Stakeholders expressed that the concept behind WMATA's New Electronic Payment Plan (NEPP) was ideal, but unfortunately the implementation was not. Implementation will be a challenge in this corridor due to the large number of stakeholder agencies. • Could this system include Capital Bikeshare and carsharing/ridesharing services? • A payment system could be an open system (point-of-service transaction) or a proprietary 3rd-party system.
Some major park-and-ride facilities and rail stations do not have adequate bicycle and pedestrian facilities for accessing the site or for storing bicycles at the site. Travelers wishing to access the site must do so by car or some other vehicular mode even if they live nearby and could bike or walk.	**12. Need improved bicycle/pedestrian amenities at targeted Metrorail/VRE/park-and-ride stations.** This can include trails and sidewalks, lighting, wayfinding, and storage such as bike racks and lockers.	i. Transit agencies should include as part of their on-board ITS systems a solution to track when and where on-board bike racks are deployed. ii. WMATA should revisit its policy banning peak-hour bicycle usage on trains. iii. Low-cost solutions such as restriping / adding bike lanes approaching transit stations. iv. Loudoun County should advertise the availability of bike lockers at park-and-ride lots.	• Many of these topics are discussed in much greater detail in the bike/ped forum notes. • Examples of cooperative agreements between transit agencies and bikeshare include an integrated back office payment system used in Salt Lake City and comprehensive cooperative agreements in cities such as San Francisco, Montreal, and Philadelphia (strategy and examples were provided by Peter Ohlms (VTRC) after the forum workshop).
At major activity centers with high pedestrian volume, many travelers may be unaware of the variety of transit options likely to be available to them.	**13. Need more real-time information displays on bus arrivals deployed at targeted major activity centers.** Other jurisdictions have expressed interested in expanding deployments of information displays currently at major transit hubs in Arlington County and at the Tysons Center mall.	i. Deploy information displays at targeted major activity centers. Integrate displays with all local transit providers, bikeshare, and ridesharing services.	• Arlington County has plans to expand coverages to East Falls Church Metrorail station and the Columbia Pike transit corridor. • Fairfax County has expressed interested in deploying at Reston Town Center and at Metrorail Silver Line Stations. • Stakeholders expressed that information displays are an amenity to those without smartphones. Additionally, they help potential passengers become more aware of their options and are very useful for alerts. These reduce the need for having a number of trip planning apps and are helpful for those who are new or unfamiliar with the region. They are also viewed as a credible source of information. • Expansion of deployment should generally ensure Metrorail station coverage, high-volume bus terminals, and major employers. • Redmond Group is working on solutions for the blind. Other vendors exist in this space as well. • Issues with sheltering from weather at outdoor bus stops. • One stakeholder expressed curiosity as to whether or not these displays could be developed in an interactive format for trip planning.
Commuters cannot always wait until they are ready to travel to consider their travel options. They often need/want to plan ahead.	**14. Need for historical/trend/behavior data to support predictive modeling**. Predictive modeling outputs based on real-time travel conditions will allow travelers to gain a good understanding of potential future conditions of their commute should particular travel mode(s), route(s) or a combination thereof be used, equipping them with enough information to choose their most suitable travel option(s).	i. Individual agencies should archive their AVL and APC data as these systems are brought on board. ii. A centralized data warehouse needs to contain an archive of transit-related data.	• (From Innovation forum) RITIS is currently pulling in AVL data from Montgomery County and Arlington, but not WMATA yet. A centralized data source first needs to obtain the data from agencies and then have these agencies approve of sharing. RITIS is currently archiving this data but is not actively engaged in analysis/analytics as of yet.

Issues	Needs	Candidate Strategies	Notes
Travelers are not fully utilizing transit because of perceptions or unfamiliarity.	**15. Need for Transit Incentives.** Incentives that provide enough of an advantage to single-occupant vehicle (SOV) commuting is recommended to appeal to SOV travelers to use transit.	i. Establish a partnership between VDOT, transit agencies, and/or managed lanes/ridesharing providers to allow transit users to receive a discount on toll facilities or ridesharing. ii. Allow those using managed lanes in HOV-mode to set up their account in such a way that rather than taking the trip for free, the dynamic toll amount is credited to their SmartTrip account for riding transit.	• Explore potential partnerships with "dynamic vanpool" services such as Bridj or Via, who are already operating in the Washington, D.C, area. • Los Angeles Metro Transit may be piloting an incentive in which transit riders can receive discounts on toll freeways in the region. • Discounts for off-peak are built into the pricing algorithms for HOT lanes already. This strategy may not be feasible for the Dulles Toll Road, either, given that toll revenues go toward the Silver Line extension. • For equity issues, perhaps implement the system described in (ii) such that those receiving transit benefits from using the managed lanes in HOV mode can transfer value to another pool (Source: Ryan Jones, FCDOT/Fairfax Connector).
Topic: Policy/SOP Needs			
When Metrorail has service disruptions or planned closures, adequate bus service is not always provided along needed parallel routes. Many Metrorail routes are supplemented by parallel or feeder service from other agencies, which further complicates coordination and planning for disruptions or closures.	**16. Need improved integration between WMATA and other bus systems during Metrorail incidents/disruptions.** This includes coordination with agencies outside of Metrobus that carry passengers along parallel routes (Fairfax Connector, ART, PRTC, Loudoun County Transit, etc.). There is a need for bus agencies to dynamically alter service (in real-time near real-time via an SOP) and alert customers when more passenger-carrying capacity is needed in place of Metrorail.	TBD	• Agencies should plan for special events, such as conducting drills or developing SOPs for major closures/shutdowns. • Internal and external information exchange is an issue. • Who will facilitate this coordination? MWCOG? MATOC? OIPI?
Travelers find it difficult to seamlessly plan a true end-to-end trip that combines mode and route shifts and include options for traveling the "first/last mile" due to lack of a comprehensive set of information in existing trip planning tools.	**17. Need to provide travelers with options to facilitate first-mile/last-mile trip needs from transit stations and park-and-ride lots.** Travelers need to be confident that there are available resources that provide connectivity between transit and their destination/trip starting point.	i. Establish public-private partnerships for park-and-ride lots to expand connectivity beyond the transit line. One solution is a partnership with ridersharing providers to provide discounted rides within a certain radius of a transit lot.	• Example solutions for partnerships with ridesharing solutions exist in Atlanta and Florida (Uber). • Equity is an issue in providing smartphone-app-based ridesharing services.
When the shoulder lane along I-66 between US 50 and I-495 is closed, some congestion or slowdowns in traffic still exist, which delays buses that use those routes and subsequently lowers trip reliability.	**18. Need alternate options for buses to bypass congested sections on I-66 and other facilities to maintain on-time performance.**	i. Implement a policy allowing transit providers to utilize the red "X" lanes or the shoulder on I-66 during congested periods. ii. Allow vehicles utilizing CV/AV technology to utilize dedicated lanes such as the future I-66 Express Lanes.	• (From Innovation forum): Consider CV/AV transit vehicles for shoulder running or dedicated lanes. • If buses are run on narrow shoulders, this could be an issue with EMS.
Travelers and transit stakeholders are frustrated when on-time performance suffers, yet agencies do not have clear standards on what constitutes "on time" and "not on time" when reporting to travelers or stakeholders.	**19. Need clearly-defined performance measures for transit on-time reliability.** Not every agency reports on-time data, and there is not a consensus on what to measure and how to report on-time performance.	i. Define and apply the performance metrics.	• A lack of uniform standards may be contributing to eroding trust and belief in WMATA's reported performance measures. Stakeholders mentioned a regional perception that transit is not reliable and reported data may not be trustworthy. • Regional standards need to be established to measure service. • ARC (Atlanta MPO) is an example of implementing uniform standards, as they facilitated deployment of a unified GTFS system among regional transit providers.
Congestion on the Dulles Toll Road has grown worse in the past several years. The parallel	**20. Need a real-time decision support system for routing buses via the Dulles Airport Access Road**	i. Deploy decision support system.	

Issues	Needs	Candidate Strategies	Notes
Dulles Airport Access road could be utilized by commuter bus routes; however, utilizing the Airport Access Road requires some buses, such as those to and from Loudoun County, to take an indirect path through Dulles Airport, so dynamic assignment to the Airport Access lanes would only be relevant during periods of congestion on the Toll Road mainline. Currently, some buses switch to utilizing the Airport Access Road on a time-of-day basis.	**rather than the Dulles Toll Road**. Worsening congestion on the Dulles Toll Road creates a need for an on-the-fly algorithm to route buses via the Airport Access Road, rather than a time-of-day based schedule. (An analogous situation is the ATMS for shoulder lane usage on I-66, which recently switched to on-demand shoulder openings rather than time-of-day openings, which has significantly improved operations in the off-peak direction and periods).		

ICM Resource Forums #2; Focus Area: Traveler Information & Communications

Summary of Candidate Strategies

Data and Information Awareness:

- Enhance VDOT's central traveler information clearinghouse to serve as the central clearinghouse for traveler information data types (parking availability, train arrival times, travel times, etc.).
- Enhance existing systems such as RITIS to serve as the clearinghouse to assimilate data types into a common standard and format for processing and dissemination.
- Disseminate comparative travel times across modes and routes pre-trip and en-route.
- Use 3rd-party data to identify real-time conditions on freeways and arterials.
- Use real-time data feeds from transit agencies to identify conditions on rail and bus routes.
- Outfit buses with AVL systems to track bus locations for use in estimating arrival times and subsequently push this data to the pertinent methods of dissemination.
- Outfit bus terminals and major bus stops with information displays.
- Utilize historical data trends of ridership data to identify potential availability.
- Perform evaluation studies to assess the accuracy of each crowd-sourced data type.
- Create a new routine "meetup" initiative for brainstorming ideas on traveler information

Information Delivery:

- Include a "back-end" archiving function of the traveler information clearinghouse that can be used in a predictive trip planning algorithm.
- Implement transit-, public-, and privately-owned parking lots with parking information systems.
- Add traveler information displays at selected transit stops and on rail and buses that display pertinent traveler information about other modes and connections.
- Develop capability to disseminate information via in-vehicle signage technology.
- Perform spot deployments of DDMS at major decision points to display comparative travel times among modes and routes.
- Develop a user-tailored "one-stop-shop" predictive point-to-point trip planning tool.
- Create a "landing page" that directs users and consolidates access to available trip planning tools.

Problem Statement

Travelers need on-demand real-time and predictive, user-centric traveler information encompassing end-to-end trips.

Issues	Needs	Candidate Strategies	Notes
Topic: Data and Information Awareness			
Data exchange standards and formats differ across jurisdictions and agencies, making it very difficult to integrate traveler information data into a common format for aggregation, processing, and dissemination.	1. **Need common data formats and standards that allow data exchange among jurisdictional DOTs, transit agencies, and other stakeholders.** In order to disseminate traveler information across routes and modes, data standards from partner agencies need to be congruent, allowing access to raw data for processing. Data feeds need to be organized in a consistent format to allow for aggregation and processing.	i. Enhance VDOT's central traveler information clearinghouse to serve as the central clearinghouse for traveler information data types (parking availability, train arrival times, travel times, etc.). ii. Enhance existing systems such as RITIS to serve as the clearinghouse to assimilate data types into a common standard and format for processing and dissemination.	• Identify a lead agency/champion to house a central traveler information data clearinghouse. • Perform a detail assessment of each agencies data availability and their existing data standards and formats. • Develop requirements for the clearinghouse to accept data in multiple standards and formats. • Identify a common data standard and format per data type. Consider congruence with data standards and formats of 3rd party data providers when deciding on common standards and formats for the clearinghouse. • Transform data feeds from varying formats into established standards and formats. • Integrate data from several agencies into the data clearinghouse. • Determine methods of dissemination before deciding on common data standards and formats. • Include archiving capability in the clearinghouse to enable future performance measurement purposes and predictive trip planning algorithms. • The use of RITIS as a central traveler information data clearinghouse is advantageous because it provides data access by regional agencies. However, major enhancements to RITIS will be required. The number of MOUs may, however, be kept to a minimum considering that RITIS is regionally-owned.
Travelers are often not aware of which routes and modes have excess capacity, at any given time.	2. **Need comprehensive corridor-wide traveler information across all modes.** In order for travelers to self-adjust their trips and potentially spread demand across available capacity in the corridor, travelers need to be presented with information to inform them of travel times, incidents, etc. along all modes and routes.	i. Disseminate comparative travel times across modes and routes pre-trip and en-route.	• Develop a real-time predictive trip planning tool that compares and presents trip times and reliability. The central data clearinghouse will feed the algorithms of the trip planning tool. • Utilize multiple dissemination methods (trip planning tool – web-based and mobile app, DDMS, in-vehicle signage, etc.). Keep infrastructure deployments to a minimum due to the advent of connected vehicles, which may replace much infrastructure. • Explore using or enhancing RITIS existing travel times API to provide data feeds to enable travel time comparison.

Issues	Needs	Candidate Strategies	Notes
			• Identify connected vehicle concepts that apply. Highly consider in-vehicle signage as a primary method of dissemination because the connected vehicle concept is a primary focus of transportation practitioners for data gathering and information dissemination. • Identify a method of processing trip times on arterials, freeways, commuter rail, buses, and biking. This should include time for connectivity such as parking, storing bikes, bus wait times, etc.
Some local agencies do not have automated mechanisms for monitoring situational awareness on their roads, particularly outside the Beltway.	3. **Need corridor-wide status monitoring.** In order for comprehensive traveler information to be disseminated to travelers, operators and automated systems must be able to obtain real-time status information about the corridor. This need relies on the ability for partner agencies to more easily gain situational awareness on each mode and route in order to identify incidents and adverse events and relay the information across agencies and to travelers.	i. Use 3rd-party data to identify real-time conditions on freeways and arterials. ii. Use real-time data feeds from transit agencies to identify conditions on rail and bus routes.	• Define data needed. • Identify pertinent technology assets already on arterials (e.g., detection, cameras, fiber). • Assess the accuracy of 3rd party data (WAZE, INRIX, etc.). • Explore using crowd-sourced transit-related data. • Explore the potential of using unmanned aerial vehicle (UAV) cameras for situational awareness. • Spot deployments should only be done at incident-prone locations. However, outfitting "gaps" with technology is likely to be short-sighted and prohibitively expensive. • Address other practical/institutional challenges.
Travelers are not aware of bus arrival and departure times while at terminals and en-route.	4. **Need access to bus arrival and departure times.** In order for travelers to adjust their trip modes and routes as they embark on their trips by bus, they need to be aware of not only bus arrival times at bus stops and terminals but also bus departure times. Buses, sometimes, hold for longer than expected periods at transit terminals before leaving, which delays travelers and lowers trip reliability. Travelers should be provided with bus arrival and departure times in order for them to choose their "best" alternative and thus spread demand across modes.	i. Outfit buses with AVL systems to track bus locations for use in estimating arrival times and subsequently push this data to the pertinent methods of dissemination. ii. Outfit bus terminals and major bus stops with information displays.	• Identify agencies and transit vehicles that currently do not use AVL technology. • Develop a method for equipping older bus systems that may not be immediately conducive to accommodate an AVL system. • Upgrade or install new transit agencies tracking and monitoring systems. • At the beginning, plan a method for sending bus arrival data to the traveler information data clearinghouse. Identify standards and formats from the project planning stage. • Display scheduled bus departure times at transit terminals on traveler information displays.

Issues	Needs	Candidate Strategies	Notes
Travelers interested in ridesharing services do not have access to real-time data on seat availability.	5. **Need access to space availability information for ridesharing services.** In order to spread demand across modes, travelers interested in exploring ridesharing services (vanpool, carpool, etc.) as an alternative travel mode need to know if seats are available ahead of time and in real-time.	i. Utilize historical data trends of ridership data to identify potential availability.	• Identify a platform on which to build an online reservation system. Commuter Connections currently has a ridesharing user base in the region and as such a system could be built on their web platform. • Display ridesharing space availability on the selected platform for reservations and subsequently send data feeds of ridesharing space availability to the traveler information data clearinghouse for further dissemination and use in trip planning tool(s). • In the interim, aggregate ridership data trends for weekday and time of day and disseminate (via Commuter Connections, traveler information clearinghouse, etc.) in an interpretable format to assist travelers in decision-making. • Define data standards and formats for sharing availability data.
Some agencies are apprehensive to utilize 3rd party traveler information data without first performing data validation.	6. **Need to establish methods for validating the accuracy of 3rd party data.** There are several robust 3rd party sources of information on traveler conditions that rely heavily on “crowdsourcing” from the public including roadway incident locations, road closures, debris, travel times, etc. These tools are increasingly being used by transportation agencies. However, there is a need to validate the data prior to being disseminated to travelers in order to maintain information credibility.	i. Perform evaluation studies to assess the accuracy of each crowd-sourced data type.	• Perform “ground-truthing” of incident data using CCTV cameras that are located in the vicinity of incidents to gauge accuracy of crowd-sourced incident data. • Review results from the existing VDOT travel time studies on accuracy of INRIX and HERE travel time data on arterial and freeway travel time data. • Perform travel time studies on arterials and freeways and compare with estimated travel times predicted by 3rd party trip planners (Google, WAZE, Apple, etc.). • Determine if the accuracy of each data set is sufficient for real-time trip planning. If successful the studies should be used to determine 3rd arty provider data that are sufficient to use in a predictive trip planning tool.
There is not sufficient open dialogue among transportation practitioners in the area to discuss collaboration and innovative ideas, solutions and issues in a multi-modal context.	7. **Need the sharing of ideas among transportation practitioners.** In order to remain abreast of and create innovative transportation strategies there is a need for practitioners in the region to occasionally exchange ideas on transportation problems and potential solutions. Such a forum could enable a focused look at issues facing the region and potentially evoke cross-agency collaborative transportation strategies to benefit travelers.	i. Create a new routine “meetup” initiative for brainstorming ideas on traveler information.	• Identify existing routine meetings that focus on traveler information and potentially influence topics for discussion. • Identify a champion for such an effort. • Involve transportation practitioners from private and public sectors – State DOTs, jurisdictional DOTs, consultants, etc.
Topic: Information Delivery			
Commuters cannot always wait until they are ready to travel to consider their travel options. They often need/want to plan	8. **Need historical/trend/behavior data to support predictive modeling.** Predictive modeling outputs based on real-time travel conditions will	i. Include a “back-end” archiving function of the traveler information clearinghouse that can be used in a predictive trip planning	• Define data needs. • Identify archiving database needs and requirements

Issues	Needs	Candidate Strategies	Notes
ahead.	allow travelers to gain a good understanding of potential future conditions of their commute should particular travel mode(s), route(s) or a combination thereof be used, equipping them with enough information to choose their most suitable travel option(s).	algorithm.	(data format, querying features, etc.). • Ensure format of each archived data type (parking availability, rail arrival times, etc.), when accessed by the planning tool, is similar to the format of real-time data. • Create a function of the archiving feature that allows automated querying by a trip planning tool and ensure data feeds from the archive are useable and made available to the 3rd party marketplace (depending on the trip planning method of choice for the project). • Enable data aggregation that allows for performance measurement.
Travelers do not feel well-informed while en-route in each mode of their trips. There is not enough en-route information that is physically displayed on travel modes and routes.	**9. Need access to information dissemination en-route.** In order for travelers to potentially adjust their trips en-route, they need access to information at key locations per mode that can advise them on potential problem areas. By being provided access to en-route information, travelers will be able to select their best alternatives.	i. Add traveler information displays at selected transit stops and on rail and buses that display pertinent traveler information about other modes and connections. ii. Develop capability to disseminate information via in-vehicle signage technology. iii. Perform spot deployments of DDMS at major decision points to display comparative travel times among modes and routes.	• Utilize a combination of strategies to achieve en-route information dissemination on multiple modes and routes of travel. • Define data needed for dissemination. • Distinguish data types (e.g., static-form vs. real-time data). • Establish data standards and formats for sharing. • Deploy connected vehicle technology to send information to in-vehicle displays based on the user's choice.
Travelers currently use multiple traveler information tools to plan trips which make it tedious to find a consolidated set of information about all modes and hence this impedes modal shifts. Travelers find it difficult to seamlessly plan a true end-to-end trip that combines mode and route shifts and include options for traveling the "first/last mile" due to lack of a comprehensive set of information in existing trip planning tools.	**10. Need a comprehensive end-to-end trip planning system.** In order to influence travelers to confidently and routinely shift modes or routes, travelers need access to information on all potential modes and routes including first/last connectivity information (parking availability, bike resources, etc.). Additionally, travelers need this information in a consolidated interactive format to more easily plan trips and modify en-route.	i. Develop a user-tailored "one-stop-shop" predictive point-to-point trip planning tool. ii. Create a "landing page" that directs users and consolidates access to available trip planning tools.	• Define data needed (including parking availability, biking resources, transit alternatives, mobility-on-demand options, etc.). Determine available data and data gaps. • Distinguish data types (e.g., static-form vs. real-time data). • Establish data standards and formats for sharing. • Explore predictive modeling capabilities. • Provide the 3rd party marketplace with useful data feeds (planned road closure information, work zone locations, etc.). • Define the role of government agencies in the private marketplace. • Provide "level-of-comfort" in traveler options in the final trip planning tool(s) (e.g. willing to walk 1 mile, bike 2 miles, etc.).
Travelers are unable to access information about park-and-ride space availability at	**11. Need to gather and disseminate park-and-ride space availability information.** There is need	i. Implement transit-, public-, and privately-owned parking lots with parking information	• Identify and prioritize lots for parking system

Issues	Needs	Candidate Strategies	Notes
lots and hence cannot tell if transit is a viable option because they don't know if they can park in a nearby lot.	for a system that gathers parking data from various park-and-ride facilities and disseminates information to travelers about parking availability. Travelers being equipped with this information in real-time will allow them to not only understand if transit is a viable option, but also if they can park their car at a nearby lot and joint the transit network.	systems.	implementation. • Consider "right-sizing" the parking technology used (in-and-out counters, space-by-space detection, etc.) for each parking lot in order to account for various lot configurations. • Utilize lessons learned from the WMATA real-time parking pilot studies conducted at the Vienna, Dunn Loring, and East Falls Church metro station lots. • Create an integration plan to integrate this data into the data clearinghouse. • Manage customer expectations of space availability information in order to account for changes in availability by the time a driver gets to a lot. • Disseminating space availability data to personal devices may be a more credible option than using signs on the roadway on approach to the lot.
Topic: Traveler Education			
Some travelers may not be technically savvy and hence there is a need to: (1) disseminate data through multiple information sources and (2) educate travelers on using these sources.	**12. Need to establish multiple traveler information dissemination sources and for public outreach.** Travelers receive information through varied sources (mobile apps, radio, TV, etc.) per their liking. In order to account for all travelers there is a need to provide them with several options for receiving information that encompasses varying types of information dissemination tools. Additionally, there is a need to educate travelers on how to access and use these tools when developed considering their varying levels of complexity.	i. Establish multiple methods for disseminating information on traveler conditions.	• Identify information that is relevant to the methods selected for traveler information dissemination (e.g. point-to-point trip planning – website and mobile apps, general traveler conditions – radio, website, apps, TV, etc.). • Tailor information for dissemination to the media and public. • Determine primary methods of information dissemination by finding out the likely magnitude of the user-base per method of dissemination in the study area. Subsequently prioritize development efforts.

ICM Resource Forums #2; Focus Area: Freight

Summary of Candidate Strategies

Freight-Specific Information:

- Collect and disseminate truck parking information.
  - Overlay this information with traffic information.
  - For the Dulles airport, combine parking information with queuing at the freight terminals.
  - Disseminate information within a 50 mile radius of D.C.
- Improve/enhance static and electronic signage in the study area to provide information on roadway restrictions, detours, etc.
  - Place signage atleast 2 miles before decision points in the network.
- Provide comparative travel times at key decision points in the network, particularly to help non-familiar truckers.
- Provide traffic alerts on I-95 to help truckers decide if they want to use US-15, 17 or Fairfax County Parkway.
- Provide traffic information to drivers through dispatchers.
- Collaborate with in-vehicle system providers such as Qualcomm, Rand McNally, TeleTRACS, etc., to push traffic information to truckers in-vehicle.

Truck Routing:

- Develop truck routing plans similar to TIM plans.
- Develop guidelines for routing truck traffic.
- Overlay O-D data with truck routes.
- Overlay truck restrictions information as a layer in 511 maps.

Incident management:

- Conduct incident response training for incidents involving trucks.
- Create a response team for smaller truck incidents.

Problem Statement

Freight operators in the study area grapple with roadway restrictions and lack of freight-specific traveler information.

Issues	Needs	Candidate Strategies	Notes
Topic: Freight-Specific Real-Time Information			
There is lack of real-time freight-specific information in the study area. The little information that is available is spread across several sources.	1. **Need to collect and disseminate real-time freight-specific information.** Truckers need information regarding traffic conditions, incidents, roadway and infrastructure restrictions and truck parking.	iii. Provide traffic information to drivers through dispatchers. iv. Collaborate with in-vehicle system providers such as Qualcomm, Rand McNally, TeleTRACS, etc., to push traffic information to in-vehicle systems. v. Improve/enhance static and electronic signage in the study area to provide information on roadway restrictions, detours, etc.	• Disseminate information within a 50 mile radius of D.C. • TeleTRACS provides information to driver laptops for re-routing. • Some of the smaller trucking companies use Android-based in-vehicle devices. • Place signage at least 2 miles before decision points in the network.
	2. **Need to consolidate freight information for easier access.** Freight-specific information is spread across several online sources.	i. Establish a clearinghouse for the aggregation of real-time freight travel conditions, routing and status information across the study area.	• The clearinghouse will aggregate information from several sources including localities, VDOT, private data providers, etc. • The data elements needed for freight include: ○ Restrictions information ○ Incidents ○ Traffic information ○ Routing ○ Parking ○ Work zones ○ Queuing ○ DMV permitting ○ Hazmat information ○ Weight restrictions (static and dynamic)
	3. **Need to consider non-local truckers when providing information.** A portion of the truck traffic in the study area is not familiar with the roadways and truck restrictions.	i. Provide comparative travel times at key decision points in the network, particularly to help non-familiar truckers.	• There are contractual issues between VDOT and toll companies.
	4. **Need for truck parking availability information.** Parking information is helpful to truckers during major incidents and traffic congestion. Truckers tend to park on ramps and shoulders if they cannot locate empty parking spaces.	i. Collect and disseminate truck parking information. ii. Overlay truck parking information with traffic information.	• There are no parking lots within approximately 50 miles of D.C. • The truck parking information can be provided to truckers for parking lots in advance of reaching the study area. • In combination with traffic information the parking availability information can help truckers decide if they should park and wait for the congestion to clear.
The delivery of in-vehicle traffic information is hindered due to lack of interoperability between truck systems and the infrastructure.	5. **Need interoperability to facilitate in-vehicle communication between information dissemination and truck systems.** Interoperability between in-vehicle devices and infrastructure irrespective of the manufacturer,	i. Collaborate with in-vehicle system providers such as Qualcomm, Rand McNally, TeleTRACS, etc., to push traffic information to in-vehicle systems.	• Carriers who deliver items such as perishables, newspapers, couriers, etc., particularly during the morning peak hours have no choice but to sit in traffic.

Issues	Needs	Candidate Strategies	Notes
	vendor or service provider is essential for disseminating in-vehicle traffic information to truckers.		
Trucks queuing up at the Dulles Airport freight terminals for deliveries and pick-ups cause traffic bottlenecks.	**6. Need for queuing information at Dulles Airport.**	i. Combine parking information (strategy ii) with queuing information at the freight terminals.	• This need was added after the meeting based on inputs from MWAA.
Topic: Truck Routing			
Currently detour routes are primarily developed for passenger vehicles.	**7. Need to give consideration to freight and related roadway restrictions when developing detour routes.** Detour routes setup for work zones, special events, emergency roadwork, etc., can lead truckers to restricted routes.	i. Develop truck routing plans similar to TIM plans. ii. Before developing rerouting plans, check if the route has heavy truck traffic. iii. Overlay O-D data with truck routes. iv. Develop guidelines for routing truck traffic.	• Phase 1 of the clearinghouse development can include static information such as TIM routing plans for freight, overlay of truck restrictions information in the 511 map and origin destination data.
	8. Need to communicate changes to roadway restrictions to the trucking industry in advance. Temporary or permanent changes to roadway restrictions can potentially cause traffic issues and economic loss to the trucking company if the changes are not communicated to them in advance.	i. Overlay truck restrictions information as a layer in 511 maps.	• VDOT already checks truck restrictions before implementing detour routes. • Working in coordination with the trucking associations, there may be an opportunity for VDOT and the trucking industry to educate each other regarding routing issues and processes.
The bidding process for delivery contracts is usually based on route distance (mileage). Truckers frequently prefer to sit in traffic rather than detour due to roadway restrictions, contract terms, legal, safety and economic issues.	**9. Need to provide more route options for freight.** Currently, freight operators have limited route options in the study area due to restrictions on several roadways.	i. Consider US 50 to 7 corners as an alternate to I-66 to 7 corners. ii. Provide traffic alerts on I-95 to help truckers decide if they want to use US 15, 17 or Fairfax County Parkway.	• US-50 has structural issues, 8-ton limit and restrictions. • By code, VDOT's Through Truck Restriction program doesn't apply to independent cities that maintain their own roads (e.g. Route 7 in Falls Church). • Even though the formal policy does not apply in cities, there may be some points that need consideration, for instance: ○ If through trucks were restricted on Route 7 in Falls Church, trucks could legally use Route 7 to access a local destination, and would not violate the restriction if they turned off of Route 7 at any intersection in the City. ○ The City may want to study how many trucks are really "through trucks" and how many are serving local businesses. Usually localities don't want to prohibit trucks from accessing local businesses because this can have severe economic implications. ○ Consideration should be given to institutional issues if the City is perceived as routing trucks outside its boundaries into Fairfax County. • Most truckers tend to avoid I-95 and use US-15, US-17 or Fairfax County Parkway.

Issues	Needs	Candidate Strategies	Notes
Topic: Incident Management			
It normally takes longer to clear incidents that involve trucks. There are limited resources for clearing truck incidents.	**10. Need to reduce incident duration for truck incidents.** Incidents involving trucks can lead to major congestion. Lack of proper equipment and tow trucks to clear the lanes, and liability concerns frequently lead to longer incident durations.	i. Conduct incident response training for incidents involving trucks. ii. Create a response team for smaller truck incidents.	• Towing industry may not like this strategy. • Identifying truck incident hotspots in advance based on historic data may help with quicker incident response. • There are limited tow companies with the proper equipment to clear tractor trailers. • Lack of guidelines on tow pricing is an issue for trucking companies. • Most trucking companies develop emergency response contingency plans including preferred tow truck company information for non-emergency situations. • VSP requests tow trucks using a list of preferred tow truck operators in the study area.

ICM Resource Forums #2; Focus Area: Bicycles & Pedestrians

Summary of Candidate Strategies

Traveler Information and Tools:

- Develop a regional, crowdsourced bicycle “level of comfort map” (similar to Arlington County’s existing map) that is interactive and mobile-friendly.
- Provide education and outreach via social media platforms and other forums to let riders know where they can find information about trail closures.
- At real-time information displays, include bicycle-related information in addition to Capital Bikeshare. For example, include alerts on trail closures and advertisements for bike lockers.
- Integrate bicycle and pedestrian movements into a “one-stop-shop” multi-modal trip planning tool.
- Incorporate amenities such as availability of bicycle racks into trip planning tools.

Expanded Monitoring of Conditions:

- Deploy bike-ped counters at targeted locations, such as along trails or cordons around central business districts.
  - Make this count data publicly available via an API.
- Develop reporting platform that allows riders to report maintenance or safety issues.
  - Provide education/outreach on how to call/report these issues (such as via signage on trails).

Bicycle and Pedestrian Integration with Transit:

- Provide for the ability for short-term bicycle locker reservations at Metrorail and VRE stations.
- Work with PRTC and Loudoun to allow bicycle storage on the side of coach buses (if this is not already part of the policy).
- Integrate bikeshare as part of any transit payment technology that will be developed in the future.
- Place a symbol or etching on VRE car windows and along platforms for railcars in which bicycles are permitted.
- Work with WMATA to modify policy restricting bicycles on railcars to be based on crowd loads rather than restricting based on a time-of-day schedule.

Problem Statement

Bicycle and walking trips are often part of the first mile or last mile to a non-automobile trip such as transit. Strategies are needed to make transit and modal shifts more accessible and easier to use for bicyclists and pedestrians.

Issues	Needs	Candidate Strategies	Notes
Topic: Data and Traveler Information Needs			
Potential bicyclists are hesitant to take trips if they are unfamiliar with local roads, as many major arterials near activity centers may not be comfortable for biking. At the same time, nearby parallel facilities may already exist which could more safely accommodate bike trips if riders are made aware.	1. **Need a "level of comfort" map for unfamiliar riders**. Arlington County has a detailed "level of comfort" map for cyclists, and VDOT recently released a similar set of maps for Northern Virginia in a 2015 study. Ideally, these maps would be integrated into a mobile-friendly format and updated as new facilities are planned and constructed.	i. Develop a regional, "crowdsourced" bicycle "level of comfort" map. ii. Engage a third-party provider to develop this map. Stakeholders noted that a private citizen has already been working on this in Arlington. iii. Seek out a regional party, such as MWCOG/511 or a university research facility such as RITIS to facilitate the development of this map across multiple jurisdictions. iv. Integrate this project with ongoing efforts such as Arlington County Commuter Services' CarFreeAtoZ effort or VDOT's ongoing bicycle facility mapping outside of Arlington County.	• Stakeholders noted that the ADC map used to be this solution, but it needs to be updated. • Stakeholders emphasized that the major need is for data outside of Arlington County. • VDOT has data for external, neighborhood routes. • Fairfax County has data in its GIS on ownership of trails. • This project could be integrated with trail use data from STRAVA and O-D data from Capital Bikeshare. • This tool needs to be updated periodically. It may be worthwhile to include MWCOG for this effort. • Will VDOT/MWCOG be replicating Google's efforts? Or could they supply data to Google to enhance Google's trip planning tools? • Whichever strategy is targeted, this effort could be integrated with a "one-stop-shop" trip planning tool (see Item 3).
Bicyclists are often unaware of important information on major bike facilities, such as incidents, closures, or maintenance which could necessitate the need to divert to a different facility.	2. **Need real-time information for riders**. This includes crowd-sourced data such as incidents or closures.	i. Provide education and outreach on social media platforms for alerts. ii. Utilize the BikeArlington forum and integrate this forum with other social media outlets or a system such as 511.	• Stakeholders emphasized that the major need here is up-to-date information on alerts and closures of trails. • Riders desire not just information on closures but directions to alternate routes when trails are closed. • Currently there is no mechanism for centralized reporting of trail closures to a clearinghouse. • Similar to efforts in (1) and (3), it is imperative that data going into this system is accurate and is continuously updated.
Travelers have tools to assist with multi-modal trip planning, but there is still no "one-stop-shop tool" that allows one to plan to drive or bike to access transit, such as via a park-and-ride lot. Travelers currently use multiple traveler information tools to plan trips, making it tedious to find a consolidated set of information about all modes and impeding multi-modal trips.	3. **Need a one-stop-shop tool for multi-modal trip planning.** This tool would present travelers with options for driving, biking, walking, or using another form of transportation such as ridesharing, to access high-capacity transit.	i. Develop a one-stop-shop multi-modal trip planning tool. ii. Integrate this tool with the regional, crowdsourced bicycle level of comfort map in proposed for addressing need (1).	• Bike level of comfort / "Level of Traffic Stress" (LTS – bike comfort performance measure) should be included in a trip planning tool.
Topic: Capital/Technology Deployment Needs			
Some major park-and-ride facilities and rail stations do not have adequate accommodations for storing bicycles, especially in light of policies that restrict	4. **Need improved bicycle storage facilities and information about these facilities at targeted Metrorail/VRE/park-and-ride stations.** This can include bike parking (long-term and short-term) and	i. Incorporate amenities such as availability of bicycle racks into trip planning tools. ii. Provide the ability for short-term bicycle locker	• Arlington County has an online tool to allow riders to locate nearby bike racks. • VDOT has information online on its park-and-ride website on whether

Issues	Needs	Candidate Strategies	Notes
bringing bicycles on transit vehicles. Travelers may have adequate access to a station via sidewalks and trails, but are constrained by a lack of space to store a bicycle.	cages/lockers, as well as the ability to make short-term locker reservations at Metrorail and VRE stations.	reservations at Metrorail and VRE stations.	or not a location has a bike rack. • Could a mechanism be developed to allow riders to "request a rack"? There may be issues with ownership and who would install (public/private, etc.). • Stakeholders emphasized the need to provide variation in bicycle storage amenities ("out-in-the-open" racks versus lockers to hide bikes). • WMATA's bicycle locker facilities are for reserving and renting for a one-year period. Other examples, such as in San Diego, allow short-term reservations. • UMD had a free bike lock program with serial numbers/ability to track a stolen bike. Arlington has a similar system with bike reservations.
Capital Bikeshare has seen significant growth and success in the inner core jurisdictions (D.C., Arlington, and Alexandria); there are activity centers in outer jurisdictions in the East-West corridor, such as Tysons and Reston Town Center, which are amenable to deployments and have major rail stations (or future rail stations).	5. **Need expansion of Capital Bikeshare locations**. These deployments are especially needed near outer jurisdiction Metrorail stations, including future Silver Line Phase II stations.	i. Develop cooperative agreements between transit agencies and bikeshare.	• Fairfax County has ordered approximately 15 Capital Bikeshare locations for Fall 2016 deployment in Reston and Tysons. • Capital Bikeshare deployments are funded by individual jurisdictions (although private developers can also fund). • The City of Falls Church has applied for a grant to fund and deploy Capital Bikeshare. • Examples of cooperative agreements between transit agencies and bikeshare include an integrated back office payment system used in Salt Lake City and comprehensive cooperative agreements in cities such as San Francisco, Montreal, and Philadelphia (strategy and examples were provided by Peter Ohlms (VTRC) after the forum workshop).
A bicyclist taking a commuter bus from Loudoun County or Prince William County to inner jurisdictions such as Arlington or D.C. cannot bring his or her bike on the bus if needed for the last-mile portion of the trip.	6. **Need bike racks for commuter buses from Loudoun County and Prince William County.**	i. Work with PRTC and Loudoun to allow bicycle storage on the side of coach buses (if this is not already part of the policy).	• Drop-off locations may impose restrictions on the ability to bring bikes along. • Should this conversation take place with the transit agencies or the bus contractors?
Travelers desire the ability to use one mechanism to pay for transit trips, bikeshare, and other non-automobile modes such as ridesharing. However, it is important to keep in mind equity issues and maintain the option for transit riders to pay with cash.	7. **Need an integrated payment system among transit, bikeshare, and other non-automobile modes that maintains a cash option.** WMATA and other transit agencies are currently in the process of planning for the New Electronic Payment Program (NEPP) as a replacement to the existing SmartTrip system, while Capital Bikeshare requires a credit card or key fob.	i. Include bikeshare as part of any payment technology that will be developed in the future.	• WMATA's New Electronic Payment Program (NEPP) has been canceled as of Spring 2016. • Capital Bikeshare contacted WMATA and was engaging in conversations with the agency when NEPP was alive. • Capital Bikeshare has explored near-field communications (NFC) for payments, although capital costs are currently an issue. Capital Bikeshare is also exploring QR codes or the ability to have a code sent to a rider's phone if they are at a station. • Payment for bikeshare can be integrated with parking payments or toll payments (Express Lanes)

Issues	Needs	Candidate Strategies	Notes
At major activity centers with high pedestrian volume, many travelers may be unaware of the variety of transit or bikeshare options likely to be available to them.	8. **Need more real-time information displays on multi-modal travel options deployed at targeted major activity centers.** Other jurisdictions have expressed interested in expanding deployments of information displays currently at major transit hubs in Arlington County and at the Tysons Center mall.	i. At real-time information displays, include bicycle-related information in addition to Capital Bikeshare. For example, include alerts on trail closures and advertisements for bike lockers.	• Fairfax County is deploying 15 new Capital Bikeshare stations in Reston and 14 new stations in Tysons in Fall 2016. • Open data is key for including additional information, such as trail closures, on real-time displays.
Commuters cannot always wait until they are ready to travel to consider their travel options. They often need/want to plan ahead.	9. **Need for historical/trend/behavior data to support predictive modeling**. Predictive modeling outputs based on real-time travel conditions will allow travelers to gain a good understanding of potential future conditions of their commute should particular travel mode(s), route(s) or a combination thereof be used, equipping them with enough information to choose their most suitable travel option(s).	i. Deploy bike-ped counters at targeted locations, such as along trails or cordons around central business districts. ii. Make count data publicly available. iii. Deploy bike-ped counters along the future I-66 Outside the Beltway mixed-use trail.	• VDOT is adding 10 count locations as a cordon around Tysons (FY17 through MWCOG). VDOT also has a screenline count set up along the I-66 area in Arlington. • VDOT's count data needs to be requested by a potential user of the data. • VDOT has begun discussions on starting research on statewide bicycle data collection. This information is needed for justifying maintenance funding. Stakeholders expressed a need to have the inventory of data include the maintenance owner and maintenance history. • Arlington County's trail count data is available online. •
Topic: Policy/SOP Needs			
Bicycles are currently allowed on VRE trains, but only on certain cars. Travelers may not be aware of which car this is and would like for this to be clearly delineated.	10. **Need to provide clear signage on VRE trains to identify railcars that allow bicycles.**	i. Place a symbol or etching on car windows and along platforms for railcars in which bicycles are permitted.	
Bicycles and wheelchairs compete for the same space in VRE rail cars. Bicyclists have to give up space to wheelchairs, and policy dictates that if a wheelchair customer enters the train, the bicyclist needs to remove himself from the train.	11. **Need to revisit policy for accommodating bicycles and wheelchairs on VRE.** Ideally, policy will allow for bicycles and wheelchairs to be accommodated together on a train.	TBD	• Follow-up with VRE regarding their bicycles and wheelchair policy.
Currently, bicycles are not allowed on Metrorail cars during peak periods (7-10 AM and 4-7 PM on weekdays). However, in the corridor study area, there exists capacity for bringing bicycles aboard in the "reverse commute" direction on the Orange and Silver lines during these periods.	12. **Need to revisit policy for accommodating bicycles during peak periods on Metrorail for "reverse commutes".** This should include an assessment of overall impacts at stations and platforms, as even if train cars in the reverse direction are not crowded, platforms may still be crowded.	i. Work with WMATA to explore a policy to restrict bikes on railcars based on crowd loads rather than time-of-day.	• Metrorail is one of the few heavy/commuter rail systems in the U.S. with an hours-based policy rather than a crowd-based policy for bringing bicycles on the train. • Stakeholders noticed that this policy would be especially useful for reverse commutes.
VDOT should include budget for maintenance and repaving of trails/sidewalks when an adjacent road is repaved.	13. **Need policies to prioritize trail and sidewalk maintenance.** Currently, there is existing policy for curb ramps, but not for trails.	i. Provide more signage for areas of trails likely to flood or be muddy, as well as unsafe areas. ii. Develop a "one-stop shop" platform to allow riders to report maintenance or safety issues. This could be an email or text forum for reporting. iii. Provide education/outreach on how to call/report trail issues (such as signage on trails). iv. Consider integrating bicycle level of traffic stress (LTS)	• Stakeholders noted this existing difficulty that riders have with reporting maintenance issues of sidewalks or trails. For example, for safety/sweeping issues on VDOT trails, a rider can report to VDOT's pothole maintenance, but may meet a "dead-end" if a trail or sidewalk is not owned by VDOT. Reporting should be handled via a "one-stop shop" – either an automated process such as a 511 redirect or an SOP. • Arlington County prioritizes trail snow removal/maintenance by counts (and measures "recovery time" using counts). Arlington has built-in

Issues	Needs	Candidate Strategies	Notes
		with annual HB2 scoring. Scoring for paving could be included as well.	counters on their trails.
Bicyclists are often confused or unsure of how to proceed upon approaching busy intersections. This can be a deterrent to taking bike trips.	**14. Need policies to continue to incorporate bicycles and pedestrians in intersection planning**. This could include green boxes designating bicycle stopping locations; incorporating bike lanes into roundabouts; and reducing cycle lengths to reduce wait time for pedestrian crossings.	i. Allow for automated requests for retrofitting traffic signals for trails. ii. Deploy automated bicycle/pedestrian detection at intersections with high counts as opposed to pushbutton requests.	• At crosswalks, VDOT has new guidance for automatic pedestrian recall (signal timing setting to automatically bring up a pedestrian phase) for crossing side streets during certain times of the day. VDOT noted that it is difficult to institute such a policy for crossing the mainline of an arterial. • There are examples of locations in which existing signals have been “retrofit” to allow automatic pedestrian recall. At Gallows Road where the W&OD trail crosses, the cycle length was cut in half to reduce bike/ped wait times on the weekends and in the middle of the day. VDOT has expressed that it is interested in expanding this is the type of solution.

ICM Resource Forums #2; Focus Area: Innovation

Summary of Candidate Strategies

Expanded Real-Time Conditions Data:

- Utilize partnerships with the private sector for arterial data, such as Waze's connected citizen program or Metropia. This could include smartphone data as these data sets are enhanced in the future.
- Use connected vehicles as probe data along roadways in which VDOT has deployed roadside infrastructure in the ICM corridor.
- Deploy Bluetooth or wifi sensors along targeted corridors.
- Deploy drones for real-time data collection.
- Share transit AVL datasets with arterial/highway operators via a centralized data warehouse.
- Encourage agencies to make all data machine-readable.
- Leverage technologies to provide predictive, user-centric information covering end-to-end trips.

Connected and Autonomous Vehicle Deployments:

- Dedicate lanes or shoulders (or potentially managed lane systems) for CV/AV use, especially transit with CV/AV technologies such as cooperative-adaptive cruise control.
- Deploy VDOT's multi-modal intelligent traffic signal system in targeted locations to facilitate CV/AV communications with signals.
- Develop partnerships with private sector for applications using CV/AV corridors in the ICM study area.

Education, Outreach, and Incentivization:

- Facilitate and partner with private sector solutions currently incentivizing carpool and ridesharing (UberPool/UberCommute, Bridj, Via, etc.).
- Consider "pricing" for parking, such as dedicated carpool spaces or off-peak spaces.
- Include information on underlying costs, including energy consumption, in trip-planning tools.
- Consider discounts for off-peak travel on the Dulles Toll Road.
- Include bikeshare, carshare/rideshare, managed lanes, etc. as part of any payment technology that will be developed in the future.
- Provide reimbursement or credit for managed lane tolls when utilizing transit.

Problem Statement

Innovative, multi-modal, outside-the-box solutions are needed to compensate for limited excess capacity and optimize traveler choice.

Issues	Needs	Candidate Strategies	Notes
Topic: Data			
Data on arterial conditions in the study area are not uniformly available. Some portions of some arterials are outfitted with cameras and sensors, though, by and large, the roadways are not instrumented. Third-party services report on arterial conditions, but have tended to be judged unreliable.	1. **Need for accurate, reliable, real-time information on travel conditions along the pertinent arterials in the study area.** The information is needed both by operators (VDOT, localities, and other partners) and travelers.	i. Utilize partnerships with the private sector for arterial data, such as Waze's connected citizen program. ii. Deploy Bluetooth or wi-fi sensors along targeted corridors, which can re-identify trips to provide estimates of speed and travel time. iii. Utilize smartphone data. iv. Deploy drones for data collection. v. Utilize third-party data providers such as Metropia. vi. Use connected vehicles as probe data given that VDOT already has connected vehicle communications infrastructure deployed along arterials within the ICM corridor.	• Waze's Connected Citizen Program is currently being integrated with RITIS, with an agreement that they can pull data from any of Waze's agency partners. VDOT is exploring such a partnership. • The accuracy and reliability of real-time arterial data still needs to be vetted considerably. The DOT has a role here. • Waze's arterial data is still limited, although they do have some historical data from Google. • Connected Vehicles (CVs) as probes for real-time data may be 5+ years away. • In Northern Virginia, VDOT's connected corridors provide the ability to build applications on the CV infrastructure to reach out to travelers even if the penetration rate will not be high. For example, VTTI is developing a "virtual DMS" via an app. • Virtual weigh stations can provide data as well.
Information on real-time conditions on transit systems in the study corridor is not consistently available. Transit agencies are at different places in technology deployment regarding their ability to identify accurate, real-time conditions. Even when information is available, it tends not to be uniform across agencies.	2. **Need for accurate, uniform, reliable, real-time information on transit schedule and travel conditions.** The need for this information extends to commuter parking lots.	i. Transit agencies should share AVL datasets with arterial/highway operators. ii. Encourage agencies to allow centralized data warehouses such as RITIS to share data externally.	• Open data is a concern with some on-board transit technologies. • This is discussed in further detail in the Transit/TDM forum as well. • Barriers to entry should be kept low. Localities should not need to reinvent the wheel to share their data. Platforms such as RITIS are built to work with different formats of data. A data dictionary is key, however. • RITIS is currently pulling in AVL data from Montgomery County and Arlington, but not WMATA yet. A centralized data source first needs to obtain the data from agencies and then have these agencies approve of sharing. RITIS is currently archiving this data but is not actively engaged in analysis/analytics as of yet.
Travelers in the Washington, D.C. region are often frustrated by their inability to reliably determine the time a trip will require. Some commuters may be open to shifting routes, modes, travel times, etc. if information laying out the comparative choices was available to them.	3. **Travelers need on-demand real-time and predictive, user-centric information covering end-to-end trips.** The information is needed both pre-trip and en-route. There is a need for improved routing and predictive algorithms. Customers need to be presented with their real-time travel options, including comparative travel times, basic benefits/costs, etc. One challenge: as customers are encouraged to re-route to arterials or transit, assessments will routinely need to be made about the alternative systems' abilities to accommodate the additional traffic	See related strategies in the Traveler Information Resource Forum Strategies Matrix.	• The private sector is leading the way in developing trip-planning tools. The government's role should be ensuring data standards and policies for now. • The challenges with WMATA's currently-canceled New Electronic Payment Program (NEPP) should serve as an example – for comprehensive tools such as this, all stakeholders need to be on board. • Predictive tools should be able to re-route across modes and work in real-time.

Issues	Needs	Candidate Strategies	Notes
	volumes.		• 511 is not a navigation system. However, Arlington's "CarFreeAtoZ" (name will change to include cars) is being integrated with 511 (accounts for historical data and links trips). This solution will cover the entire region. This tool's integration with 511 is still part of the I-66 TMP. • UMD is developing a smartphone application which can function as a predictive trip-planning tool for the D.C. area. • Should such a tool be extended beyond the public sector?
In addition to the commuter populations served in the study area, a tremendous number of tourists visit the region year-round. These tourists often need specialized guidance, and tend not to be familiar with the conventions of the region, such as "Inter- and Outer-Loop."	4. **Need for traveler information tailored to tourists.** This information might include real-time travel time to major tourist destinations, and guidance on navigating the region's travel alternatives. Availability of the information at common tourist venues is also needed.	i. Provide information on real-time information displays.	
The role of public and private organizations in the collection, management, and delivery of traveler information is evolving rapidly. For instance, VDOT is currently grappling with future directions for its own 511 program.	5. **Need to define the role of VDOT and its partner agencies in the collection, management, and delivery of traveler information.** This includes clarifying the roles of public agencies as data-collectors vs. data-providers vs. data-facilitators; and their roles in data-standardization, data-warehousing, etc. Also need to clarify the role of private entities in the traveler-information arena.	ii. Encourage agencies to make all data machine-readable.	• The public sector has a role as a facilitator and data broker. • There is a reluctance from some public agencies to give out data if it cannot be limited. • Is it the government's role to create a "one-stop-shop" app or rather to collaborate with each other and encourage data to be shared? • The government has a role to helping underserved populations (enhancing mobility, not just congestion relief). There are services in existence that jurisdictions provide (paratransit) that could be significantly enhanced with technology.
Topic: Data-Sharing and Information Delivery			
For many of the agencies and jurisdictions responsible for the operation of roadways, transit systems, etc. in the study area, information-sharing is not routine. Operations organizations are often ignorant of the data, video, etc. their partner agencies have.	6. **Need broad-based coordination and sharing of information between public agencies, and between public agencies and private entities.** Need to clarify data-ownership and data-sharing issues. Data-sharing needs to be routine and ubiquitous among partner organizations. Need the MOU's and staff in place to support and coordinate the information-exchange. Also, when one entity gains access to new or third-party data, ideally need	i. Use platforms such as RITIS for data sharing.	• Data needs to be machine-readable. • Localities should not need to reinvent the wheel to share their data. Platforms such as RITIS are built to work with different formats of data. A data dictionary is key, however.

Issues	Needs	Candidate Strategies	Notes
	negotiated agreements, legal authority, and distribution mechanisms to share the data among partners. Data standards and data formats need to be agreed upon.		
As data-sharing expands, there is concern about increased data-security risks. For instance, data sent from one agency to another could be maliciously altered, as could information for the public displayed on DMS. Signal control data could be intercepted, altered, and manipulated.	7. **Need for a data-security management plan.** Data "pushing" – rather than data "pulling" – may help mitigate security risks.	i. Develop data-security management plan.	• Security is a concern for the centralized data warehouse, decision support systems, etc.
Over the next several years, very significant changes in how information is delivered to travelers are anticipated. These are expected to include in-vehicle delivery of information via heads-up windshield displays, etc. At the same time, not all travelers will have access to the latest technology at the outset. Also, demographic, economic, and generational differences in how technology is embraced and used will need to be taken into account.	8. **Need to leverage and build on new, emerging technologies and mechanisms for delivering information to travelers.** Even as the new technologies evolve, however, there will continue to be a need to accommodate and support information delivery using more traditional approaches. Need to evaluate relationship in information delivery between DMS, smart devices, and in-vehicle.	TBD	
Topic: Alternative Travel			
Beyond personal vehicles and transit, a range of alternative travel modes and mechanisms are theoretically available to travelers as they navigate their way across the study area. These include the exclusive or supplemental use of one or more of the following: carpooling and ridesharing, biking, walking, car-sharing services (e.g., Zipcar), transportation network company (TNC) services (e.g., Uber and Lyft), and "slugging." Slugging, which has been popular on the I-95/I-395 corridor into Arlington and Washington for several decades, has never really caught on along the I-66 and RT-267/Greenway corridors. Also, first-mile/last-mile travel is a recurring issue for transit users.	9. **Need strategies to promote the use of alternative travel, when appropriate.** Need to determine which modes/services should be added to the menus of options presented to travelers. Need to determine how much information on alternative travel services is appropriate to gather and present to travelers.	TBD	• Uber has public sector partnerships with transit agencies, such as commuter rail in Orlando and MARTA in Atlanta. Uber is exploring partnerships with paratransit.
Topic: Payment			
Inflexibility in the payment options available to travelers across different travel modes and services is often inconvenient, can cause backups and delays, and may discourage multi-modalism.	10. **Need to accommodate multiple forms of payment across multiple modes and services.** As appropriate, forms of payment might include: toll tags, Smart cards, cash, debit cards, credit cards, prepaid accounts, Smart phone apps, etc.	ii. Include bikeshare, carshare/rideshare, managed lanes, etc., as part of any payment technology that will be developed in the future.	
Topic: Signalization			
The timing of traffic signals is a potentially important tool for managing the flow of traffic along arterials. Rather than always have signals cycle through preset timing sequences, traffic signal timings can be modified to respond to changes in travel conditions, give priority to transit vehicles and emergency vehicles, etc. Work is under	11. **Need to harness traffic signalization to optimize traffic flow along arterials.**	See strategy for CV/AV – deploy VDOT"s multi-modal intelligent traffic control signal system in targeted locations. Follow-up with Sanhita on what this technology entails.	

Issues	Needs	Candidate Strategies	Notes
way by VTTI and others to accommodate automated vehicle travel along arterials – e.g., vehicles traveling at a specified speed would be able to pass through a succession of traffic lights without stopping.			
Topic: Automated and Connected Vehicles			
Activity is underway in the study area on the topic of automated and connected vehicles. The study area includes a federally-funded test-bed for connected vehicles.	**12. Need to define the role of automated vehicles in the ICM plan.** In general, the ICM plan must be sufficiently fluid and flexible to accommodate future emerging technologies and innovations.	i. Develop partnerships with private sector for applications using CV corridors in the ICM study area. ii. Dedicate lanes or shoulders (or potentially managed lane systems) for CV/AV use, especially transit with CV/AV technologies such as cooperative-adaptive cruise control. iii. Deploy VDOT's multi-modal intelligent traffic signal system in targeted locations to facilitate CV/AV communications with signals.	• VDOT should continue to advance the CV/AV environment in the ICM corridor – pilot implementations, not just research. • VDOT/VTTI currently working on AV Level II vehicle deployments. • CV/AV communication back to the public sector for early adopters. • AV technology is currently in the midst of two different models: sensor-based versus AI-based. • Potential equity issues with having dedicated capacity for CV/AV on corridors. These issues could be mitigated if transit is connected/autonomous. • If buses are run on narrow shoulders, this could be an issue with EMS. • Need to consider CV/AV synergy with freight/trucks. The CV/AV corridors could be a platform or test bed. Truck fleets turn over rapidly and already have specialized technology such as AVL which could be incentivized.
Topic: Education, Outreach, and Incentivization			
Educating the public about transportation options may help to promote a climate of congestion management and energy conservation. Travelers often do not know how to go about identifying and evaluating their transportation options.	**13. Need to educate the general public on available transportation options, benefits/costs, etc.** Need to encourage travelers to consider options that are not automobile-centric. Need to promote activities with employers to encourage more telecommuting, flexible work schedules, etc. Shift the conversation from "moving vehicles" to "moving people."	i. Consider pricing parking as opposed to continuing to subsidize "free" parking. "Pricing" could come in the form of dedicated carpool spaces of off-peak spaces. ii. Include information on underlying costs, including energy consumption, in trip planning tools.	• Stakeholders agreed that travelers need to be educated on the underlying needs and costs. • Education is needed on "what to do with my car". Should this be professional marketing / branding? Community outreach? • Pricing and "making things more expensive" can be politically sensitive. • Consider potential intended consequences of incentivizing.
"Good" commuter behavior may be worthy of nominal reward.	**14. Need to define strategies to incentivize "smart traveler" choices.** Need to structure approach to monetize benefits (e.g., reduced delay) in relation to investment. Ideally incentives are in the form of investments back into the programs, rather than "external" rewards.	i. Private sector solutions currently incentivizing carpooling/ridesharing include UberPool/UberCommute and Bridj/Via (operating in D.C.). ii. Consider toll discounts for off-peak travel on the Dulles Toll Road.	• Discounts for off-peak are built into the pricing algorithms for HOT lanes already. This strategy may not be feasible for the DTR, either, given that toll revenues go toward the Silver Line extension.
Topic: Performance			
As part of the ICM program, mechanisms should be put into	**15. Need to define and implement measures of effectiveness (MOE's) to assess performance.**	i. Define and apply the performance metrics.	

Issues	Needs	Candidate Strategies	Notes
place to monitor and evaluate success.	Emphasize person-throughput, rather than vehicle-throughput. Assess impacts on delay, travel-time reliability (over-the-road, transit, etc.), and energy consumption.		

ICM Resource Forums #2; Focus Area: Incident and Emergency Management

Summary of Candidate Strategies

Data Sharing and Expanded Communication between Agencies:

- Integrate each agency's CAD feeds as independent one-to-one agency links or using a centralized tool.
  - Utilize CAD feeds or a centralized tool to share information about planned roadway closures between agencies.
  - Establish policies that allow the sharing of localities' dispatch feeds.
- Procure 800 MHz portable radios for VDOT personnel to enable communications with localities.
- Upgrade or replace the STARS system to allow communications between VSP and localities.
- Provide training and refresher courses on incident management concepts to first responders, including cross-jurisdictional table-top exercises.

Incident Response in the Field:

- Use third-party data to identify real-time conditions on freeways and arterials.
- Develop a partially or fully-automated multi-modal decision support system to allow agencies to understand collective roles and responsibilities.
- Provide advanced messaging to inform drivers to move way from blocked shoulders/lanes, such as in-vehicle messaging to vehicles with CV technologies.
- Upgrade signal preemption systems, including on-board equipment and roadside equipment from infrared technology to a GPS-based preemption system.

Problem Statement

Incidents impacting travel need to be cleared in a safe, efficient and effective manner, across all modes, utilizing proper communication and collaboration with appropriate partner agencies.

Issues	Needs	Candidate Strategies	Notes
Topic: Data Exchange and Situational Awareness			
Communication and data sharing between appropriate agencies is sometimes inefficient and there are barriers to some agencies sharing information.	1. **Need a more robust information exchange capability among emergency responders.** There is a need for an enhanced method of information exchange among the fire, police and transportation dispatchers at the state, city, and county levels. This exchange of information will help manage incident sites more effectively. 2. **Need for expanded and upgraded communication systems and connections between agencies.** Communications systems between agencies need to be more robust and should extend to the pertinent local jurisdictions.	iii. Integrate each agency's computer-aided-dispatch (CAD) feeds across agencies as independent one-to-one agency links. iv. Alternatively, utilize Capital Wireless Information Net (CapWIN) or RITIS as the central tool for access to incident information across jurisdictions.	• Determine information and data need (incident location, response status, clearance status, detour routes, etc.) • Include arterial incident data. • Identify gaps in information sharing among first responder agencies in the corridor (i.e. identify which agencies currently exchange information and agencies that do not). Create access between agencies that currently do not exchange data. • Identify the capability maturity of each agency in order to determine the potential for integration of and access to incident data feeds. • Enhance CapWIN, if selected as the strategy, to integrate CAD data feeds from first responder agencies in the corridor. • Several first responder agencies in the corridor do not use CapWIN. Training and a tolerance for a change in incident tracking procedures are pivotal to successfully using CapWIN. • Upgrade first responder agencies systems as needed to create the capability to integrated new data feeds or a "new" system – CapWIN. • Establish MOUs and agreements as necessary.
Outside of the interstates, situational awareness of travel conditions on other routes and modes of travel (bike paths, transit corridors, etc.) are lacking.	3. **Need corridor-wide status monitoring across all modes and routes.** ITS devices that can assist with incident and emergency management should be considered for all relevant projects, across all agencies and modes. Also, process and technologies for sharing existing and proposed feeds should be developed and agreed upon by all relevant partner agencies.	i. Use 3rd-party data to identify real-time conditions on freeways and arterials. ii. Perform spot deployments at "hotspots" along the corridor (including arterials).	• Define data needed. • Identify pertinent technology assets already on arterials (e.g., detection, cameras, fiber). • Outfitting "gaps" on arterials with technology likely to be short-sighted and prohibitively expensive. Spot treatments at major hotspots are more feasible. • 3rd party agencies may include WAZE information system, RITIS, INRIX, etc. • Establish a "regional" MOU/agreement with each 3rd party in order to provide access by multiple corridor agencies without the need for multiple agreements. • Identify datasets that could provide for a mutual exchange with 3rd parties.

Issues	Needs	Candidate Strategies	Notes
			• Identify standards and formats for data exchange.
Radios from Virginia State Police (VSP) and localities, emergency personnel (police, fire, EMS, etc.) are not on the same platform. VSP uses Statewide Agencies Radio System (STARS) and the localities' emergency personnel use 800 MHz band (e.g., City of Alexandria)	4. **Need a consistent standard platform for first responder agencies' communication radios.** Several incident responders are unable to communicate via radio en-route to an incident and at the incident scene to share pertinent information that could impact incident response and clearance times.	i. Purchase 800 MHz portable radios for VDOT personnel to enable communications with localities. ii. Perform patch updates to the STARS system to allow communications with localities 800 MHz platform. iii. Perform a total system replacement of either the STARS' or localities' radio system.	• Purchase of portable radios is costly (approx. $7k each) and additional radios are cumbersome for traveling on person. • Patches to the STARS system is done by RPAC-I but is a very time-consuming process. • A system replacement is an unlikely option due to the significant cost and time required.
Emergency response travel routes are not always appropriately accounted for in the development of projects and construction zones.	5. **Need for project review and circulation to the appropriate emergency response agencies.** In the development of projects, the impact to existing emergency response routes is often not considered, including the impacts during construction. Sharing of these project plans could result in less conflict.	i. Utilize RITIS for roadway operations agencies/divisions to share planned closures with first responder agencies. ii. Utilize CAD feeds to share road closures. iii. Continue using the method of phone call notification for "disconnected" agencies in the interim.	• Integrate RITIS data feeds. • Establish protocol that requires operations agencies to share planned closures in advance. • Monitor RITIS feeds for planned closures information. • Have RITIS disseminate "media-ready" planned/emergency road closure information. • Share emergency road closures via phone call and email in addition to using RITIS.
While traffic signal preemption gives "green time" priority to emergency vehicles (mainly fire trucks), it has a negative impact on traffic signal operations, placing the signal timings out of sync and taking a long time to bring the optimized timing plans back to the normal cycle.	6. **Need optimal timing strategies that accommodates both traffic signal preemption and general mobility operations.** Drivers frequently experience extra delay on arterial routes that are caused by emergency vehicles use of signal preemption because it disrupts regular signal timing plans on a corridor. This disruption could impact miles on an arterial. While signal preemption is important for efficient incident response, mobility decreases for drivers and there is a need to accommodate both.	i. Upgrade signal preemption systems (including on-board-equipment – OBE – and road-side equipment - RSE) from infrared technology to the Opticom GPS-based preemption system.	• Build on the concept study that is underway for replacing infrared signal preemption systems with GPS-based system. • Identify signal controllers that require upgrades. • Upgrade signal controllers and cabinets and add new roadside hardware (in the cabinet) to provide capability for a GPS-based preemption system. • Prevent unwanted signal preemption triggers using a GPS-based system, which will use emergency vehicle location for signal activation in instead of line-of-sight.
Topic: On-Scene Operations			
On some roadways drivers do not receive en-route incident location information with sufficient time to move out of blocked lanes where an incident has occurred.	7. **Need better and earlier messaging to inform drivers to move away from the blocked shoulders/lanes.** Drivers, depending on roadway and location, become aware of an incident location at close proximity to the incident, which does not allow adequate time to safely change lanes away from the blocked lane. This poses a safety risk for emergency responders and drivers.	i. Provide in-vehicle notifications. ii. Perform spot deployments of DMS in advance of known incident hotspots. iii. Utilize real-time alerts on social media (e.g. Twitter). iv. Enhance advanced warning signing and TIM area delineation.	• It will take some time for sufficient vehicles to become equipped with connected in-vehicle technology. A counterpart interim strategy should be utilized. • It would take a concerted effort among first responders to provide more advanced TIM area set up. • DMS may prove to be infrastructure- and cost-intensive though is generally a successful strategy

Issues	Needs	Candidate Strategies	Notes
			for informing drivers en-route. • Real-time social media alerts requires dedicated staff and quick communications between first responders at the scene and in-house operations staff.
Topic: Policy and Legislation			
Clearance time for incidents can be elongated by inefficient policies and procedures.	8. **Need for more efficient and effective quick clearance policies.** Policy and procedural changes and agreements between emergency response agencies are necessary to allow quick clearance of critical incidents.	i. Establish policies that allow the sharing of localities' dispatch feeds across jurisdictions. Currently, Fairfax, Arlington and Alexandria share feeds. ii. Share agency CAD feeds across all pertinent emergency responder stakeholder agencies. iii. Establish a standard policy for vehicle towing applicable to all jurisdictions.	• Monitoring multiple agency dispatch feeds provides a quick method of becoming aware of incidents in other jurisdictions. • Establish MOUs and agreements among jurisdictions to enable sharing CAD feeds. • Enhance current traffic management systems to receive CAD data feeds from other jurisdictions.
In emergency situations, agencies tend to focus on their own goals.	9. **Need interactive communication and clearly defined overarching goals among agencies in order to facilitate coordinated response**. Corridor agencies need to work together in order to plan for incident remediation and efficiently execute actions to clear incidents in a timely manner, in order to improve the response to incident events.	i. Provide regular training on SHRP 2 incident management concepts and refresher courses to first responders. ii. Coordinate regular cross-jurisdictional meetings that involve incident management table-top exercises.	• Establish routine meeting dates among first responder agencies. • Identify a "champion" to perform meeting coordination, routinely gather and consolidate inputs into meeting topics, and facilitate meetings and table-top exercises. • Establish routine SHRP 2 training schedules or refresher training for each first responder agency. • Include tow contractors in training exercises.
	10. **Need to establish incident response plans among partner agencies (jurisdiction DOTs, transit, VDOT, law enforcement, etc.)** Corridor agencies need a means to collect and store pre-agreed response plans in order to allow agencies to understand collective roles and responsibilities, communicate effectively and improve response times in responding to events.	i. Develop a fully automated, partially automated or manual multi-modal decision support system (DSS).	• Build from existing decision support methods used by corridor first responders. • Assess the capability of each first responder agency in order to determine the level of sophistication that is possible for the decision support system. • Establish roles for stakeholder agencies in each stage of incident management. • Establish and share FITM plans, arterial operational changes, traveler information plans, etc.
Topic: Evacuation Planning			

Issues	Needs	Candidate Strategies	Notes
Evacuation planning and real-time awareness among emergency operations personnel and the public is lacking.	11. **Need for greater awareness of evacuation plans by emergency operations personnel and the public.** There is a need for agencies to generate continuous awareness of evacuation processes and agencies roles and responsibilities in preparation for potential evacuation events.	TBD	