Appendix A

Statewide ATMS Operating Platform: Concept of Operations

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Draft

DOCUMENT CONTROL

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Version 1.0	November 15th, 2011	Initial Draft Document
Version 2.0	December 16th, 2011	RFI Version

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1 SCOPE

This document serves as the Concept of Operations (ConOps) for the Virginia Department of Transportation's (VDOT's) Statewide Advanced Traffic Management System (ATMS) Operating Platform. The structure of this document is based on the Institute of Electrical and Electronics Engineers (IEEE) Standard 1362-1998, *IEEE Guide for Information Technology – System Definition – Concept of Operations (ConOps) Document*.

VDOT is responsible for building, maintaining, and operating the third largest state-maintained highway system in the nation with almost 58,000 miles of roadways, and serves a large and diverse constituency including citizens, contractors, and its own employees in fulfilling these responsibilities. Like other transportation departments across the nation, VDOT finds itself challenged to make its surface transportation system function more effectively. No longer do transportation agencies routinely have the luxury of undertaking massive new road-building and expansion projects on a statewide basis. Instead, bolder, more innovative approaches must be employed to maximize capacity of the existing transportation infrastructure and achieve heightened operational efficiencies.

To streamline its business and reduce costs, VDOT is implementing several Intelligent Transportation System (ITS) projects. Specifically VDOT is:

- Implementing a consolidated service to manage its Transportation Video & Data Distribution process (referred to as TV&D throughout the remainder of this document).
- Sourcing a new common Statewide ATMS Operating Platform to replace its current Virginia Traffic Information Management System (VaTraffic) and ATMS offerings, to improve interoperability among the systems deployed across its Transportations Operations Centers (TOCs).
- Striving to improve interoperability of the processes across its TOCs through a common Statewide ATMS Operating Platform.

The integration of these initiatives is of critical importance to fulfill VDOT's mission. These efforts also require coordination among the TOCs that are impacted by these business changes.

The need for VDOT to pursue many of these initiatives was identified in the recent *Performance Audit of Significant Operations of the Virginia Department of Transportation*. The audit specifically addresses the need for the agency to deploy communication systems which improve interoperability across the TOCs and other partner agencies.

VDOT currently has five (5) independent ATMS platforms – four (4) OpenTMS (same version) systems and one (1) DYNAC system. Two regions, the Northwest and Southwest Operations Regions are unique in that they are the only two regions to have the exact same software versions and their TOCs have failover capabilities. The five (5) ATMS platforms include local implementations of software modules with local and unique configurations. Examples of these local and unique software models include tunnels, fog detection, highway advisory radio (HAR), gate control, ramp metering, and lane control signals (LCS). VDOT's current ATMS situation results in several challenges, including:

- Numerous standalone systems requiring redundant data entry by operators,
- Limited interoperability between Regional TOCs,
- Inconsistent interfaces to share data across Regional TOCs, and

- Costly and duplicative system environments with varying levels of redundancy ranging from no redundancy, to full redundancy in the Northern Operations Region, to redundancy between the Northwest and Southwest Operations Regions that requires a considerable amount of configuration.

VDOT is conducting a project to develop a new Statewide ATMS Operating Platform that allows for control of ITS field devices and enables information exchange between partner agencies. The goal of the Statewide ATMS Operating Platform is to have a common operating platform for traffic management and operations in the Commonwealth of Virginia.

By implementing a common Statewide ATMS Operating Platform, VDOT's vision is to increase TOC interoperability and leverage technology to achieve more efficient operations and to improve mobility, safety, and the environment in the Commonwealth of Virginia. Using a common Statewide ATMS Operating Platform for traffic management and operations, VDOT can:

- Improve interoperability between Regional TOCs by allowing users to operate the system from anywhere within the state as long as they have appropriate permissions.
- Allow the vendor to provide single roll-out of ATMS enhancements across the Commonwealth.
- Move away from localized software platforms to a common statewide solution, with the potential for long-term savings in software maintenance costs.
- Centralize staff training for TOC operators, Safety Service Patrols, and ITS technicians. Additionally, specialized staff such as network and fiber technicians can be shared among TOCs.
- Consolidate existing systems into a common operating platform that includes the ATMS, VaTraffic, Lane Closure Advisory Management System (LCAMS), Traffic Signal Systems, and Tunnels Control Systems.
- Support remote access to the system from any approved device (e.g., desktops, laptops, tablets, or smartphones) for situational awareness, data entry, and command/control to users with appropriate permissions.

1.1 Document Overview

The purpose of the ConOps document is to communicate user needs for and expectations of the proposed system to its developer. The ConOps document also serves to build consensus among VDOT user groups concerning these needs and expectations. This includes VDOT upper management, VDOT Central Office staff, VDOT Regional Operations Directors (RODs), VDOT TOC Managers, TOC Operators, Operations Planners, system engineers, designers, and integrators. It is expected that users will read the ConOps document to determine whether their representative has correctly specified their needs and desires and that they have been correctly captured in this document. Developers will use the approved ConOps document as a basis for understanding the purpose and scope of the proposed system, and to familiarize new team members with the problem domain and the proposed Statewide ATMS Operating Platform.

This ConOps document will be included as an appendix to a Request for Information (RFI). It will also serve as the starting point for development of functional requirements. The ConOps document and its companion functional requirements will be included as appendices in procurement documents for the Statewide ATMS Operating Platform.

The structure of this ConOps document follows IEEE Std. 1362-1998. It contains the following sections:

- **Section 1** provides an overview of Statewide ATMS Operating Platform ConOps document.
- **Section 2** identifies all documents referenced and interviews conducted in developing the ConOps document.
- **Section 3** describes VDOT's ATMSs as they currently exist. This section is tailored as appropriate to describe the motivation for the development of a new Statewide ATMS Operating Platform and enables readers to better understand the reasons for the desired changes and improvements.
- **Section 4** describes the shortcomings of the current systems that motivate development of a new Statewide ATMS Operating Platform. This section provides a transition from Section 3 of the ConOps document, which describes the current VDOT ATMS, to Section 5, which describes the proposed Statewide ATMS Operating Platform.
- **Section 5** describes the proposed Statewide ATMS Operating Platform resulting from the desired changes specified in Section 4 of the ConOps document. It describes the proposed system in a high-level manner, indicating the operational features that are to be provided, without specifying design details.
- **Section 6** provides a summary of the ConOps document and discusses the next steps for the project as it relates to the Systems Engineering Lifecycle Process.

1.2 Role of ConOps in Systems Engineering Life Cycle Process

The International Council of Systems Engineering (INCOSE) defines systems engineering as following:

> *"Systems Engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem.*
>
> *Systems Engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems Engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs."*

Many different process models have been developed over the years that specify a series of steps that make up the Systems Engineering Life Cycle Process. Among these models, the "Vee" Diagram, shown in Figure 1, has emerged as the de facto standard way to represent systems engineering for ITS projects.

As shown in the "Vee" diagram, the systems engineering approach defines project requirements before making technology choices and implementing the system. On the left side of the "Vee", the system definition progresses from a general user view of the system to a detailed specification of the system design. The system is decomposed into subsystems, and the subsystems are decomposed into components – a large system may be broken into smaller and smaller pieces through many layers of decomposition. As the system is decomposed, the requirements are also decomposed into more specific requirements that are allocated to the system components.

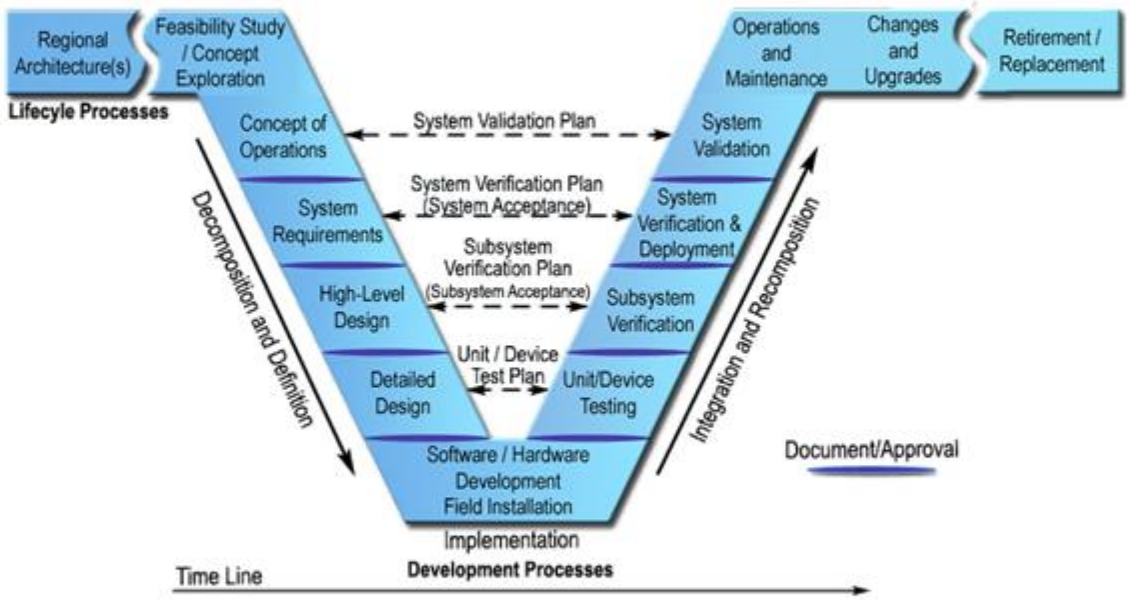

Figure 1: Systems Engineering "Vee" Diagram[1]

The ConOps document serves as the bridge between the early project motivations and the technical requirements. It is technology independent and focuses on the functionality of the proposed system. The ConOps document plays a critical role as it forms the basis for the rest of the project. It is much easier to resolve conflicts and fix bad requirements early in the process rather than building the system from a poor basis. It is also very useful toward the end of the System Engineering Life Cycle Process, as it provides the guidance used to verify and validate the new system.

The ConOps document serves two additional purposes. The first is to communicate the user's needs for, and expectations of, the proposed system. These needs provide a description of the way stakeholders desire to conduct business on a day to day basis. The ConOps document aims to identify high-level user needs and system capabilities later used to develop the requirements of the proposed system. The ConOps document derives from extensive interviews with the stakeholders and users of the current system. The ConOps document development gives stakeholders the opportunity to provide their input on what they want the proposed system to do. The document is the users' document and should reflect all of their needs accurately.

The second purpose is to formulate a consensus from VDOT stakeholders for the new Statewide ATMS Operating Platform. The ConOps document is intended to help form a consensus among all stakeholders to create a single vision for the system moving forward. The ConOps becomes a living document for the rest of the System Life Cycle. It should be updated throughout the lifecycle process as new needs are identified and defined.

[1] *Systems Engineering for Intelligent Transportation Systems*, United States Department of Transportation (USDOT) Federal Highway Administration. http://ops.fhwa.dot.gov/publications/seitsguide/index.htm

1.3 System Overview

The Department's intent is to convert its current ATMS to outsourced software that organizes and delivers an operating platform to manage and operate Virginia's roadways. The scope of the project is to implement a common software platform for statewide use with capability for local device/technology interface and control. Once the Statewide ATMS Operating Platform is implemented, it should allow users to operate the system from anywhere within the state as long as they have appropriate permissions.

An ATMS is a computerized transportation communication system that employs communication technology to gather traffic information from field devices. It uses traffic sensors, environmental sensors, cameras, and other devices deployed along the roadside to monitor traffic conditions. The system enables control center managers to detect traffic incidents and congestion rapidly, and subsequently dispatch resources to the incident scene. Other technologies such as ramp metering, and Active Traffic Management (ATM) strategies, are used to smooth the flow of traffic. Finally, ATMS disseminate real-time information to motorists using devices such as dynamic message signs (DMSs), and HARs.

The new Statewide ATMS Operating Platform will exist in an environment with other transportation and emergency management systems. Figure 2 provides an operational overview of the future system, taking into consideration the following major data terminators:

- **Users** – This includes TOC Operators and other VDOT staff that interface with the ATMS.
- **Tunnel Industrial Systems** – This includes industrial systems at VDOT tunnels that control life critical systems such as ventilation, fire suppression, and water pumps.
- **VDOT Vehicles** – This includes VDOT Safety Service Patrols (SSP) and VDOT Maintenance vehicles and their operators or drivers.
- **Virginia State Police (VSP) Computer-Aided Dispatch (CAD) and Local Public Safety Access Point (PSAP) Systems** – These systems interface with the ATMS providing incident and event data.
- **Other State or Regional Systems** – This includes local transportation systems, other state transportation system, and other regional systems that collect traffic or incident data.
- **ITS Field Devices** – This refers to ITS field devices from which data and video images are provided as well as the devices provide traffic control and access management functions.
- **Integrated Corridor Management System (ICMS)** – The set of procedures, processes, data, information systems, and people that support transportation system managers in making coordinated decisions involving the optimal performance of all transportation networks within a corridor and in executing those decisions in an effective manner.
- **Maintenance and Asset Management System** – This includes systems used to track VDOT maintenance activities, including ITS field devices.
- **VDOT Traffic Signal Systems** – This includes systems used by VDOT to control traffic signals.
- **Customer Service Center (CSC) Portal** – VDOT's call center responsible for taking citizen calls and answer transportation questions 24 hours a day, seven days a week.

- **TV&D Distribution Center** – A centralized Distribution Services Center that makes traffic and video available, in a secure manner, to VDOT's 511 system and other external partners and agencies including the media.

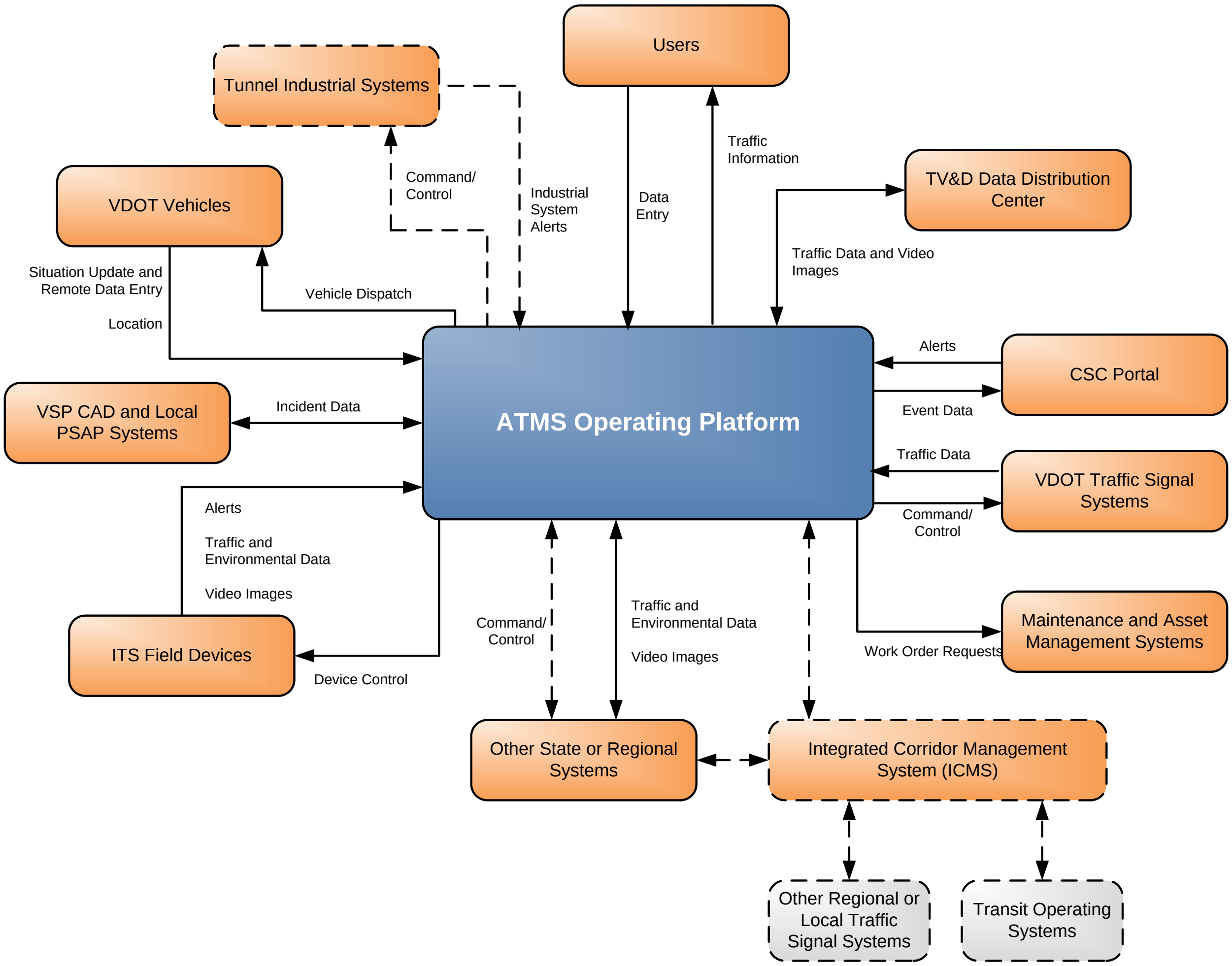

Figure 2: Statewide ATMS Operating Platform

2 INFORMATION SOURCES

2.1 Referenced Documents

The following documents were referenced in developing the Statewide ATMS Operating Platform ConOps document:

- Electrical and Electronics Engineers (IEEE) Standard 1362-1998, *IEEE Guide for Information Technology – System Definition – Concept of Operations (ConOps) Document*.
- I-66 Active Traffic Management (ATM) System Concept of Operations
- Washington State Department of Transportation (WSDOT) Active Traffic Management Concept of Operations
- VDOT Northern Virginia Go-Forward Plan
- OpenTMS Enterprise System- System Requirements Specification (SyRS)
- OpenTMS Operator Training Manuals
- Virginia Traffic (VaTraffic) System Requirements Specification
- Lane Closure Advisory Management System (LCAMS) Concept of Operations
- Software Development and Integration for the Hampton Roads Smart Traffic Center Request for Proposal
- DYNAC System Design Document
- VTrans 2035: Virginia's Long-Range Multimodal Transportation Plan
- VDOT/Open Roads Transportation Operations Technology Support Services Contract (2009)
- VDOT/Transdyn Transportation Operations Technology Support Services Contract (2009)

2.2 Site Visits

A series of site visits with VDOT staff were also conducted. A list of site visits is provided below:

- VDOT Statewide ATMS Operating Platform Kickoff Meeting (*Richmond, VA*)– September 24th, 2011
- Central Region Operations (CRO) Site Visit (*Richmond, VA*) – October 4th, 2011
- Eastern Region Operations (ERO) Site Visit (*Hampton Roads, VA*) – October 6th, 2011
- Southwest Region Operations (SWRO) and Customer Service Center (CSC) Site Visit (*Salem, VA*) – October 11th, 2011
- Northwest Region Operations Site Visit (*Staunton, VA*) – October 12th, 2011
- I-81 Corridor/Interoperability Meeting (*Lexington, VA*) – October 12th, 2011
- Asset Management System (AMS) Teleconference – October 24th, 2011
- Hampton Roads Bridge-Tunnel Site Visit (*Hampton Roads, VA*) – October 25th, 2011
- Northern Region Operations (NRO) Site Visits (*Chantilly, VA*) – November 1st and 3rd, 2011
- VDOT Statewide ATMS Project Leadership Staff Interview (Richmond, VA) – November 4th, 2011

3 CURRENT SYSTEMS AND SITUATION

3.1 Background, Goals, and Objectives

As shown in Table 1, Virginia's largest urban areas (Northern Virginia, Virginia Beach, and Richmond) rank 4th, 27th, and 53rd, respectively, in travel time delay in the United States according to the 2010 Urban Mobility Report. In these areas alone, there is nearly 239 million hours in travel delay and over 107 million gallons of excess fuel consumed because of congestion. The 2010 Urban Mobility Report estimates the total congestion costs for these three urban areas is $4.8 billion.

Table 1: 2010 Urban Mobility Statistics

Urban Area	Travel Delay		Excess Fuel Consumed		Truck Congestion Cost		Total Congestion Cost	
	(1,000 Hours)	Rank	(1,000 Gallons)	Rank	($ Million)	Rank	($ Million)	Rank
Washington, DC-VA-MD	188,650	4	95,365	4	683	5	3,849	4
Virginia Beach, VA	36,538	27	9,301	28	98	40	693	27
Richmond, VA	13,800	53	3,105	53	92	41	262	53
TOTAL	**238,988**	--	**107,771**	--	**873**	--	**4,804**	--

Congestion is also common in non-urban areas in Virginia. I-81 in the western part of the state experiences high volumes of truck traffic as well as traffic associated with numerous colleges and universities located along the corridor. As with urban areas, incidents are also common in rural areas, but may be more severe due to heavy truck volumes.

With the expectation that travel demand will continue to grow, and with only nominal planned expansion in highway capacity, congestion levels are expected to increase. ITS, together with effective incident management strategies, have the potential to lessen the impact of recurring and non-recurring congestion. In addition, these strategies can also help provide safety and environmental benefits to the Commonwealth of Virginia.

Over the years, VDOT has taken a proactive approach towards operations. However, ITS practices across the state are fragmented. This is the result of VDOT's previous organization where ITS planning and operations were conducted at the District level with each District implementing its own system. VDOT recently restructured its systems operations centralizing ITS planning, project development and delivery functions.

Each VDOT Operations Region has unique attributes. Northern Region Operations (NRO), with its vicinity to the nation's capital, is one of the most congested metropolitan areas in the nation with homeland security an integral part of operations. Central Region Operations (CRO) experiences high volumes of both through and local traffic on I-95, along with special events in the Richmond area. Eastern Region Operations (ERO) is unique in that it is home to several military bases and ports. High volumes of beach traffic in the summer, along with the operations of numerous bridges and tunnels provide unique traffic problem to ERO. Finally, Northwest Region Operations (NWRO) and Southwest Region Operations (SWRO) experience high volumes of truck traffic on I-81. They are also responsible for transportation operations for large rural areas.

While the VDOT Operations Regions have unique local characteristics, they share similar transportation operations and management vision and goals with an emphasis on improving safety, mobility, the environment, and security. VTrans 2035, Virginia's Long-Range Multimodal Transportation Plan, identified the following vision:

Virginians envision a multimodal transportation system that is safe, strategic, and seamless.

The goals identified in VTrans 2035 include:

- **Goal #1: Safety and Security** – to provide a safe and secure transportation system.
- **Goal #2: System Maintenance and Preservation** – to preserve and maintain the condition of the existing transportation system.
- **Goal #3: Mobility, Connectivity, and Accessibility** – to facilitate the easy movement of people and goods, improve interconnectivity of regions and activity centers, and provide access to different modes of transportation.
- **Goal #4: Environmental Stewardship** – to protect the environment and improve the quality of life for Virginians.
- **Goal #5: Economic Vitality** – to provide a transportation system that supports economic prosperity.
- **Goal #6: Coordination of Transportation and Land Use** – to promote livable communities and reduce transportation costs by facilitating the coordination of transportation and land use.
- **Goal #7: Program Delivery** – to achieve excellence in the execution of programs and delivery of service.

Transportation Operations and Management help VDOT address the vision and goals identified in VTrans 2035. At the heart of VDOT operations are TOCs. TOCs are the primary "hub" for all traffic management and operations for each Operations Region. TOCs house 24/7 mission critical systems supporting VDOT operations and provide information and situational awareness to VDOT management and the public. Within each TOC is an ATMS that acts as the software "hub" to connect authorized users to ITS field devices, external transportation agencies, third party information service providers, and the traveling public.

3.2 Description of the Current System

VDOT's current ATMSs allow operations staff to manage traffic congestion, incidents, events, and work zones through the deployment of state-of-the-art sensing, communications, and data processing technologies. These systems assist transportation agencies in addressing both recurring traffic congestion (congestion resulting for traffic volumes exceeding roadway capacity) as well as non-recurring traffic congestion (congestion resulting from crashes, disabled vehicles, work zones, adverse weather events, and planned special events). VDOT's current ATMSs use information provided by roadside infrastructure, and data from other transportation systems, to develop optimal traffic control strategies addressing real-time traffic needs along an arterial or freeway, along a given corridor, or throughout a region.

VDOT currently has five (5) independent ATMS platforms. Four (4) VDOT Operations Regions use Open TMS, an ATMS operating platform developed by Open Roads Consulting. OpenTMS is used by TOCs in

NRO, NWRO, CRO, and SWRO. ERO uses DYNAC ATMS (DYNAC), an ATMS operating platform developed by Transdyn. Overviews of these systems are described below.

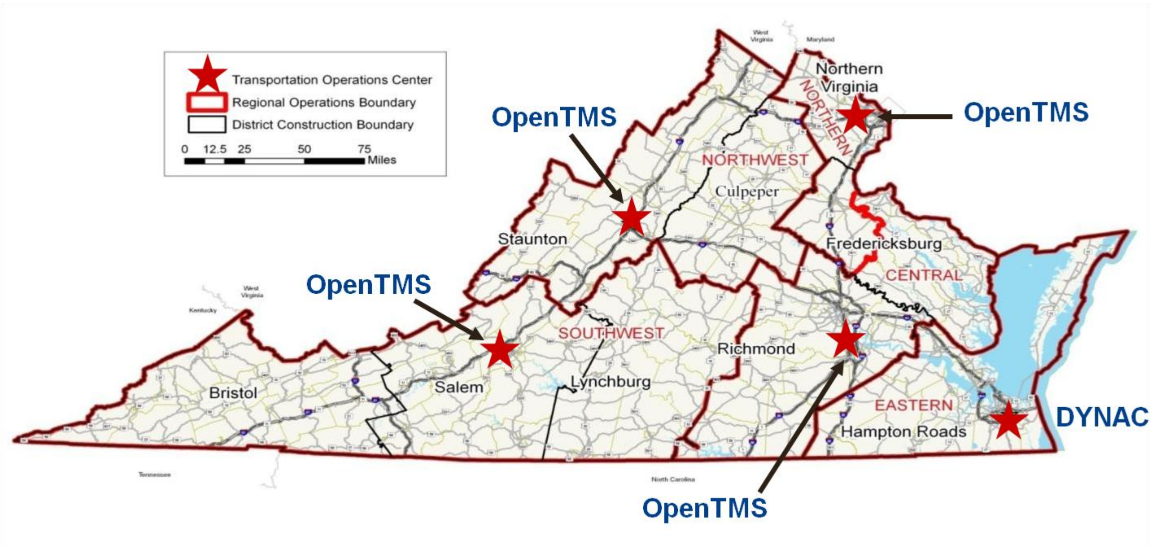

Figure 3: Current ATMS Platforms

OpenTMS Enterprise – OpenTMS Enterprise is a customizable solution that has been tailored to meet VDOT regional operational requirements. It is a highly scalable, modular ATMS that encompasses data gathering, presentation, device control, real-time decision support, information dissemination and archival. OpenTMS features a core system consisting of:

- Real-time GIS User Interface
- SQL Database for Extensive Logging and Data Collection
- Web Admin – System Configuration Tool
- System Schedule – Schedule Management
- System Security – Multi-level Security Protection
- Situation Manager – System Health Notification System
- OpenReports – Standard and Customizable Reports

In addition to the core system, OpenTMS is comprised of subsystems or components. These components include:

- OpenVDS – Manages Video Sources
- OpenDMS – Dynamic Message Signs
- OpenESS – Environmental Sensor Stations
- OpenTSS – Traffic Sensor System
- OpenHAR – Highway Advisory Radio System
- OpenGCS – Gate Control System
- OpenLCS – Lane Control System
- OpenSLC – Shoulder Lane Control System
- OpenTTS – Travel Time System
- OpenVSL – Variable Speed Limit System
- OpenWZM – Work Zone Management

While the system uses some COTS components and open system standards, the core of the system is proprietary. VDOT owns all source code which is in-scope to the Transportation Operations Technology Support Services (TOTSS) contract, whether developed under TOTSS or any prior contractual relationship between VDOT and Open Roads. The contract grants Open Roads an unrestricted license to market the TOTSS software to other customers provided they notify VDOT in advance of their intention to do so.

DYNAC – DYNAC software is used by the ERO TOC in Hampton Roads, Virginia. The DYNAC Central Computer System (CCS) is composed of software that has been configured and modified to meet VDOT ERO's needs. DYNAC consists of a suite of applications, designed specifically for real-time data acquisition, traffic management, supervisory control, general-purpose process control, and facilities management using a modern graphical user interface (GUI). DYNAC was developed using open system standards such as X windows, Ethernet, TCP/IP, POSIX, ODBC, and SQL. Features of DYNAC include:

- Vehicle detection and traffic monitoring
- Automatic incident detection
- Integrated video management
- Real-time decision support
- Stopped vehicle detection
- Motorist advisory information through DMS and HAR
- Integrated real-time travel time advisories
- Integrated dispatch communications
- Ramp metering
- Automatic emergency and maintenance vehicle location, reporting and dispatch
- Integrated road weather information
- Dynamic gate control, scheduled high-occupancy vehicle (HOV), high-occupancy toll (HOT) and reversible roadways
- Supervisory control of traffic signalization systems
- Closed loop control of ventilation systems
- Integrated bridge and tunnel facility lighting, standpipe and electrical controls
- Interface to site access, security, and fire protection systems

While not all of the subsystems described above have been implemented in Virginia, the software provides these capabilities.

Similar to OpenTMS, the system uses some COTS components and open system standards; however, the core of the system is proprietary. Transdyn owns the DYNAC source code, but VDOT has a statewide license and may access the source code within the bounds of a non-disclosure agreement. The license agreement allows VDOT to hire a third party systems integrator to maintain the source code, within the constraints of the non-disclosure agreement.

Other VDOT Systems Supporting the ATMS – In addition to OpenTMS and DYNAC, VDOT operations uses other systems at its TOCs to operate and manage the transportation system. These systems include VaTraffic, LCAMS, and traffic signal systems.

- **VaTraffic** – VaTraffic is a statewide system that provides a mechanism for users throughout the state to enter data related to events. These events include traffic incidents, planned events, road conditions, and security events. VaTraffic allows users to share information about all of these event types, and provides certain information processing functions related to event management. This event data is stored in an Archival Database accessed by the VaTraffic Reporting Application and serves as a data provider for other systems, such as VDOT's 511 system and the VDOT Dashboard. Both the 511 website and the telephonic Interactive Voice Response (IVR) systems consume VaTraffic data. VaTraffic is a stand-alone java-based software system developed and hosted by Open Roads. At the time this ConOps was written, VaTraffic is not integrated with OpenTMS or DYNAC, although VDOT is in the process of integrating VaTraffic with OpenTMS and expects to demonstrate these capabilities at the CRO TOC soon.

- **LCAMS** – LCAMS serves as an enhanced input tool in support of VaTraffic, providing an opportunity to dynamically apply business logic to events that impact VDOT roadways, specifically pre-planned lane closures. The system assists VDOT in automating the largely manual process of monitoring lane closures, resolving conflicts, and exchanging information about lane closures within the Commonwealth. The application is an easy-to-use, map-based information management tool with calendar filters and reporting capabilities. LCAMS features form-based entry for entering lane closures (map click, mile markers, or cross streets) and prepares visual feedback, graphically mapping advisories to check for potential conflicts. This java-based software application is based off the VaTraffic development framework and accessed through a standard web browser. LCAMS is built on a centralized database that is hosted by Open Roads. It is not integrated with OpenTMS or DYNAC.

- **Traffic Signal Systems** – VDOT currently operates and maintains approximately 2,900 traffic signals across the five (5) operations. Each region is responsible for operating and maintaining its own traffic signals and associated signal systems. Just over 1,650 (nearly 60 percent) of the traffic signals in the state are coordinated with at least one or more adjacent signals.

  The type of signal controller equipment used for VDOT traffic signals varies between Operations Regions. The majority of the traffic signals in the state (1,310) are located in NRO. The Northern Region operates Type 170E controllers from McCain. However, NRO is currently beginning the process of transitioning to type 2070 controllers and using 4th Dimension (D4) firmware. CRO, with approximately 750 signals, and NWRO, with approximately 320 signals, currently use the Eagle NEMA TS-1 controller. SWRO, with approximately 345 signals, recently switched their equipment standard from Siemens Eagle NEMA TS-1 to the Naztec NEMA TS-2 Type 1 controller. Approximately 40 percent of the SWRO controllers are still Eagle. ERO, with approximately 175 signals, uses the Eagle TS-2 Type 2 controller.

  Central System software is used in each region to manage the traffic signal operations. All five (5) of the regions use the Marc NX software package provided by Siemens to communicate with some of their field devices. SWRO also uses the Naztec Streetwise system to communicate with their new standard Naztec equipment. NRO makes use of the MIST package provided by Telvent and Quickload provided by BiTrans.

  Traffic signal communications media varies between regions, ranging from 100 percent leased line DDS drops in NRO to a mixture of wireless, fiber, twisted pair, and telephone drops in other regions. The DDS leased line service used in NRO provides higher speeds than some of the other regions but is still not comparable to DSL or fiber. Only SWRO has implemented fiber to provide communications to some of its signals. All of the regions rely on varying speed telephone drops for some of their communications. CRO, ERO, SWRO, and NWRO use wireless radio and twisted pair to communicate between master controllers and local intersection controllers.

A significant number of VDOT traffic signals have communication capabilities that allow for remote monitoring and troubleshooting. However, there is wide discrepancy between the numbers of signals with communication between the regions. NRO and ERO have communication with virtually all of their traffic signals while CRO has communications with 70% of their controllers. NWRO has communications to approximately 50% of their signals and is working to get more intersections online. SWRO is working to provide communications in districts that previously did not have those capabilities. Currently, SWRO has 100% communications in the Lynchburg District, 75% in the Salem District, and 30% in the Bristol District. The most predominant form of communications infrastructure amongst the regions is a telephone drop. Direct communication between field masters controllers to TOC is lacking in many areas.

In 2011, VDOT began a pilot project to implement adaptive signal control on approximately 11 corridors and 100 intersections across the state. Currently, the pilot project has 4 corridors and 25 intersections operating with adaptive traffic control in two of the regions (NWRO and NRO) with plans to implement more in 2012. VDOT procured the InSync system developed by Rhythm Engineering for the pilot. It uses video based detection and requires Ethernet communications to transmit and remotely monitor the video.

All regions, with the exception of the Northern Region, are using traffic responsive in at least a few locations. CRO uses the most traffic responsive systems. NRO uses only time-of-day plans with the exception of one adaptive signal system implemented as part of the InSync pilot project.

3.3 Current ATMS Subsystems

A system context diagram (SCD) is used to describe the existing OpenTMS and DYNAC systems. The SCD, depicted in Figure 4, provides a high level view of these two (2) systems showing the systems as a whole and its inputs and outputs from/to external factors.

At the top of the context diagram are users that interface with the current ATMS. This includes ATMS System Administrators, TOC Supervisors, and TOC Operators. VaTraffic, LCAMS, and traffic signal operators are depicted using dotted lines, since VaTraffic, LCAMS, and traffic signal systems are not integrated with the ATMS, but are used to support the ATMS.

The left side of the SCD includes the ITS field devices that currently interact with the ATMS. These devices are located along the roadway and are used to either collect traffic and environmental data or to disseminate information to travelers. Rectangles shown with a dotted line are not currently integrated into the ATMS.

The center of the SCD includes subsystems or components internal to the ATMS. These subsystems are categorized into the following groups:

- **Field Device Subsystems** – Subsystems that collect data from, send data to, and operate ITS field devices.

- **Decision Support and Processing Subsystems** – Subsystems that process data collected from ITS field devices and other sources and turn the data into information that can support transportation decisions. For example, traffic data collected from traffic sensor stations is compared to historical data in the incident detection subsystem to determine potential incidents along the freeway.
- **Incident and Event Management** – Subsystems used to manage incidents, work zones, and other events. These subsystems receive alerts from other subsystems and are used by operators to support management of traffic events.
- **User Interface and Map Display** – Subsystems that support user interface capabilities to the ATMS. These subsystems allow for a common and unified interface for the users to perform their duties. It also provides a map display for monitoring and controlling ITS field elements.
- **Other Subsystems** – Subsystems that support ATMS security or other ATMS subsystems.
- **Tunnels** – Systems outside of OpenTMS or DYNAC used for tunnel traffic and industrial operations. These systems are depicted using a dotted line to show that they are outside of OpenTMS and DYANC.
- **AVL** – AVL Systems. These systems are used to track VDOT vehicles such as SSP vehicles.
- **Traffic Signal Systems** – These systems are used to collect data from and control traffic signal systems.
- **VaTraffic** – The VaTraffic System. This system is outside of OpenTMS and DYNAC.
- **LCAMS** – The LCAMS System. This system is outside of OpenTMS and DYNAC.
- **Message Libraries** – Libraries supporting messages for DMS and HAR.
- **Data Log and Storage** – This subsystem logs and archives key ATMS system events within the ATMS.

The right side of the SCD depicts the current systems that the ATMS interfaces with. This includes systems that receive data from the ATMS (e.g., media), systems that send and receive data to the ATMS (e.g., RTIMIS and RITIS), and systems that provide data to the ATMS (e.g., VSP CAD system).

Regions have customized their ATMS platform for their operational needs. Table 2 depicts the subsystems that are included in each regional ATMS installment.

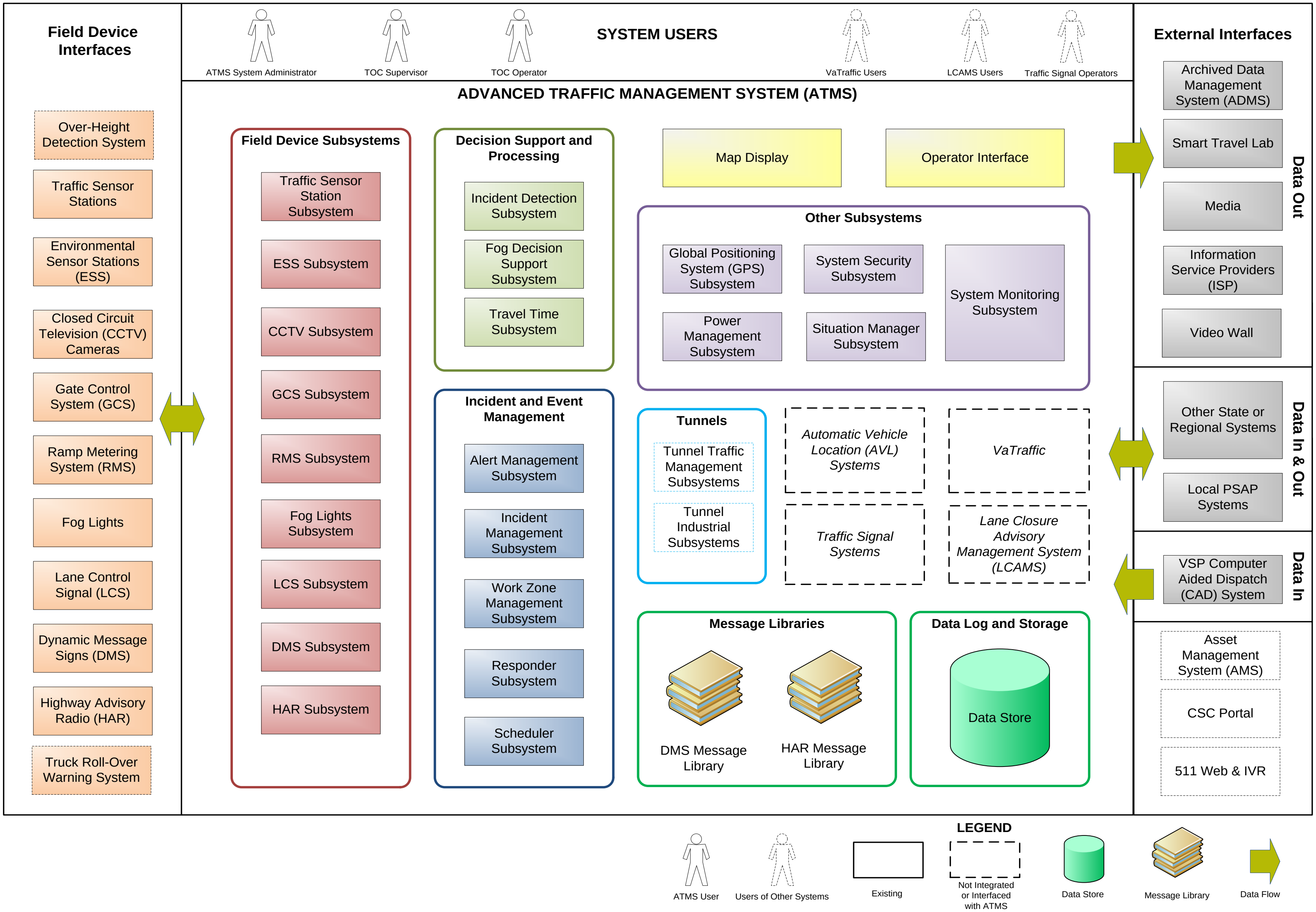

Figure 4: Existing Statewide ATMS Operating Platform Context Diagram

Table 2: Current ATMS Subsystems by Operations Region

Subsystem		CRO	ERO	NRO	NWRO	SWRO
Field Device Subsystems	Traffic Sensor Station Subsystem	•	•	•	•	•
	ESS Subsystem				•	•
	CCTV Subsystem	•	•	•	•	•
	Gate Control System Subsystem		•	•		
	Ramp Metering Subsystem			•		
	Fog Light Subsystem				•	•
	LCS Subsystem			•		
	DMS Subsystem	•	•	•	•	•
	HAR Subsystem	•	•	•		•
	Over-Height Detection System		***Not integrated into ATMS***	***Not integrated into ATMS***		***Not integrated into ATMS***
	Truck Roll-over Warning System	***Not integrated into ATMS***				
Decision Support and Processing	Incident Detection Subsystem	•	•	•		
	Fog Decision Support Subsystem				•	•
	Travel Time Subsystem			•		
Incident and Event Management	Alert Management Subsystem	•	•	•	•	•
	Incident Management Subsystem	•	•	•	•	•
	Work Zone Management Subsystem	•	•	•	•	•
	Responder Subsystem	•	•	•	•	•
	Scheduler Subsystem	•	•	•	•	•
Other Subsystems	GPS Subsystem			•		
	Power Management Subsystem				•	•
	System Security Subsystem	•	•	•	•	•
	Situation Manager Subsystem	•	•	•	•	•

Subsystem		CRO	ERO	NRO	NWRO	SWRO
AVL	Automatic Vehicle Location Subsystem			***Not integrated into ATMS***		
Tunnels	Tunnel Traffic Management Subsystems		***Not integrated into ATMS***			***Not integrated into ATMS***
	Tunnel Industrial Subsystems		***Not integrated into ATMS***			***Not integrated into ATMS***
Message Libraries	DMS and HAR Message Libraries	•	•	•	•	•
Data Log and Storage	Data Store	•	•	•	•	•
External Interfaces	Archived Data Management System	•	•	•	•	•
	Smart Travel Laboratory	•	•	•	•	•
	Media and ISPs	•	•	•	•	•
	Other State or Regional Systems		•	•		
	Virginia State Police CAD and PSAPs	•	•	•	•	•

3.3.1 Field Device Subsystems

3.3.1.1 Traffic Sensor Station Subsystem

Traffic sensor stations deployed by Operations Regions are integrated into their associated regional ATMS. Traffic sensor stations are also deployed throughout the state by VDOT Central Office Traffic Engineering as continuous count stations for collecting traffic counts and vehicle classification data. These VDOT Central Office Traffic Engineering traffic sensors are not integrated into the ATMS. Instead, data from these traffic sensors feed a database managed by VDOT Central Office Traffic Engineering.

The Traffic Sensor Station Subsystem provides a means for operators to collect and consume data from traffic sensor station field devices including loop detectors, radar detectors, acoustic detectors, and other traffic detection devices. Traffic data collected from these devices include speed, volume, occupancy, and vehicle classification data.

The ATMS collects data by polling the field device's controller. The data collected from the controller is sent to the ATMS where it is associated with a roadway link. Links consist of detectors located on a logical section of roadway, meaning a set of lanes in a certain direction (e.g., northbound). Traffic sensor controllers may interface loops on both directions of the roadway (multiple links). Additionally, there may be more than one controller on a link, thus presenting a many-to-many relationship for that link.

Traffic data is collected and maintained on both the lane level and link level. Link volume is computed by averaging the observed volume of all lanes. Link speed is a weighted average, with the speed in each lane weighted by the number of vehicles counted in that lane. Link occupancy is the average of all occupancies counted in that link.

Vehicle classification data is also collected from traffic sensor stations. When a vehicle passes through a classification sensor station, the controller examines the information provided by the traffic sensor and uses that information to determine the vehicle's total wheelbase, number of axles, and distance between axles. The class of each passing vehicle is determined using this information.

Within the ATMS, the Traffic Sensor Station Subsystem allows users to adjust configuration parameters of the traffic monitoring and vehicle classification controllers. It also allows users to monitor traffic sensor stations using the map display. The map display shows traffic sensor stations as icons on the map. The map colors the sensor depending on the communication status with the device (e.g., red means the sensor is down, green means normal communication). By clicking on an icon on the map or selecting a button on the toolbar, a user can see the volume, occupancy, speed, and vehicle classification data for that traffic sensor station.

In addition to viewing the status of traffic sensor stations using the map display, ERO's DYNAC system also includes a customized display to assist operations staff in monitoring the region's choke points. This display uses traffic sensor station data to monitor queues or back-ups at the various bridge tunnels in the Eastern Region. The tool visually shows color bar charts depicting the length of queues at the following choke points:

- George P. Coleman Bridge
- High Rise Bridge
- Berkeley Bridge
- Downtown Tunnel (DTT)
- James River Bridge
- Hampton Roads Bridge-Tunnel (HRBT)
- Monitor Merrimac Memorial Bridge-Tunnel (MMMBT)
- Midtown Tunnel (MTT)

During the ConOps team's site visits with the VDOT Operations Regions, ERO staff stated that the new Statewide ATMS should have the functionality of the choke point tool. The figure below depicts the choke point display.

Figure 5: DYNAC Choke Point Display

3.3.1.2 Environmental Sensor Station Subsystem

The Environmental Sensor Station Subsystem allows the ATMS to gather data from environmental sensor stations, including: fog warning status, visibility, air temperature, humidity, average wind speed, and barometric pressure. This information is made available to users for monitoring weather conditions.

While environmental sensor stations are deployed locally in some Operations Regions, devices are also deployed throughout the Commonwealth by VDOT Central Office. These environmental sensor stations are deployed by a third party vendor. Environmental data from these third party sensors are made available to the regions through an external website. Data from third party environmental sensors deployed at the direction of VDOT Central Office are integrated into OpenTMS in NWRO and SWRO; however users in other regions must open a web browser to see the environmental sensor information from these devices. During the ConOps team's site visits with VDOT staff, each Operations Region articulated that the new Statewide ATMS Operating Platform should integrate environmental sensor station data from the third party vendor into the ATMS.

Within the ATMS, data collected from environmental sensor stations can create an alert that results in a weather event in the Incident Management Subsystem. The system creates an alert if data from environmental sensor stations exceeds a configurable threshold. Users can accept the alerts and turn them into weather events. When sensors reach predefined threshold values at weather sensor stations, OpenTMS has the capability of sending messages via email-to-pager to a distribution list of VDOT TOC employees maintained within the ATMS. This messaging system is used in some of the Operations Regions and is configurable by ATMS System Administrators.

The visibility reading from environmental sensor stations is important in VDOT Regions susceptible to fog (i.e., the Northwest and Southwest Regions). If at any point the visibility reading falls below a configurable threshold, users receive an alert from the ATMS. If the information is coming from a known fog area, the Fog Decision Support Subsystem recommends a response plan to the user. The response plan includes recommended DMS messages as well as the recommendation to turn on fog lights. The ATMS does not implement these actions itself, but recommends a strategy that users can implement.

Temperature is another important data element received by the ATMS from environmental sensor stations. In severe weather events, road temperature is critical in determining when road conditions deteriorate and roads may begin to freeze. This is important both for road safety and for deploying salt trucks and plows during the weather event. These sensors are especially effective as early warning systems for weather events such as light rain beginning to freeze or high winds on bridges.

3.3.1.3 Closed Circuit Television (CCTV) Camera Subsystem

The CCTV Camera Subsystem allows operators to view traffic conditions, detect and verify incidents, verify whether other field devices are functioning properly, and provide information of traffic conditions to the public, media, and other regional systems. The major capabilities of the CCTV Camera Subsystem include:

- Controlling CCTV cameras in the field
- Routing video inputs to system monitors located in the TOC, to video walls, and to operator workstations
- Making video available for distribution

Each VDOT Operations Region has implemented different strategies for command and control of video cameras. CRO is the only Region with a CCTV module in OpenTMS. While the actual video solution (Analog Video Switch) is not part of the ATMS, the CCTV module allows for PTZ control of the cameras and video matrix control for the video wall. Other regions leverage third party video solutions including Open Roads' VICADS solution in NRO, a Cisco solution in the SWRO, and third party analogue switches in CRO and ERO.

Regardless of the video solution, the functionality of the CCTV Camera Subsystem is the same. Users access the CCTV Camera Subsystem's GUI by either selecting a CCTV name from the toolbar or a camera icon from the map. Users can switch video inputs and video tours to the video wall or to an operator's monitor. This includes monitor selection, camera selection, camera control (i.e., pan, tilt, and zoom, and focus), camera position, feedback, tour selection and control, preset programming, and preset selection.

Each camera is assigned a unique ID number and name and communication parameter when its icon is created. An icon on the Geographic Information System (GIS) map display represents each CCTV camera in the field. The icon indicates to operators the status of the camera. Users can select cameras and "lock" control to prevent two users from trying to control the same camera concurrently. Users may control multiple cameras at once and, if an operator attempts to gain control of a camera already "locked", the operator receives an "access denied" message and is told the username of the current operator in control.

The CCTV Camera Subsystem supports both software and hardware joysticks for all camera control functionality. Users use the ATMS to control of all the features of the camera. They can pan, tilt, zoom, and focus the camera. Along with controlling all the movements of the camera, the user can define camera preset positions. Each preset position has a caption to describe the captured image. Video tours can also be set-up in the CCTV Camera Subsystem to allow a user to tour a series of cameras. The CCTV Camera Subsystem also collects all camera diagnostic data available to allow users to monitor the condition and status of each device.

VDOT shares images with the general public and regional stakeholders through VDOT's Video Sharing Clearinghouse, currently Trafficland. This allows the public to view video images using a public website, www.trafficland.com. Video images are also made available to VDOT's 511 website, www.511va.org. There are certain instances throughout the Commonwealth where the media has been provided direct video feeds to some VDOT CCTV cameras.

3.3.1.4 Gate Control System (GCS) Subsystem

The Gate Control System (GCS) Subsystem provides users control of gates on reversible and HOV lanes. There are three (3) types of devices involved with the GCS, including:

1. The gate controller and gate arm.
2. A DMS associated with the gate that provides messages about the status of the lanes for travelers.
3. CCTV cameras used by operators to verify gate positions and perform visual inspection of areas before any gate actions.

GCS Subsystems exist in OpenTMS, in NRO, and in DYNAC in ERO. The functionality of each system is similar. Both systems prohibit gates opening in opposite directions through a complex series of interlocks. This process is based on a sally port process leveraged from prison entryway logic.

The GCS Subsystem represents gate controllers as icons on either a map display or user interface. The ATMS indicates the status of the gate. From the GCS control panel an operator can begin the opening or closing process and view all log information about the gates. The operator panel also reminds operators to visually inspect gate areas before beginning any sequence.

The GCS Subsystem enforces a strict sequence of events for opening and closing of gates. Since a mistake in the control of gates could lead to traffic from both directions entering a single lane, the GCS Subsystem takes all precautions to ensure safe operation. Gates that are open in a conflicting direction automatically generate an alert. The GCS Subsystem also generates an alert if a gate controller switches into local mode and the ATMS no long has direct control.

When controlling a gate, operators first must use the DMS(s) associated with the gates to announce that the lanes are closing. After posting messages to the DMS, the operators must make sure the lanes are clear before closing or opening the gates. Operators use cameras associated with the gates they are controlling to view the area. Once the operator determines visually that the lanes are clear, the operator begins to close the gates. After the gates are closed, Safety Service Patrol staff will verify that all traffic has moved out of the closed area. Once the lanes are clear, the process recycles to open the gates to traffic in the opposite direction.

The GCS Subsystem logs all gate controller information into the ATMS's database; this information includes: operator name, road, direction, mile marker, location description, and gate ID. Each gate is also associated with a gate group that may include other controllers, cameras, signals, or signs. The GCS Subsystem logs all gate events and actions into the database.

3.3.1.5 Ramp Metering System (RMS) Subsystem

NRO is the only Operations Region with ramp meters. These devices are deployed on Interstates 66 and 395. Ramp metering devices regulate the rate of vehicles entering or leaving a freeway. Restricting the number of vehicles entering freeways can result in a reduction in congestion and bottlenecks on freeway. Ramp meter lights change between red and green based on a rate set by a timing plan. These signals minimize traffic congestion on the mainline as well as help maintain stable queues and flows for vehicles entering the highway.

The RMS Subsystem provides an interface for operators to use the ATMS to turn ramp metering devices on or off and run predefined timing plans. Timing plans are based on day of the week and time of the day. These plans can be scheduled and run automatically. The subsystem also has the ability to calculate a timing plan based on current conditions. The timing algorithm examines three important pieces of information. The first is bottlenecks forming on the freeway. If bottlenecks form the ramp meter needs to restrict the flow of traffic into the freeway. At the same time the subsystem must monitor the queue length on the ramp. If the queue length exceeds a set threshold then the ramp meter must speed up allowing more cars to enter the freeway. The last piece of information considered is the weather at the location. Weather can impact the capacity on the freeway so the ramp meter adjusts accordingly.

Traffic sensor station data associated with ramp metering systems is integral to the dynamic operations of ramp metering systems. However, traffic sensor stations associated with ramp metering systems on I-66 and I-395 are outdated and unreliable. As a result, NRO currently operates its ramp meters using pre-defined schedules and timing plans. NRO has plans to operate its ramp meters more dynamically based on real-time traffic conditions. This includes adjusting the timing and cycle length of the ramp meters (i.e., green and red times). Dynamic ramp metering is an integral part of NRO's I-66 ATM project.

3.3.1.6 Fog Light Subsystem

NWRO implemented fog lights on specific stretches of roadway that are highly susceptible to dense fog. The lights only exist in NWRO, but SWRO, during failover, is responsible for controlling and monitoring the lights. The Fog Light Subsystem interfaces with the controls of lights embedded in the roadway to mark the edge of the roadway and exits.

The Fog Light Subsystem relies on information collected from the environmental sensor stations. The environmental sensors provide visibility information to the Fog Decision Support Subsystem that will evaluate the visibility, assess pre-defined thresholds, and recommend what actions to take. Using this data, the Fog Light Subsystem provides a means for users to access, monitor, and control fog lights. Using input from sensors, the Fog Light Subsystem determines if the fog lighting in the coverage area is adequate. Operators have the ability to view logs that contain a record all of the fog light's status and events. Operators can request Constant Current Regulator (CCR) readings from any fog light station. This information includes kilowatt, electrical current, volt, and actual brightness values.

3.3.1.7 Lane Control Signal (LCS) Subsystem

LCSs are overhead signs that show either a red "X" or a green arrow to show the status of a lane. A red "X" alerts a driver to a closed lane, while a green arrow indicates an open travel lane. This LCS Subsystem allows the LCSs to operate on a time of day basis. Lane controls are used during rush hour periods to increase the number of lanes in the congested direction. The LCS device controllers have two working modes, autonomous backup or direct communication to the ATMS.

NRO is the only region with LCS devices deployed; however, ERO is planning a project that will instrument LCSs in the region. The I-66 ATM Project and other ATM projects in the Commonwealth will incorporate LCS as integral devices for managing traffic. The I-66 ATM project, currently in the design phase, identified a third state for LCS. In addition to a red "X" and a green arrow, ATM also will use yellow diagonal arrows. These yellow diagonal arrows advise motorists of a transition from an open lane to a closed lane.

Within OpenTMS, operators control LCSs individually or as a group to open a lane. The LCS Subsystem requires a specific order of events to open a lane for travel. Operators receive a notification based on the time of day that it is time to open a lane. Once an operator acknowledges the notification, the LCS Subsystem initiates a camera tour for the operator to verify that the lane is clear. If any abandoned or disabled vehicles are in the lane, the operator aborts the opening process. After a successful camera tour showing no blockages in the lane, the operator gives the command for the LCS Subsystem to change the lane signals. The map display includes icons representing LCS devices. The icon indicates the status of the lane control device. The LCS Subsystem logs all events involving lane control devices into a database in the ATMS.

3.3.1.8 Dynamic Message Sign (DMS) Subsystem

DMSs are lighted, fixed or portable, message boards deployed along the roadway used to disseminate information to the traveling public. DMSs on roadways provide motorists with information about traffic conditions, incidents, work zones, events, speed limits, detours, or any other information a traveler may need.

The DMS Subsystem is responsible for the control and monitoring of fixed and portable DMSs. The DMS Subsystem allows users to control all types of signs (e.g., from different manufacturers such as Daktronics, LEDStar, Mark IV, ADDCO, and Lake; different types of DMSs) through a consistent method of control within the ATMS. The DMS Subsystem allows users to create a message for posting to a DMS. Users can either select a DMS from the map display or from the toolbar.

When a user selects a DMS in the ATMS, they gain control and "lock" the sign, preventing other operators from changing the sign at the same time. In cases where there is a need to post more than one message on a DMS, the ATMS allows multiple messages to be stored in a queue. In this scenario, a configurable message priority is used to decide which message is sent to the DMS. For example, a message about an incident may have a higher priority than a travel time message. In this example, once the duration assigned to the higher priority message ends, the next message in the queue would be sent to the DMS.

Operators have the ability to display a new message, display a message from the DMS message library, blank the sign, or perform a number of diagnostic tasks. The DMS subsystem packages the DMS commands and sends them to the DMS controllers in the field, which ultimately posts the message on the sign. An operator can create sign groups to allow other operators quick access to a group of signs that often display the same messages. The DMS Subsystem is also responsible for receiving status updates and diagnostic information from the sign.

The DMS Subsystem also provides an approved word library to assist operators while crafting a message. The DMS Subsystem contains a message library of over 2,000 messages that operators can search by keyword to find old messages and re-use all or part of them.

DYNAC also ties DMSs to pre-defined incident response management plans established within its ATMS. These response plans are entered into a rules-based system within the ATMS depending on the incident type, location, and characteristics (e.g., number of lanes blocked). These rules-based incident response management plans are associated with DMS(s) and HAR. When a user enters an event into the Incident Management Subsystem, the ATMS determines the appropriate incident management response plan to implement based on the information entered. DYNAC provides users with recommended DMS messages for dissemination.

3.3.1.9 Highway Advisory Radio (HAR) Subsystem

The HAR Subsystem operates two (2) field devices. The first field device is the HAR Transmitter which is the device that actually transmits the traveler information over a radio signal. The second field device is the HAR Beacon, which is a roadside sign with blinking lights that alerts travelers to tune to a specific AM frequency for urgent traveler information.

The HAR Subsystem provides the operator with the ability to record and activate messages that keep the motorist up to date with the latest information on congestion or other events in the broadcast areas. The HAR Subsystem reads an audio file from a pre-defined file location and broadcasts that message. The operator may also create schedules to pre-define when a message broadcasts for one or more HAR units.

When a user selects a transmitter, the user gains control and "locks" the device to prevent other operators from controlling the same device. Users have the ability to select a message from an audio message library or create their own message by voice recording or text-to-speech. Operators have the ability to preview selected audio messages before sending the message to the transmitter. The HAR Subsystem logs all messages and the status of each beacon and transmitter in the field.

In CRO the subsystem is also capable of receiving messages from external agencies, such as tourism councils, that can use the same HAR Transmitters to broadcast tourist messages. These agencies can upload a file to the correct location within the ATMS; the HAR Subsystem recognizes the new file and begins to broadcast the message.

Similar to the DMS Subsystem, DYNAC also ties HAR to pre-defined incident response management plans. When a user enters an event into the Incident Management Subsystem, the ATMS determines the appropriate incident management response plan to implement based on the information entered. DYNAC provides users with recommended HAR messages for dissemination.

3.3.2 Field Devices Not Interfaced with the ATMS

3.3.2.1 Over-Height Detection Systems

Over-height detection systems exist in VDOT Operations Regions as standalone systems. These systems detect over-height vehicles moving toward obstacles such as bridges, tunnels and other overhead structures and warn drivers of a potential collision. An audible alert and/or DMS are activated in the field when an over-height vehicle is detected by the system. These systems are comprised of a transmitter and a receiver. Transmitters include either infrared or a high intensity, visible red light source that is pulsed across the roadway from the transmitter to the receiver. The receiver is designed to issue an alert if the light beam is blocked by an object (i.e., an over-height vehicle). The over-height detection system activates a warning sign with alternating flashers, a DMS, or an audible alert in the field.

Over-height detection systems are also found at tunnels. These systems are integrated into the Tunnel Traffic Management Systems. These systems issue an alert to the ATMS when a vehicle is over-height. Approaches to tunnels typically have multiple over-height detectors. Once a tunnel operator receives an alert from the first over-height detection system, tunnel operators follow the over-height vehicle using CCTV cameras to ensure that the vehicle stops or exits before the tunnel. If the vehicle triggers numerous over-height detectors, the Tunnel TMS begins an automatic shutdown of the travel lanes and the tunnel operator calls field staff at the beginning of the tunnel to pull over the vehicle before it enters the tunnel. If this happens, a full lane closure in both directions is required to turn the vehicle around.

3.3.2.2 Truck Roll-Over Warning Systems

VDOT currently has truck roll-over warning systems in NRO and SWRO. These systems determine the potential for truck rollovers as a function of vehicle type, weight, and speed. If a truck is traveling too fast, a message sign is activated on the roadside advising the truck driver to reduce speed. These systems are not currently integrated into OpenTMS.

3.3.3 Decision Support and Processing Subsystems

3.3.3.1 Incident Detection Subsystem

The purpose of the Incident Detection Subsystem is to detect possible incidents by comparing current traffic sensor data with historical traffic sensor data. If an anomaly occurs (i.e., current traffic sensor station data exceeds a threshold when compared to historical traffic sensor station data), the Incident Detection Subsystem creates an alert that is made available for processing by the Alert Management

Subsystem. At this point, a user may elect to manage the incident in the Incident Management Subsystem.

Both OpenTMS and DYNAC include Incident Detection Subsystems. Such a subsystem has been implemented in some of the regions but over time each implemented Incident Detection Subsystem has been disabled because it created numerous false alerts. The weakness of the current system is primarily due to a high failure rate of loop detectors and a low density of detectors in some geographic areas.

During site visits with VDOT staff, it was articulated that VDOT would support an Incident Detection Subsystem in the future if the subsystem's algorithms reduced the number of false alerts. It was noted by ERO staff that Old Dominion University (ODU) and Virginia Polytechnic University (Virginia Tech) have conducted research into developing algorithms to support incident detection from traffic sensor stations, but additional research needs to be conducted before incorporating such algorithms into the ATMS.

3.3.3.2 Fog Decision Support Service (DSS) Subsystem

The Fog Decision Support Subsystem is a subsystem in OpenTMS, implemented in the Northwest and Southwest Operations Regions. Using input from environmental sensor stations, the Fog Decision Support Service (DSS) Subsystem determines if the visibility in the coverage area is adequate. When the visibility falls below an established minimum configurable threshold, the Fog DSS Subsystem will alert the operator of the situation and initialize a preconfigured response plan. Responses include turning on fog lights and disseminating messages using DMSs. While the Fog DSS Subsystem recommends preconfigured response plans, operators must verify the response before its implementation. Operators rely on SSP, Virginia State Police, or CCTV cameras to verify a fog event.

In addition to creating fog events in OpenTMS, fog events are also entered into VaTraffic for dissemination of information to 511. VaTraffic does not allow for bi-directional events. As a result, users must enter two events into VaTraffic for a fog event—one for each direction of travel along the road where a fog event takes place. This requires users to enter a fog event three (3) times—once in OpenTMS and twice in VaTraffic.

3.3.3.3 Travel Time Subsystem

Posting travel time messages on DMSs not only provides useful information to motorists, it also assists them in planning their routes. This planning can cause a small number of drivers to divert away from the congested highway. Thus, posting travel time messages provides critical additional capacity and assists in the management of congestion.

VDOT recently implemented a pilot project to disseminate travel time messages on DMSs. The first project is using data provided by a third party vendor—INRIX—for dissemination of travel times on DMSs on I-66 in Northern Virginia. INRIX travel time data is made available to VDOT through an XML stream. The XML stream includes:

- Speed
- Travel Time
- Confidence level ratings (10, 20, 30)
- Expected Speed
- Free Flow Speed

- Road Segments
- TMC location codes
- Update Rate / Latency

The second DMS Travel Time Project will be implemented in the ERO in the future. This project will use traffic sensor data to determine travel times for roadway segments.

The NRO Travel Time Subsystem generates travel times for posting on DMSs. It calculates travel times for a segment once every minute, uploads travel times to a DMS every five minutes, and incorporates data smoothing features necessary to generate accurate travel times over the five minute period.

The NRO Travel Time Subsystem also uses pre-defined and fully configurable “thresholds” and rule-based decision logic for determining maximum and minimum operating conditions and to manage periods when travel conditions are changing. Thresholds include:

- A cap on maximum travel speeds used in the calculation or as part of the final output for each segment’s designated speed limits.
- The ability to filter out INRIX Type 10 (confidence) data. These data are considered unusable for travel time calculations and not used for those calculations (only confidence level 20 or 30 data are used for this purpose).
- Identification of data errors or failures to attain travel time data for a continuous period of greater than 15 minutes for any segment. In these cases, the travel time system will automatically notify the operator of an error and remove travel time messaging for that segment.

The Travel Time Subsystem supports the ability to implement automated dissemination of all DMS messaging that is in agreement with a defined, yet reconfigurable hierarchy of messaging priorities. The preliminary prioritization of all messaging includes:

1) Emergency
2) Incidents
3) Amber Alerts
4) Construction/Work Zone
5) Weather
6) Special Events
7) Travel Time
8) Ozone
9) Safety Campaigns
10) Test Messages
11) VDOT Hearing

When the selected DMS signs are initially blank, OpenTMS software automatically displays travel time messages, as a default. When operators post messages with priorities higher than travel time on these signs, OpenTMS automatically replaces the default travel time message with the messages posted by operators. When operators take down higher priority messages, travel time messages will be automatically posted back onto these DMS signs.

When operators post lower priority messages, OpenTMS should automatically prompt an alert of priority conflict. Operators can override (posting lower priority messages) or accept (not posting lower priority messages) the alert. Similarly, when the non-travel time messages are taken down by operators, OpenTMS automatically posts the travel time messages back onto the signs.

As VDOT's DMS travel time efforts mature, it is expected that VDOT will aggregate data from various data sources including private sector data feeds, traffic sensor station data, and potentially toll tag data to calculate travel times. When these data sources are available, the Travel Time Subsystem is expected to aggregate multi-source data and fuse it.

3.3.4 Incident and Event Management Subsystems

3.3.4.1 Alert Management Subsystem

The Alert Management Subsystem receives information about unverified events (e.g., incidents, traffic congestion, weather alerts, and field device failures) and alerts users with pop-up windows. Alerts may originate from other subsystems within the ATMS or from information transmitted to the ATMS from external systems. For example, a congestion alert may be created from the Incident Detection Subsystem or from environmental sensors. Additionally, an alert may be created from information received from the VSP CAD system.

Within the ATMS, alerts appear to the user as pop-ups or audible alerts, although each TOC using OpenTMS has deactivated audible alerts from the Alert Management Subsystem. Once a pop-up alert occurs, users are required to take any of the following actions on the alert:

- **Ignore the Alert** – Users can ignore the alert
- **Examine the Alert** – Users can examine an alert in detail by displaying the alert in an alert detail screen which provides more information about the alert
- **Generate an Incident** – Users can generate an incident based on the information provided in the alert
- **Update and Associate Incident** – Users can update and associate incidents with an existing incident

All users within the region receive all alerts in the region. If an alert pops up, the user is not permitted to perform any other activities within the ATMS until action has been taken on the alert. For example, if a user was in the process of crafting a message for dissemination on a DMS and an alert popped up in the process, the operator would not be able to complete the process of disseminating the DMS message until the operator took action on the alert.

3.3.4.2 Incident Management Subsystem

The purpose of the Incident Management Subsystem is to provide users the means to manage a traffic incident or other event (e.g., weather event, work zone, etc.). The Incident Management Subsystem provides the means for tracking the actions taken for managing a specific event.

The OpenTMS and DYNAC Incident Management Subsystems contain different levels of functionality. Descriptions of the Incident Management Subsystems in each ATMS are provided below.

OpenTMS Incident Management Subsystem – The Incident Management Subsystem is the part of OpenTMS that allows users to manage and record all information associated with an incident or event (e.g., work zone or congestion event). The OpenTMS Incident Management Subsystem is currently being used by Operations Regions to create and manage all events including incidents, work zones, and weather events. Incidents or events may originate from either: (a) the Alert Management Subsystem, or (b) user input. If an incident or event is created from an alert, the information from the alert automatically populates incident information fields. Users can create an incident or event by either clicking on the map or creating an incident or event in the Incident Management Subsystem's data entry window.

Within OpenTMS, incidents or events exist in one of four states:

- **Suspected** – All new incidents, whether automatically detected or manually entered are initially marked in the system as "suspected"
- **Verified –** If the user determines that the incident is a true incident, the user can enter descriptive information about the incident and mark the incident as "verified"
- **Rejected –** If the user determines that the incident is a false incident, the user enters a reason for the false incident and marks the incident as "rejected"
- **Closed** – At the completion of the incident, the user marks the incident as "closed"

Within OpenTMS, after the operator selects a suspected incident or creates an incident from an Alert Message, the GUI displays a separate Incident Operator Panel. This panel allows the user to manage the incident. Users enter information about the incident including detection source, incident type, county, route, direction, mile marker, the time first responders arrived on the scene, the time SSP arrived at the scene, number of lanes blocked, and the time the incident was cleared. The Incident Operator Panel also includes an area where users can enter notes using free text.

The Incident Operator Panel also allows users to associate DMSs, HAR transmitters, HAR beacons, and other field devices to the incident or event. Users associate these field devices by selecting them from the map display or from a toolbar listing all devices in the ATMS. Once a field device is selected, users can also control it.

Once an incident is created, it appears as an icon on the map display as a separate theme/layer. Incident icons reflect if the incident is verified, selected by a user, is verified and being managed by a user, and if the incident originated from an agency outside of the TOC (e.g., an incident created by the Maryland State Highway Administration (MDSHA) and shown in the OpenTMS through RITIS integration). When an operator scrolls over an incident, the operator can view the incident type, status, road, direction, mile marker, and a graphical depiction of the lanes closed. The Incident Management Subsystem also keeps the elapsed time of verified incidents.

The Incident Operator Panel also allows short email messages to be created with incident and event details for distribution to a pre-configured distribution list. The distribution list is configurable from the OpenTMS System Administration page.

The Incident Management Subsystem notifies the user when an incident or event has been idle for a specified period of time. This period of time is configurable within OpenTMS. An idle incident is one that is not yet closed but has neither been updated by the operator nor updated by an associated Alert. Once an incident or event is open, only the managing operator (or supervisor) can close it. Users with Supervisor privileges can close all incidents or events.

The OpenTMS System Log and Data Archive Subsystem maintains an audit log of all interactions that have taken place with an incident or event. The audit logs records the incident ID, location including roadway and direction of travel, duration, and response actions. Incident data older than 13 months may be archived and removed from the system.

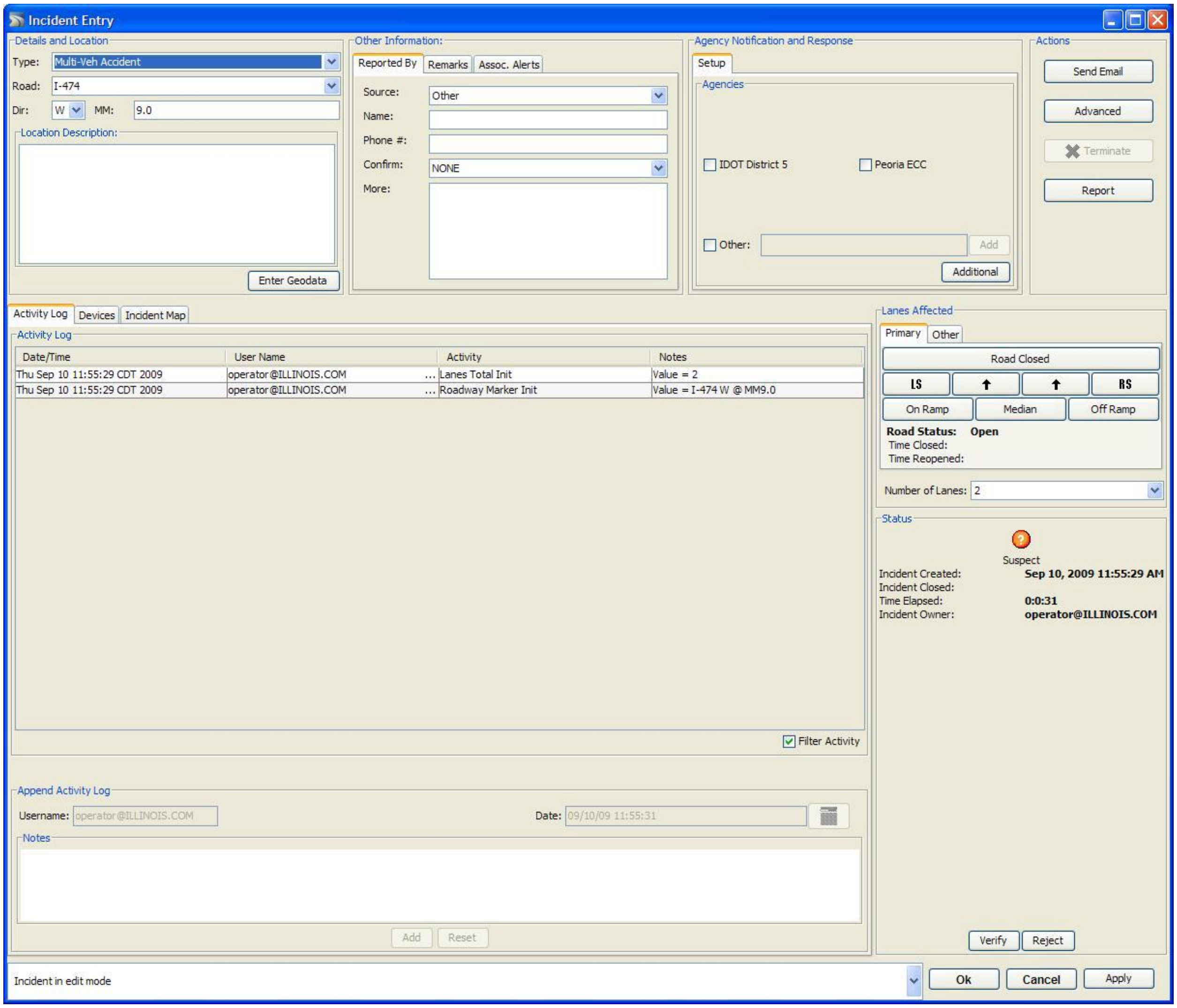

Figure 6: OpenTMS Incident Data Entry Screen[2]

DYNAC Incident Management Subsystem – The DYNAC Incident Response Management Subsystem includes similar functionality as defined above for the OpenTMS Incident Management Subsystem. The major difference is that the DYNAC Incident Management Subsystem supports Incident Response Management (IRM) plans – pre-defined response plans included in the ATMS to assist operators in managing DMS and HAR messages in response to an incident or an event from a geographical impact point of view.

[2] OpenTMS Operator Training - Incident Management Subsystem Manual

DYNAC's IRM functionality guides operators though confirmation and classification of an incident, selection of a pre-defined response plan (which consists of a set of proposed actions), and implementation of the plan. It accomplishes the following functionally:

1. Operator incident confirmation
2. Operator initiation and execution of incident response plans and activities
3. Operator management and modification of in-progress response plans
4. Detection and conflicts in response plans
5. Activation of response plan to field devices

A database contains configurable pre-defined response plans made up of rules-based (dynamic) plans. These rules are based on the type of incident, the incident's location(s), and number of lanes blocked. Using this information, the ATMS generates dynamic plans based on pre-defined rules that determine which devices to use and dynamically generates DMS, HAR, paging, and other messages. Based on the location of an incident and the information entered by an operator the Incident Management Subsystem recommends these plans to the operator for implementation. The plans include proposed DMS and HAR messages. Operators have the option to implement the response plan or modify the response plan before sending messages to field devices.

The Incident Management Subsystem includes a War Room graphical look at the current state of the roadway and active incidents. The graphic depicts, using colored lines, the location of an incident and the associated devices tied to the incident. This enables users to see a macro-level view of all incidents in ERO. Figure 7 shows a screenshot of the War Room Graphic.

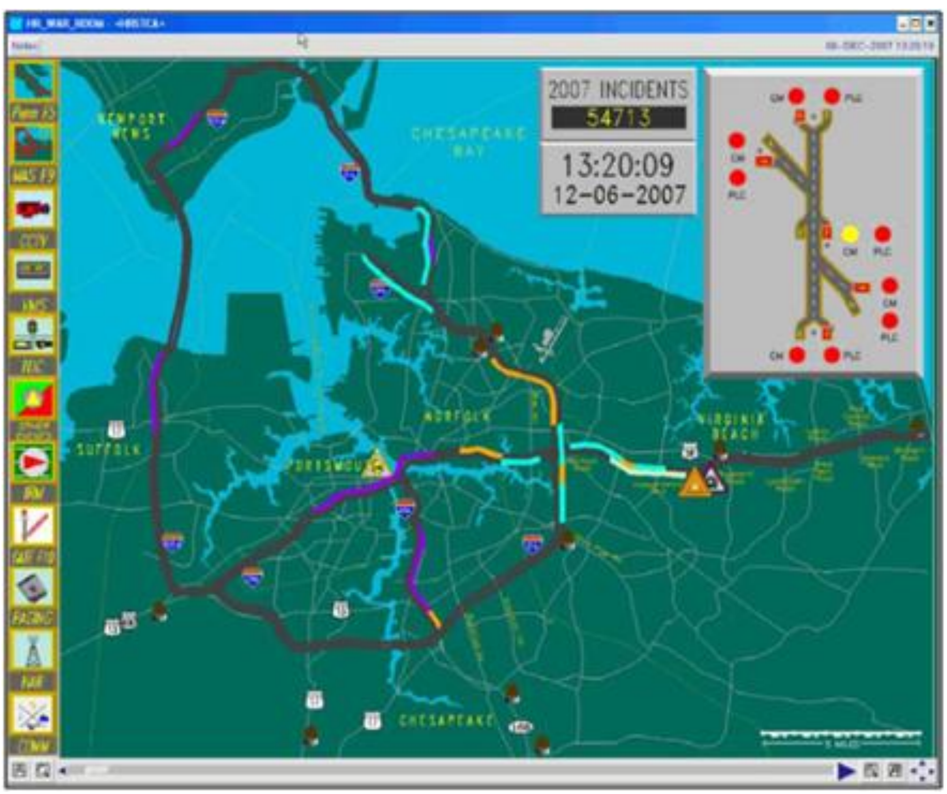

Figure 7: DYNAC War Room Graphic

The DYNAC system also provides the functionality to manage SSP vehicles. Prior to a SSP shift, the SSP Supervisor enters in the patrollers on the shift into the ATMS. As TOC operators enter data into the ATMS, they record when SSP arrives at the scene of an incident as well as the vehicle (and patroller) on the scene. TOC operators can select the SSP vehicle on the scene within the Incident Management Subsystem's data entry window. DYNAC also includes a display window that indicates if SSP vehicles are: (1) available, (2) on scene, or (3) off duty. This status is conveyed using green, yellow, and red boxes, respectively.

3.3.4.3 Work Zone Management Subsystem

OpenTMS includes a Work Zone Management Subsystem intended to provide a means for users to predefine work area response plans for a future date and time. Using this subsystem, users can add response plans including predefined messages for a DMS or HAR. Users can also set the date and time for the plans to activate including recurring work zone schedules that activate on a periodic basis. A comprehensive activity log is included to enable an automated audit of the work zone activities.

The Work Zone Management Subsystem is not being used by the Operations Regions using OpenTMS. DYNAC does not include a Work Zone Management Subsystem. Instead VDOT staff use the Incident Management Subsystem and LCAMS to manage work zones.

3.3.4.4 Responder and Scheduler Subsystems

Both DYNAC and OpenTMS allow users to schedule ITS-related tasks in the ATMS, such as displaying a message on a DMS, or managing a ramp meter or LCS devices. The primary difference between OpenTMS's Scheduler and Responder Subsystems is that the Responder Subsystem executes schedules on demand while the Scheduler Subsystem requires activities to be scheduled in advance.

The Responder Subsystem is responsible for managing planned activities that can activate in response to certain events. For example, this subsystem can be used to post messages to multiple signs to alert motorists to an area wide alert. The Scheduler Subsystem provides a means for users to predefine device plans for a future date and time. The user can add device plans such as a predefined message on a sign. The user can also set the date and time for the plans to activate including recurring schedules that activate on a periodic basis (e.g., congestion events).

3.3.5 Other Subsystems

3.3.5.1 Global Positioning System (GPS) Subsystem

The Global Positioning Subsystem (GPS) Subsystem allows the ATMS to poll a GPS enabled portable unit and email the on-site support staff that the unit has moved. The on-site support staff will then update the coordinates of the applicable devices based on input from the field technician that relocated the device. The reported coordinates can vary by as much as 15 to 30 meters depending on the accuracy of the GPS.

3.3.5.2 Power Management Subsystem

The Power Management Subsystem provides the means for the operator to access and monitor power supplies associated with ITS field devices. Using input from sensors, the Power Management Subsystem determines if the power in the coverage area is adequate. When the power falls below an established minimum threshold, the Power Management Subsystem will alert the operator of the situation. The Power Management Subsystem was put into place in rural VDOT Operations Regions where there were reliability issues with field power and communications. The purpose of the system was to allow for remote power shutdown and reset of equipment that failed. Many of the field devices requiring the Power Management Subsystem have been replaced.

3.3.5.3 System Security Subsystem

The System Security Subsystem provides a common framework for enforcing user security and privileges within the ATMS. In particular, this subsystem is used to assign required security roles to system functions.

3.3.5.4 Situation Manager Subsystem

OpenTMS includes a Situation Manager that provides situational awareness to users. A situation is a notification about an event that has occurred in the OpenTMS Enterprise System. There are four types of situations:

- An Operation situation can alert the operator that a device poll has failed and a possible problem may exist with the device. The original failure time along with the time of the last polling attempt. The operator can retry the poll to rule out a communications error.
- A Condition situation, such as a pixel error, can be reported to maintenance. With the enhanced diagnostic, the operator can run a pixel test, capture the output and send additional information with or without a call to maintenance personnel.
- An Alarm situation, such as a time drift error, can be reported to Maintenance. It may indicate a battery failure or that the device clock needs to be reset.
- A Reminder situation is generated to notify the operator of pending operations within the system. These situations occur prior to the scheduled action and normally terminate when the scheduled action is performed.

3.3.6 Automatic Vehicle Locations (AVL) Systems

VDOT NRO currently has an AVL system to track the location of VDOT and contractor SSP vehicles. This system is a standalone system and is not integrated into the ATMS. The primary purpose of this AVL system is to monitor the location of vehicles. Because it is not integrated with the ATMS, the AVL system does not consider incident locations when dispatching vehicles.

VDOT uses a separate AVL system to monitor contractor snow plows during winter weather events. Contractor snow plows are encouraged to install GPS devices in their vehicles and make this data available to VDOT through www.networkfleet.com. The system allows VDOT to collect the following information:

- Location, based on latitude and longitude
- Ignition status
- Odometer
- Maximum Speed
- Current and Average Speed
- Last stop and duration of the stop
- Speed history
- Miles per gallon trends
- Fuel efficiency

This information is then used by VDOT to monitor the status of its vehicles and contractor vehicles.

3.3.7 Tunnels

Tunnels exist in the Southwest and Eastern Regions. Six (6) tunnels are operated by VDOT. These tunnels include:

- **The Big Walker Mountain Tunnel** – A 4,200 foot vehicular tunnel in SWRO carrying traffic along I-77 through Big Walker Mountain between the communities of Bland, VA and Wytheville, VA. The tunnel is located approximately 20 miles south of the East River Mountain Tunnel.
- **The East River Mountain Tunnel** – A 5,412-foot vehicular tunnel in SWRO carrying traffic along I-77/US-52 through East River Mountain between the communities of Bluefield, West Virginia and Rocky Gap, Virginia.
- **The Downtown Tunnel (DTT)** – Located on I-264, this tunnel crosses the Southern Branch of the Elizabeth River linking the City of Portsmouth with the City of Norfolk. In conjunction with the Berkley Bridge, the Downtown Tunnel connects I-464 to the City of Chesapeake.
- **The Hampton Roads Bridge-Tunnel (HRBT)** – A 3.5-mile-long crossing for I-64 and Route 60. It is a four-lane tunnel facility comprising of bridges, trestles, man-made islands, and tunnels under the main shipping channels for Hampton Roads harbor in the southeastern portion of Virginia.
- **The Midtown Tunnel (MTT)** – This tunnel crosses the main channel of the Elizabeth River linking the City of Portsmouth with the City of Norfolk. It carries U.S. Highway 58 traffic and operates without tolls.
- **The Monitor Merrimac Memorial Bridge-Tunnel (MMMBT)** – A 4.6 mile-long crossing for I-664 in the southeastern portion of Virginia. It is a four-lane bridge-tunnel composed of bridges, trestles, man-made islands, and tunnels under a portion of the Hampton Roads harbor where the James, Nansemond, and Elizabeth Rivers come together.

Each tunnel has its own common traffic management system that operates ITS field devices. These systems are typically SCADA systems, built in the 1950's or 1960's, which have old communications infrastructure and ITS devices. These systems collect data from or control the following ITS field devices:

- Traffic Sensor Stations
- Over-Height Detection Systems
- CCTV Cameras
- DMS
- VSL Signs
- Traffic Signals used as LCS
- Gates

Each tunnel's traffic management system interfaces with the ATMS at its Regional TOC. Each tunnel's traffic management system sends the following data to the Regional TOC's ATMS:

- VSL Status
- Traffic Sensor Station Data
- DMS Message Display Status
- LCS Status
- Over-Height Detector Status

In ERO, Tunnel TOCs have VaTraffic workstations. Tunnel operators use VaTraffic to enter incident and other event data. In addition to entering events into VaTraffic, tunnel operators also call the VDOT TOC when an event occurs. Tunnels in the Eastern Region also have DYNAC workstations. These workstations allow tunnel operators to view devices and control CCTV cameras a few miles on each side of the tunnels. Tunnel personnel have a lower priority then TOC personnel when controlling those cameras.

All tunnels must comply with National Fire Protection Agency (NFPA) 502: Standard for Road Tunnels, Bridges, and Other Limited Access Highways. VDOT elects to man the tunnels 24/7 to meet the requirements. The standard also requires life safety industrial system infrastructure to be located at the facility. Industrial systems include the tunnel's ventilation system and fans, fire suppression, water pumps, and power systems. These systems are critical for the safety of all travelers in the tunnel. Operators monitor the system for alerts, flooding, or other potentially harmful conditions.

3.3.8 Data Store

The Data Store is responsible for logging all significant events in the ATMS. Significant events include any user interactions with field devices, devices failures, incident and event information, and all the traffic and environmental data collected by the system. The systems also log device status at least once a day for records. Both Data stores use the standard ATMS Data Dictionary whenever possible.

The system stores all of the data for a configurable amount of time before the system archives the information. Currently, the OpenTMS system stores the data for 13 month to ensure the system always has one (1) year of data accessible. DYNAC is configurable and stores different data for different amount of time. For example, traffic data is collected and computed into five (5) min averages that are stored for 40 days whereas the one (1) hour and daily averages are stored for 400 days. The system stores event and alarm information in a 40 day circular file. Once the system archives data the information is still accessible from the Archived Data Management System (ADMS).

3.3.9 External Interfaces

3.3.9.1 Archived Data Management System (ADMS)

The ATMS interfaces with VDOT's ADMS. The purpose of ADMS is to retain this data, subject to strict quality control standards, and make the data, along with associated analytical tools, available to transportation professionals. The design philosophy used in Virginia's ADMS is a "data warehousing" concept to create a system that effectively supports improved decision-making for the stakeholders.

The ADMS collects traffic, environment, and logs from the various ATMS systems across all five VDOT Operations Regions. This data is made available to users through an innovative web-based system. As a result of this design, a user from any location or organization can gain access to the system with simply a web browser and internet connection. The system includes modules tailored for specific users of the system, and also incorporates web-based GIS capabilities.

3.3.9.2 Smart Travel Laboratory

In addition to sending data to the ADMS, the ATMS also sends archived data to the University of Virginia's Smart Travel Laboratory. The Smart Travel Laboratory is a joint effort between the Department of Civil Engineering at the University of Virginia and the Virginia Center for Transportation Innovation and Research (VCTIR). The distinguishing characteristic of the lab is the direct connection established between the lab and transportation management systems operated by VDOT. This connection provides researchers with direct access to real ITS data and systems. This direct access has allowed the lab to provide substantive contributions to VDOT's ITS initiatives.

3.3.9.3 Media and Information Service Providers (ISPs)

VDOT TOCs currently share traffic sensor station data, incident data, and CCTV video with the media and ISPs. This information sharing is different throughout the state. For example, some Regional TOCs allow the media to have direct video feeds to CCTV cameras while others direct the media to use VDOT's statewide video-sharing clearinghouse, currently Trafficland.

3.3.9.4 Other State or Regional Transportation Systems

The ATMS sends and receives center-to-center (C2C) traffic, environmental, and event data from other systems and other TOCs. This allows the ATMS to collect and report traffic data, environmental data, and events from systems collecting data in jurisdictions outside of VDOT ATMS geographic boundaries. Examples of data sharing with other transportation systems include data sharing with Regional Integrated Transportation Information System (RITIS) and the Real-Time Incident Management Information System (RTIMIS). These systems are described below.

RITIS is an automated data sharing, dissemination, and archiving system. RITIS improves transportation efficiency, safety, and security through the integration of existing transit and transportation management data in Virginia, Maryland, and Washington D.C. The emphasis of RITIS is on data fusion and standardization, and their relationship to data collection, regional transportation systems management, regional traveler information dissemination, and system evaluation. RITIS automatically fuses, translates, and standardizes data obtained from multiple agencies in the region to provide an enhanced overall view of the region's transportation network. Participating agencies are able to view regional traffic information and use it to improve their operations and emergency preparedness. RITIS uses regional standardized data to enable traveler information, including web sites, paging systems, and 511.

OpenTMS in NRO is integrated with RITIS. The purpose of this integration was to provide a bi-directional link between RITIS and OpenTMS. This allows VDOT NRO to receive information on and coordinate incidents and events across state boundaries with transportation agencies in Maryland and the District of Columbia. RITIS publishes active incidents and events and subscribes to incidents and events from OpenTMS. OpenTMS also publishes active verified incidents and subscribes to incidents and events from RITIS. RITIS also subscribes to DMS messages published by OpenTMS.

The following data are not currently being sent to RITIS, but are desired for future integration as the information becomes available:

- CCTV video images
- HOV and other lane configuration data including lane control information that is currently enforced (e.g., shoulder lane control and reversible HOV lanes)
- Injury reports containing a count and type of injuries
- RWIS and other environmental sensor systems (e.g., fog detection, ice detection, etc.) data

RTIMIS is a scalable platform, developed by Open Roads, to improve regional traffic management by fusing and exchanging real-time incident information across multiple stakeholders. Through RTIMIS, transportation stakeholders, such as 911 dispatch centers, local authorities, municipalities, and TOCs can share critical data and create a common situational awareness to support regional transportation operations and emergency response. RTIMIS implements a service that filters, fuses, and formats event data from stakeholder systems into industry standards. The resulting event feed is made available to the stakeholders to display data in their own systems and to publish data to other systems.

In the ERO, a DYNAC workstation can be found at the Tunnel TOCs and at local City TOCs. This is how the region currently attempts to share information and command and control of devices from center-to-center. The tunnels have a DYNAC workstation to control ITS devices near the Tunnels and bridges. The Cities have a DYNAC workstation to control cameras within their city limits. Cities and tunnels both have lower priorities then the ERO TOC.

3.3.9.5 VSP CAD and Local PSAP Systems

The current ATMS interfaces with the VSP CAD system. VSP CAD is a system used to initiate public safety calls for service, dispatch, and maintain the status of responding resources in the field. It is generally used by the Virginia State Police emergency communications dispatchers, call-takers, and 911 operators in centralized, public-safety call centers, as well as by field officers using mobile data terminals (MDTs) located in their police vehicles. VSP CAD alerts form a majority of incident detection across the state of Virginia. Most VDOT Operations Regions rely heavily on the VSP CAD data for incident detection, especially regions currently without SSP.

VSP CAD messages are integrated into the ATMS's Alert Management Subsystem creating an alert based on the information provided by the CAD system. Upon receiving data from the VSP CAD system, the ATMS uses a look-up table to assign a traffic impact severity level to an event. Table 3 shows a sample of the look up table. Event codes relevant to the TOC are shown in bold text.

Table 3: Sample of VSP Event Code Information Mapping to Traffic Impact Severity

Event Code	Description	Traffic Impact Severity Code	
		Not On-scene	On-scene
ABD	ABDUCTION/KIDNAPPING	Moderate	Moderate
ANIM	**LIVESTOCK IN HIGHWAY**	**Moderate**	**Moderate**
ANIMT	**ANIMAL IN HIGHWAY-PHONE**	**Unknown**	**Unknown**
ASST	ASSIST OTHER AGENCY	Low	Low
ASSTT	ASSIST OTHER AGENCY-PHONE CALL	Unknown	Unknown
BREATH	BREATHALYZER	Unknown	Unknown
CRANK	NUISANCE CALLER	Unknown	Unknown
DEB	**DEBRIS IN ROADWAY**	**Moderate**	**Moderate**
DEBRIS	**DEBRIS IN ROADWAY**	**Moderate**	**Moderate**
DIP	INTOXICATED PEDESTRIAN	Unknown	Unknown
DVA	**DISABLED VEHICLE ABANDONED**	**None**	**Low**

Event Code	Description	Traffic Impact Severity Code	
		Not On-scene	On-scene
DVH	DISABLED VEHICLE HAZARD	Moderate	High
DVO	DISABLED VEHICLE OCCUPIED	Moderate	Moderate

VSP CAD messages also have a text field that dispatchers can type free form text into. Some of this information, however, is deemed to be sensitive so VDOT is not permitted to receive that information. As a result, VSP created a "ROADI" field specifically for VDOT. CAD operators can add information to the "ROADI" to call out information that could be important to VDOT ATMS operators, without passing along sensitive information. This function helps ATMS operators filter out a lot of CAD messages that have no impact on their operation. They can look for the "ROADI" and ignore things such as breathalyzer call. Once the subsystem creates the alert, it alerts the operators to the CAD information the system received. A similar process takes place if VSP update a CAD message. The Alert Management Subsystem recognizes that the data is an update to a previous message and updates the corresponding alert. The Incident Management Subsystem would then automatically update the associated event, if there is one, with the new alert information.

In addition to VSP CAD information, VDOT Operations Regions are also pursuing opportunities to receive CAD information from local public safety access points (PSAPs). These interfaces would be similar to the interface described for the VSP CAD system.

3.4 Modes of Operation

OpenTMS and DYNAC have different modes of operation. Each system's modes of operation are described below.

DYNAC Modes of Operation – DYNAC's CCS has four (4) software modes of operation:

- Init – The computer system is being initialized.
- Startup – The system is creating software processes and loads the database into memory.
- Running – The DYNAC software processes are created and initialized and the system is running.
- Unknown – A failure mode that prevents the software from determining a mode.

The CCS also has several operational states:

- Off-Line – The system is offline when the DYNAC processes are not running.
- On-Line – The system is online when the DYNAC processes are started and running.
- Stand-By – The system is in standby when the DYNAC processes are started and running and the system is placed in hibernation awaiting a wake-up command to take over a failed online system.

DYNAC also has three (3) failover modes it can enter:

- Single – Only a single computer system is available for the system to run.

- Dual – Two computer systems are available and failover can occur. Both computers would be in the 'running' software mode with one computer in the 'on-line' state and the other in the 'stand-by' state for back-up.
- Catch-Up – After a failed system is rebooted it enters catch-up to reload all information including history, changes to the system, and the database.

Because DYNAC must remain operational at all times the system has been architected so that two computer systems are in the 'running' mode at all times. One of the computer systems is in the 'on-line' mode while the other is in 'stand-by'. When a failover occurs the stand-by computer takes over as the online system and the failed system goes into 'off-line' mode.

OpenTMS Modes of Operation – OpenTMS requirements documentation only defines one mode of operation, "operational." The Northwest and Southwest regions also have the ability to operate in a failover mode. The two regions are the only regions with region to region failover capabilities. Either region can take complete control of all devices and operations remotely if the local ATMS where to fail.

3.5 User Classes

The existing ATMS supports four types of user classes: (1) guest, (2) operators, (3) supervisors, and (4) administrators. These user classes are described below:

- **Guest** – Guest users have read-only access to the ATMS. This group of people does not need any access to control devices. They are simply monitoring the system or using it to view traffic and event information. For example the VDOT upper level staff can have access to the ATMS to view what happening but they are not on the control floor and do not need any device control or data input capabilities.

- **Operators** – Operators are the primary users of the ATMS. Operators have daily interaction with the ATMS managing incidents, controlling field devices, monitoring travel conditions, and disseminating traveler information. Operators monitor CCTV cameras, VSP CAD, traffic sensors, environmental sensors, and Safety Service Patrol for events that occur on the roadways. Once an operator discovers a verified event, the operator begins the appropriate response leveraging the tools within the ATMS. Operators are also the primary users of traffic management devices such as DMSs, GCS, LCS, and HAR. Operators record and log all activity with the ATMS. They also answer phone calls from the Customer Service Center or other people giving them potential event information. Another responsibility of operators is to disseminate traveler information, currently via VaTraffic. Operators are the main data entry personnel into the ATMS. They do not have access to capabilities above and beyond the normal day-to-day operations within the TOC.

- **Supervisors** – Supervisors have all of the capabilities of an Operator plus other access rights. Supervisors have more control over the ATMS and may override events or operators actions in the system. Supervisors may also edit stored information such as allowable sign message words, incident response plans, or field device timing plans. Supervisors are responsible for all operations in the ATMS and oversee all of the Operators.

- **Administrators** – The System Administrator is the person that sets up, configures, and maintains the ATMS. System Administrators have the highest level of access to the system and can configure it to meet the needs of the other user groups. They can also perform any action in the system that an Operator or Supervisor would do. The System Administrator also is responsible for all the TOC hardware and servers that the ATMS relies on to function.

3.6 Support Environment

VDOT currently has a contract with Transdyn and Open Roads to provide turn-key support for DYNAC and OpenTMS, respectively. Open Roads also provides support for VaTraffic and LCAMS. Support provided by these contractors includes:

- Production Support
- Maintenance Support
- After Hours On-Call Support
- On-Site System Administration Support

3.6.1 Production Support

Production support entails restoring the system to an operational state as soon as possible after a failure. Failures are categorized as either (a) critical failures or (b) non-critical failures.

- **Critical Failures** – Critical failures are system errors or malfunctions that result in an operational impact to user(s), inhibiting them from performing their assigned duties. Critical failures require continuous work effort during and after business hours until the incident is resolved.
- **Non-Critical Failures** – Non-critical failures are system errors or malfunctions that degrade performance or operational capability of the system, but can be tolerated for short periods before correction. Non-critical failures require continuous work effort during normal business hours until the incident is resolved.

Production support is available to VDOT via a toll free number.

3.6.1.1 Incident Management and Tracking

Contractors are responsible for incident management and tracking of incidents. Their responsibilities include:

- Answering calls via a toll free number provided by VDOT
- Investigating incidents
- Resolving incidents and restoring the production system to operational status
- Providing a root-cause analysis report. A mitigation strategy must be provided as appropriate
- Logging, defining, and describing critical failures

3.6.1.2 Response and Resolution Metrics

Contractors are responsible for responding to critical support calls within 15 minutes. Each month, four (4) hours of unplanned downtime is allowed. Any additional downtime results in fines unless extenuating circumstances exist.

3.6.1.3 Bug Fixes

Bugs are defined as a coding error or software malfunction in a computer program that prevents it from functioning as designed. The contractors are responsible for all bug fixes that may be needed in the software. VDOT reports bugs in the software and the contractors must create patches for the system on a routine basis. Contractors are also responsible for reporting bugs they discover via email to VDOT.

3.6.2 Maintenance Support

Contractors are responsible for the maintenance and support of all delivered software applications. Servers, network, and communications related to the ATMS are maintained by VDOT. Contractor maintenance support includes:

- Preventive and Scheduled Maintenance
- Configuration and Release Management
- Routine Software Updates and Upgrades
- System Monitoring
- Maintenance and Support Documentation
- System Security

These activities are described below.

3.6.2.1 Preventive and Scheduled Maintenance

Contractors are responsible for the necessary preventive and scheduled hardware and software maintenance activities required to ensure the operational stability of the ATMS.

3.6.2.2 Configuration and Release Management

VDOT established a Configuration Management Board (CMB) for each TOC. These groups are the first line of approval for enhancements and upgrades to the system. Contractors participate in these meetings at the request of the board's chairperson.

3.6.2.3 Routine Software Updates and Upgrades

Software packages regularly publish new versions in terms of upgrades and enhancements. To maintain system security, reliability, and supportability, it is important to upgrade/update all dependent software and firmware in a timely fashion. Contractors are required to provide these services as necessary when changes occur. Services provided include researching the necessity/feasibility of upgrades/updates, compatibility and performance testing, change planning, installation instructions, and roll-back methods

3.6.2.4 System Monitoring

Contractors monitor performance and errors related to the ATMS and other software applications to detect issues that may impact operations. VDOT performs systems monitoring for non-hosted products. Contractors have monitoring tools in place for hosted products.

3.6.2.5 Maintenance and Support Documentation

Contractors maintain the following documentation for the ATMS and other software applications:

- **System Maintenance Plan** – This plan describes the activities covered, maintenance approaches, roles and responsibilities, and processes and procedures on all aspects of maintaining the ATMS. Activities covered include routine maintenance, preventative maintenance, back-up and recovery, continuous operation, performance measures, and system security.

- **System Log Book** – This book logs work performed that impacts system configuration.

- **Monthly Maintenance Activity Reports** – These reports provide an overview of system performance, incidents and resource usage, and other items specified in the System Maintenance Plan.

- **Root Cause Analysis and Resolution Reports** – These reports detail failures (critical and non-critical), describe their resolution, and propose future mitigation strategies.
- **Design Documents** – Requirements and design documents are updated when enhancements and/or bug fixes are applied.

3.6.2.6 System Security

Contractors are required to report all security breaches to VDOT within 4 hours of detection and respond to the incident as a critical failure. VDOT also reports all security breaches to contractors within four hours of detection.

3.6.3 After Hours On-Call Support

After hours on-call support provides production support to restore the ATMS, VaTraffic, and LCAMS after a critical failure occurs outside of normal business hours. VDOT defines business hours as 6:00 a.m. to 6:00 p.m., Monday through Friday. For after hours on-call support, the contractor is required to restore the system to a functional state within four (4) hours of notification. The goal of on-call support is to get the system operational as soon as possible after a critical failure.

3.6.4 On-Site System Administration Support

The criticality of the ATMS requires on-site System Administration Support. Contractors provide on-site staff to perform core support services to ensure continuous availability of the ATMS. Listed below is a high-level summary of activities on-site support staff are required to perform:

1. **System Administration Tasks** – This includes tasks such as system back-ups, back-up verifications and restoration testing, security monitoring and reporting, system performance monitoring, hardware and software upgrades, system failover testing, and other actions to ensure optimal performance and availability to users.
2. **Field Device Problem Management** – The ATMS employs field devices managed by vendors other that Open Roads or Transdyn. On-site System Administrators are responsible for working with VDOT staff and vendors when issues arise with field devices.
3. **Development of Maintenance Plans and Documentation** – On-site support staff is responsible for ensuring documentation is complete and that logs of maintenance activities are kept up-to-date.
4. **End User Support** – On-site staff assists TOC operators in diagnosing and remedying issues they may encounter. These issues may include software or hardware problems, or questions related to how the system works.

3.6.5 Enhancements, New Initiatives, and Special Task Support

Contractors are also required to design, develop, test, and deploy software enhancements or new initiatives as requested by VDOT under separate task orders to be executed as needs arise and funding allows. The specific work to be performed is identified by VDOT and provided to the contractor in writing.

Delivery of upgrades and enhancements are performed in accordance to industry-recognized development life-cycle standards. In general, each task entails the following phases of development:

- **Requirements Definition** – Requirements clearly enumerate the functional and technical requirements necessary to satisfy the user needs identified in the ConOps. Requirements should be managed in a traceability matrix to ensure all requirements trace back to a user need.

- **Design Document** – Requirements are translated into Design Specifications that guide the development f the technical work to be performed.
- **Development** – The contractor performs the technical work to provide the functionality specified in the Requirements and Design Phases. This phase includes unit testing for all components of the solution.
- **System Testing** – The contractor conducts testing to ensure the new version of the software is ready for deployment. This includes integration and system testing. Upon completion of system testing, the contractor identifies and rectifies any "bugs" or other issues with the application.
- **User Acceptance Testing** – The contractor supports final User Acceptance Testing conducted by VDO-designated end users. The contractor designs Acceptance Test Procedures for testing, approved by VDOT.
- **Implementation** – The contractor prepares the software release package(s).

4 DESIRED CAPABILITIES

This section describes the desired capabilities of a new Statewide ATMS Operating Platform. It provides a transition from Section 3, which describes the current VDOT ATMS, to Section 5, which describes the proposed Statewide ATMS Operating Platform.

4.1 Background

The need for VDOT to pursue a new Statewide ATMS Operating Platform was identified result of the recent *Performance Audit of Significant Operations of the Virginia Department of Transportation*. The audit specifically addressed the need for the agency to deploy communication systems that improve interoperability across the TOCs and other partner agencies. The table below identifies the business issues from the recent audit and recommendations to address the business issues.

Table 4: Business Issues from the TOC Business and Technology Modernization Plan

ID	Business Issue	Recommendation
Business Issue 1	– Two ATMS platforms were inherited from the original "district based" program – Two ATMS platforms complicate TOC interoperability – Each of the four regions using OpenTMS has a different installation of OpenTMS, even though they share the same software version – Maintaining two ATMS increases long-term O&M costs	– Initiate an independent cost benefit analysis and requirements analysis for a common statewide TOC software platform immediately
Business Issue 2	– Each TOC has a different organizational structure (except for Staunton and Salem), multiple contracts (approximately 7 major contracts), and varying levels of outsourcing to manage TOC operations and maintenance.	– Award Statewide TOC staffing contract by 12/31/11 that includes operations floor staffing, SSP staffing, and ITS field maintenance
Business Issue 3	– ITS field devices are outdated or not maintainable and there are insufficient resources to keep the technology modernized	– Operations Security Division (OSD) to develop statewide Transportation Technology Modernization Plan that leverages existing efforts and establishes a funding source in the Six-Year Improvement Plan (SYIP)
Business Issue 4	– Significant reductions in Transportation Trust Funds (TTF) to Highway, Maintenance, and Operations (HMO) funds crossover need to be implemented	– Establish Safety Service Patrol (SSP) branding and/or marketing plan to generate revenue – Continue implementation of TVD contract to maximize return on distribution of VDOT data and video

As a result of the audit, VDOT decided to convert its current ATMS, VaTraffic, and LCAMS systems to an outsourced service that organizes and delivers a common operating platform for statewide use with capability for local device/technology interface and control. Once implemented, the software could be operated from anywhere in the state, and with appropriate permissions, can control/manage any device. Finally, VDOT plans to employ additional (temporary) leased lines to achieve immediate connectivity to ITS devices.

4.2 Desired Capabilities

This subsection identifies the desired capabilities for the new Statewide ATMS Operating Platform and provides a description or justification for the capability. These desired capabilities address both needs fully addressed by the current systems (e.g., 24/7/365 operations) as well as new or modified needs (e.g., ATM). Descriptions of the desired capabilities address:

- If the proposed system is to meet a new capability, the reasons why the new system should be developed to meet this opportunity are described.
- If the proposed system improves a current operation, the rationale behind the decision to modify the existing systems is described (e.g., to reduce lifecycle costs or improve personnel efficiency).
- If the proposed system implements a new functional capability (e.g. ATM), an explanation of why this function is necessary is provided.

Table 5 identifies the desired capabilities for the new Statewide ATMS Operating Platform.

Table 5: Statewide ATMS Operating Platform Desired Capabilities

Category	ID	Title	Description
External Data Collection	DC-1	Traffic Data Collection and Consumption	The ATMS needs to collect and consume traffic data (e.g., volume, speed, occupancy, vehicle classification, vehicle location, parking information) from ITS field devices, third party data providers, and probe vehicles. This allows the ATMS to report real-time traffic conditions and vehicle location data, and to process traffic data to create congestion alerts, and calculate travel times, and messages about parking availability.
	DC-2	Environmental Data Collection and Consumption	The ATMS needs to collect and consume environmental data (e.g., pavement temperature, fog, air temperature, precipitation) from ITS field devices, third party data providers, and probe vehicles. This allows the ATMS to report real-time environmental conditions and process data to create environmental alerts.
	DC-3	Event Data Collection and Consumption	The ATMS needs to collect and consume planned and unplanned events data from external in-state sources. This allows the ATMS to report and manage events such as incidents, work zones, and weather events entered by other than ATMS operators. Allowing data to be entered by external entities reduces the amount of data entry that VDOT operators have to do. This capability could also be coupled to a feature that permits external entities to check for conflicts with other entities over lane closures and other nearby events that could interfere with planned work. This allows the ATMS to collect and log planned and unplanned event activities from maintenance staff, construction staff, and CSC staff.
	DC-4	Field Device Diagnostics Data Collection and Consumption	The ATMS needs to collect and consume all available diagnostic data from ITS field devices and traffic signals, and collect the location of portable field devices. This allows the ATMS to report the condition of ITS field devices and their communication status and to provide the location of portable ITS field devices.
	DC-5	Center-to-Center Data Collection and Consumption	The ATMS needs to receive center-to-center traffic, environmental, and event data from other systems and other TOCs. This allows the ATMS to collect and report traffic data, environmental data, and events from systems collecting data in jurisdictions outside of VDOT geographic and jurisdictional boundaries.
Data Entry	DE-1	Data Entry	The ATMS needs to allow for a single data entry source for operations personnel. Types of data entry may include: events (e.g., incidents, weather events, work zones, and work order requests), field device messages (e.g., DMS, HAR), and access control information. This allows the ATMS to collect and log actions by ATMS operations personnel.
	DE-2	Remote Data Entry	The ATMS needs to allow for remote data entry from any approved device (e.g., desktops, laptops, tablets, or smartphones). This will allow maintenance staff, SSP, or other personnel to enter data (e.g., incident, work order and work zone information) remotely.

Category	ID	Title	Description
Field Device Control	FD-1	Field Device Control	The ATMS needs to control portable and fixed ITS field devices through a common control point with redundancy. This allows TOC operations personnel to use the ATMS to control devices such as DMS, CCTV cameras, gate control, ramp meters, fog lights, LCS, HAR, and VSL signs without having to go to multiple workstations or access control points. Conceptually, capabilities that address this need could be used to allow a TOC to geo-fence its own devices and allocate control of them to a single operator within the TOC or to use device control groups to accomplish the same aim.
	FD-2	Statewide Field Device Control	The ATMS needs to be able to control the field devices of all TOCs when one or more centers needs to cede control of its devices for operational reasons. This need encompasses the concept of geo-fencing of devices, such that a TOC can establish a geographic region that bounds a set of devices, all of which can be taken over by another TOC with a single command.
	FD-3	Traffic Signal Control	The ATMS needs to support the selection of alternate traffic signal timing plans. This allows TOC operators to adjust traffic signal timings on arterials near major events or incidents, supporting integrated corridor management (ICM) strategies.
	FD-4	Tunnel Industrial System Control	The ATMS needs to support the potential integration with tunnel industrial systems. This allows TOC operators to monitor the status of industrial systems and potentially control these systems through the ATMS.
Data Processing and Decision Support	DS-1	Event Response Management – Pre-defined Plans	The ATMS needs to include pre-defined event response management plans that can be activated by an ATMS operator based on planned and un-planned event data. This allows the ATMS to provide recommended traffic management strategies (e.g., recommended messages or actions for ITS field devices or traffic signals located near the event) to the ATMS operator for implementation.
	DS-2	Event Response Management – *ad hoc* Plans	The ATMS needs to allow ATMS operators to enter *ad hoc* event response management plans that can be activated based on planned and un-planned events. This allows the ATMS to execute traffic management strategies based on ATMS operator judgment. The ATMS shall also support future response plans for a given day and time.
	DS-3	Active Traffic Management (ATM) – Pre-defined Plans	The ATMS needs to include pre-defined traffic management strategies that can be activated by an operator based on real-time traffic conditions, environmental conditions, and events. This allows the ATMS to provide recommended active traffic management strategies (e.g., recommended messages for DMS, HAR, LCS, VSL located near the event) to the ATMS operator for implementation.
	DS-4	Active Traffic Management (ATM) – *ad hoc* Plans	The ATMS needs to allow operators to activate *ad hoc* traffic management strategies based on real-time traffic conditions, environmental conditions, and events. This allows the ATMS to execute active traffic management strategies (e.g., messages for DMS, HAR, LCS, VSL located near the event) based on ATMS operator judgment.

Category	ID	Title	Description
	DS-5	Travel Times	The ATMS needs to consume and calculate travel times for roadway segments using multiple sources of traffic data (e.g., data collected from traffic sensors, traffic probes, and third party data providers). This allows the ATMS to create travel times for dissemination on DMS, 511, and allows travel times to be shared with other entities through the TV&D Distribution Services Center.
	DS-6	Traffic Anomalies	The ATMS needs to compare real-time traffic data to historical traffic data to determine traffic anomalies (e.g., congestion events). This allows the ATMS to create an alert for a traffic congestion event.
	DS-7	Automated Incident Detection	The ATMS needs to support automatic incident detection through data such as video and traffic sensor information. Automatic incident detection leverages data from field devices to alert users of potential incidents (e.g., disabled vehicles, accidents) or events (e.g., congestion) that may impact traffic.
	DS-8	Event Priority	The ATMS needs to be able to analyze event data and based on a defined set of rules and assign an event priority level that may change as an event is updated or ages. This allows the ATMS to highlight the most important events for operators to manage.
Alert Notification	AN-1	Alert Notification – Internal to ATMS	The ATMS needs to notify operators of events (e.g., congestion, incidents, weather events, and work zones), based on operator-configured alert thresholds. Alerts shall not prevent an operator from performing other activities in the ATMS. This allows the ATMS to report alerts to the ATMS operator so they can manage the event while minimizing the number of unnecessary alerts presented to the operators.
	AN-2	Alert Notification– External to ATMS	The ATMS needs to notify personnel of events via a configurable communication system (e.g., e-mail, paging, text messaging) that permits end user configuration as well as the configuration of alert thresholds. This allows the ATMS to notify staff (e.g., TOC supervisors, TOC Mangers, Duty Officers, District Administrators, Maintenance Staff, and Contractors) of events requiring action from VDOT or contract staff while minimizing the number of unnecessary alerts provided to these staff.
Vehicle Dispatch	VD-1	Vehicle Dispatch	The ATMS needs to support the dispatching of VDOT vehicles (e.g., SSP, signal technicians) to an event. This allows TOC operators to notify field staff of events so that that the closest vehicle can respond.
Data Dissemination	DD-1	Disseminate Traffic Data	The ATMS needs to provide traffic data to TOC staff, other VDOT staff, and the TV&D Distribution Services Center. This allows the ATMS to initiate the dissemination of traffic data to entities such as 511, other state and local TOCs, third party data providers, and TOC operators on any approved device (e.g., laptop, tablet, smartphone, desktop).
	DD-2	Disseminate Environmental Data	The ATMS needs to provide environmental data to TOC staff, other VDOT staff, and the TV&D Distribution Services Center. This allows the ATMS to initiate the dissemination of environmental data to entities such as 511, other state and local TOCs, third party data providers, and TOC operators on any approved device (e.g., laptop, tablet, smartphone, desktop, video wall).

Category	ID	Title	Description
	DD-3	Disseminate Event Data	The ATMS needs to provide event data to TOC staff, other VDOT staff, and the TV&D Distribution Services Center. This allows the ATMS to initiate the dissemination of event data to entities such as 511, Customer Service Center (CSC) portal, other state and local TOCs, third party data providers, and TOC operators on any approved device (e.g., laptop, tablet, smartphone, and desktop).
	DD-4	Video Sharing	The ATMS needs to facilitate the sharing of video with TOC staff, other VDOT staff, video walls, and the TV&D Distribution Services Center. This allows the ATMS to initiate video sharing with entities such as 511, other state and local TOCs, first responders, media, third party data providers, and TOC operators on any approved device (e.g., laptop, tablet, smartphone, desktop, video wall).
	DD-5	Work Order and Service Requests	The ATMS needs to provide service and work order requests to VDOT staff and asset management systems. This allows the ATMS to initiate service or work order requests. Service requests include maintenance of ITS field devices. Work order requests include non-ITS activities such as guard rail replacement.
User Interface	UI-1	Map Display	The ATMS needs to provide a map display with configurable layers with as much detail as possible and support geospatial data. All significant roadways must be included. This allows the ATMS to display items such as roadways, boundaries, maintenance responsibilities, location of field devices, traffic condition data, and location of events on individual layers that an operator may select. Operators may have as many or as few layers shown on their displays as they consider necessary for the work they are performing.
	UI-2	User Interface	The ATMS needs to provide a user interface. This allows an operator to interact with the ATMS with minimal effort keyboarding. The user interface may vary depending on the user group. For example, an ATMS operator may have a different interface then field personnel using a mobile device.
Data Archive	DA-1	Data Storage	The ATMS needs to store all traffic, environmental, and event data along with all ATMS user actions. This allows the ATMS to keep a record in the system of all data needed for reporting, for using historical data to determine traffic anomalies, for providing data to the Smart Travel Laboratory and VDOT's Archive Data Management System (ADMS), and for assessing the effectiveness of operator actions and response plans.
	DA-2	Automated Operations Information	The ATMS needs to store any information operations personnel may need to perform their job, to the extent possible. This allows the ATMS to be the single source of data for operations personnel to access.
Reporting	R-1	Pre-defined Reporting	The ATMS needs to provide pre-defined reports. This allows operators to request reports from a known set that addresses known reporting needs.

Category	ID	Title	Description
	R-2	*ad hoc* Reporting	The ATMS needs to allow for the configuration of reports using standard data elements and simple data selection mechanisms. This allows operators to present information (e.g., performance measures) from data elements stored in the data archive without having to learn another software product.
System Level Needs	SL-1	Security from External Sources or Entities	The ATMS needs to protect itself from unauthorized access by external sources or entities. This protection addresses both cyber-attacks from all external sources and unauthorized entry by outside individuals to sensitive operations areas.
	SL-2	Security from Internal Sources or Entities	The ATMS needs to protect itself from unauthorized access by internal sources or entities. This protection addresses both cyber attempts to gain access to ATMS resources and unauthorized entry by inside individuals to sensitive operations areas.
	SL-3	User Permissions	The ATMS needs to support multiple levels of access to the system. This allows the ATMS to control permission levels of different user groups and access levels within a group.
	SL-4	Remote Access – Situational Awareness	The ATMS needs to allow for remote access to the system from any approved device (e.g., desktops, laptops, tablets, or smartphones) for situational awareness. This will allow different user groups to access the system from any location for situation awareness and viewing of roadway conditions.
	SL-5	Remote Access – ATMS Control	The ATMS needs to allow for remote access to the system from any approved device (e.g., desktops, laptops, tablets, or smartphones), for users with appropriate permissions, to execute ATMS functions. This allows the ATMS to be accessed and run from locations outside of the TOC.
	SL-6	Configurable User Profiles	The ATMS needs to support configurable user profiles that save user settings until a user deletes or changes the profile. This allows the ATMS to adapt specific functionality to specific users (e.g., a user that always manages I-64 will automatically have only I-64 information loaded on their map display after user log in).
	SL-7	Interoperability	The ATMS needs to support interoperability among regional TOCs. The ATMS shall provide the ability of two or more TOCs to exchange information and to use the information that has been exchanged. This shall allow for command and control of ITS field devices in all regional TOCs using a common operating platform.
	SL-8	Availability	The ATMS needs to be operational 24 hours a day 365 days a year.
	SL-9	Extensibility	The ATMS needs to be capable of being modified to increase its storage or functional capacity (e.g., the ATMS shall allow for more devices and more device types to be added than are originally deployed).
	SL-10	Maintainability	The ATMS needs to be easily modifiable to correct faults, improve performance or other attributes, or adapt to a changed environment.
	SL-11	Reliability	The ATMS needs to consistently perform its required functions under stated conditions 24 hours a day 365 days a year.

Category	ID	Title	Description
	SL-12	Flexibility	The ATMS needs to allow the system to be modified for use in applications or environments other than those for which it was specifically designed.
	SL-13	Usability	The ATMS needs to have an intuitive, simple interface that allows a user to learn to operate, prepare inputs for, and interpret outputs of a system or component.

4.3 Capabilities Considered But Not Included

There were some capabilities discussed with VDOT stakeholders that were considered, but not included in the Statewide ATMS Operating Platform. These capabilities are discussed below and will be useful to personnel involved with system development, whether it is users or developers, should they want to know if a certain change or feature was considered, and if so, why it was not included.

- **Maintenance and Asset Management Functionality** – The Statewide ATMS Operating Platform will not serve as VDOT's Maintenance and Asset Management System. However, the ATMS should provide information into these systems such as ITS field device diagnostics data and work order requests.
- **Simulation Forecasting** – The Statewide ATMS Operating Platform will not include the functionality to simulated traffic conditions and traffic management responses. While the ATMS will not perform this functionality, it should provide the capability to provide input into such models so simulations can be run.

4.4 Assumptions and Constraints

This section describes the assumptions or constraints applicable to the changes and new features identified in this section. These assumptions and constraints will affect users during development and operation of the new or modified system. An assumption is a condition that is taken to be true. A constraint is an externally imposed limitation placed on the new or modified system or the processes used to develop or modify the system. Assumptions and constraints are listed below.

<u>Assumptions</u>

- The new user interface will be based on a Graphical User Interface (GUI) similar to the interface that exists in the current ATMS platforms. The assumption is that the interface will include things such as a map display, icons, menus, tools bars, and a video wall.
- Each region will continue to operate a TOC that manages traffic in their region and have local capabilities that may be unique and only relevant to their region or a small subset of the regions. Any Regional TOC should be able to inherit the unique capabilities of other regions during failover. For example the Northwest Region will continue to operate Fog Light Systems while other regions in the state do not, but they could take control if the NRO TOC fails.
- Current ITS field devices will remain in operation for the coming years. There is not a major initiative to replace the ITS devices in the field before the new Statewide ATMS Operating Platform is implemented. Therefore, the ATMS needs to operate all devices currently in the field and accommodate for new devices as they are installed throughout the state.

<u>Constraints</u>

- The Statewide ATMS Operating Platform must operate using the existing hardware in the TOC facilities with the flexibility to acquire new hardware for the system, as needed.
- The Statewide ATMS Operating Platform must operate with the existing communications networks. This constraint will have more flexibility as VDOT plans to upgrade and add to the existing communications networks in conjunction with the development of the Statewide ATMS Operating Platform.

5 CONCEPTS FOR THE PROPOSED SYSTEM

This section describes the proposed Statewide ATMS Operating Platform based on the desired capabilities specified in Section 4 of this document. This section describes the proposed system at a high-level indicating the operational features or functionalities that are to be provided without specifying design details.

5.1 Background, Goals, and Objectives

VDOT's vision for the new Statewide Operating platform is to have a common ATMS Operating Platform that:

Increases TOC interoperability and leverage technology to achieve more efficient operations and improve mobility and safety, in the Commonwealth of Virginia.

VDOT's intent is to have a common source code base for development and maintenance. Since each VDOT Operations Region has unique local needs, it is important to develop a software solution that will allow VDOT Operations Regions to "pick and choose" software modules based on their operational needs. With this approach the Commonwealth of Virginia can leverage its existing development funds by developing software one time and deploying it multiple times. This will also provide a significant savings on software maintenance because a common code base will be maintained for all users.

VDOT intends to acquire the most technically comprehensive ATMS platform available. The software is to be flexible and expandable to match the needs of each VDOT Operations Region. VDOT has endorsed the concept of providing a common operating platform to support the functionality of regional TOCs.

5.2 Description of the Proposed System

The primary purpose of the ATMS system is to collect, process, store, and provide access to data that will be delivered from the field equipment. Due to the critical nature of these functions, it is necessary that the system will provide for high availability though not necessarily instantaneous recovery of all functions. Tunnel Control and specifically tunnel over-height detectors require instantaneous recovery or failover. Other functions such as reversible lane controls will also need instant recovery. Consequently it is expected that the proposed architecture shall include redundancy and some fault tolerance design characteristics. In addition, the proposed architecture shall be modular, allowing for rewrite or replacement of functional components that do not require reengineering of the entire system. The modular architecture shall also provide enhanced scalability, the ability to grow as new functional components are added to the system or as individual subsystems volume growth pushes capacity limits for the overall system.

The proposed Statewide ATMS Operating Platform should be a system for statewide use with capability for local device/technology interface and control. Once the Statewide ATMS Operating Platform is implemented, it should allow users to operate the system from anywhere within the state as long as they have appropriate permissions. Additionally, the ATMS should support remote access to the system from any approved device (e.g., desktops, laptops, tablets, or smartphones) for situational awareness. This will allow different user groups to access the system from any location for situational awareness and viewing of roadway conditions. The ATMS should also allow for remote access to the system from any approved device, for users with appropriate permissions, to execute ATMS functions. For example, users should be able to send a message to a DMS.

The Statewide ATMS Operating Platform should include the functionality currently provided by the existing ATMS operating platform as well as the desired capabilities described in Section 4. Figure 8 depicts a SCD of the proposed system. The rest of this section describes the subsystems and interfaces within the proposed Statewide ATMS Operating Platform. The system is broken down into these subsystems to discuss functionality and does not reflect how the Statewide ATMS must be organized. The section is broken down into the following subsections:

- Field Device Subsystems
- Data Processing Subsystems
- Event Management Subsystems
- Decision Support Subsystems
- Map Display
- Tunnel Management
- Other Subsystems
- ATMS Data Store
- ATMS Reporting
- Interfaces to Other Systems

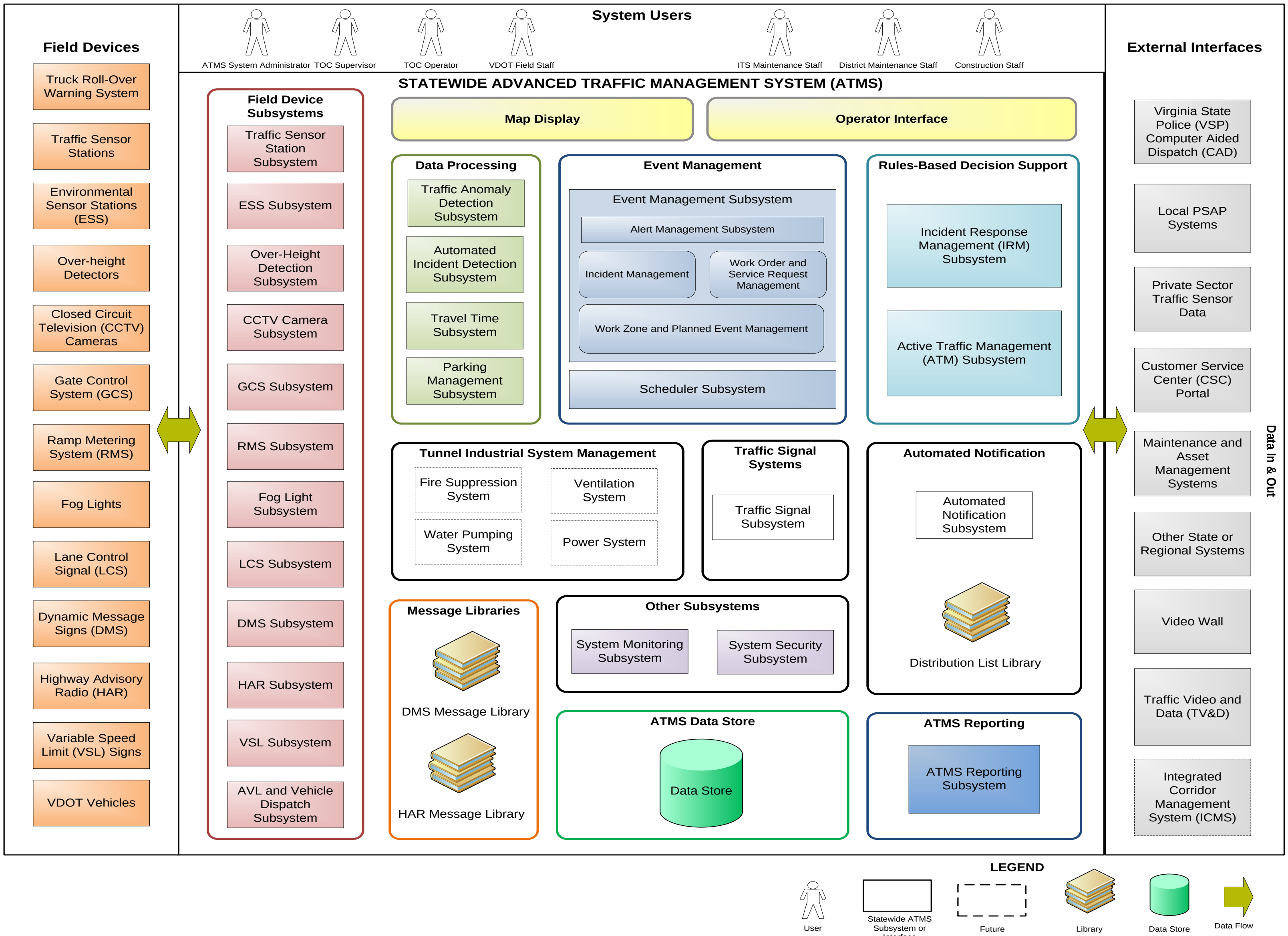

Figure 8: New Statewide ATMS Operating Platform Context Diagram

5.2.1 Field Device Subsystems

5.2.1.1 Traffic Sensor Station Subsystem

The purpose of the Traffic Sensor Station Subsystem is to collect and distribute traffic condition and vehicle classification data from ITS field devices, third party data providers, and probe vehicles. This allows the ATMS to report real-time traffic conditions and process traffic data to create congestion alerts and calculate travel times. The Traffic Sensor Subsystem should compile traffic data from all available sources and provide a single representation of traffic conditions for a link.

Traffic condition data should be obtained by polling traffic sensor field controllers to collect status, speed, volume, and occupancy data. The polling scheme should be configurable based on parameters defined by the ATMS's central system. At a minimum, devices should be polled at a one (1) minute interval. All traffic condition data should be brought back to the central system and associated to a roadway link. This data should be collected on both the lane level and link level. Link volume should be computed by averaging the observed volume of all lanes. Link speed should be a weighted average, with the speed in each lane weighted by the number of vehicles counted in that lane. Link occupancy should be the average of the occupancies observed in each lane.

In addition to VDOT traffic sensor data, the ATMS should also collect traffic data from other transportation systems. For example, the ATMS should also receive traffic data from localities or states bordering the Commonwealth. The Traffic Sensor Station Subsystem should also collect data from third party data providers and probe vehicles. This includes data from toll tag readers and Bluetooth readers as well as data from third party XML or other feeds, similar to how VDOT receives data from INRIX.

The Traffic Sensor Station Subsystem should also collect vehicle classification data. When vehicles pass through a classification station on the roadway, the field controller examines the information provided by the detector to determine the vehicle's wheelbase, number of axles, and distance between axles. The class of each vehicle is determined by the data collected and total wheelbase, axle count, and distance between axles. Vehicle classes should be configurable within the ATMS. Data collected from field devices should be sent to the ATMS at 15 minute intervals, 24 hours a day, 7 days a week. Intervals should also be configurable.

The Traffic Sensor Station Subsystem should collect latitude and longitude information for all portable traffic sensor stations equipped with GPS. This data should be used by the subsystem to determine the location of portable traffic sensor stations. Additionally, the Traffic Sensor Station Subsystem should collect all available diagnostics data from traffic sensor station field devices. This data should be used to issue an alert anytime a device, component, or communications failure is detected. Alerts should be sent to the Work Order and Service Request Management Subsystem.

The user interface should allow the user to change configuration parameters of the traffic monitoring and vehicle classification controllers. The user should also be able to create and modify schedules for data collection intervals. Each traffic sensor station should have a unique ID and Name. Traffic sensor stations should appear as icons on the map display that display the status of the traffic sensor station. Icons should indicate if the traffic sensor stations current speed using red, yellow, and green to indicate the speed (or occupancy) at the station. By clicking on the icon on the map display or a button on a toolbar, users should be able to determine the condition of the device. This includes:

- Traffic Sensor Station ID
- Traffic Sensor Station Name
- Direction
- Detector Type (e.g., inductive loop, acoustic detector, radar detector)
- Date and time of the last update
- Average Speed
- Volume
- Graph depicting speed and volume over a period of time

The map should also display traffic conditions, on a configurable layer, for the roadway links. Figure 9 depicts link level traffic conditions where red, yellow, and green links indicate link level speeds (or occupancy). These thresholds should be configurable in the ATMS by users.

Figure 9: Traffic Condition Map[3]

As mentioned in section 3.3.1.1, a choke point screen should be an included functionality in the new ATMS. Users should be able to define choke points for their regions in the Traffic Sensor Station Subsystem. The choke points will allow users to monitor queues in areas highly susceptible to congestion. Choke points should be displayed in a visual manner, possibly similar to the display currently used in ERO.

5.2.1.2 Environmental Sensor Station Subsystem

The purpose of the Environmental Sensor Station Subsystem is to collect, consume, and distribute environmental data from ITS field devices, third party data providers, and probe vehicles. This allows the ATMS to report real-time environment conditions and process the data to create weather alerts.

Environmental data should be obtained by polling environmental sensor stations, also known as Road Weather Information Systems (RWIS). Environmental sensor stations collect environmental condition data including visibility, air temperature, road temperature, humidity, wind speed, pressure, and

[3] Regional Integrated Transportation Information System (RITIS). www.ritis.org

precipitation. The polling scheme should be configurable based on parameters defined by the ATMS. All environmental condition data should be brought back to the ATMS.

The Environmental Sensor Station Subsystem should include configurable thresholds to determine a potential weather event. This might include a fog event, road freezing event, or high winds. The subsystem should support at a minimum, three thresholds. If data collect from an environmental sensor exceeds a threshold, a weather alert should be created. If an alert is created for an environmental sensor station, the subsystem should not issue another alert for that station until the alert has been acted on by an operator. If a second threshold has been crossed before an operator responds to the first alert then an alert of higher priority should be issued. If an alert is turned into an event, there should not be any new alerts created for that same threshold at that station until the event is closed. This should prevent multiple alerts from being issued if, for example, the temperature was jumping above and below a threshold repeatedly. If new thresholds are crossed, then new alerts would be issued for that event.

The Environmental Sensor Station Subsystem should also collect and consume environmental data from other transportation systems, third party data providers, the statewide environmental sensor stations managed by VDOT Central Office, and probe vehicles. Data collected from these sources should include data from environmental sensor stations, weather overlays depicting precipitation, and data collected from sensors in probe vehicles.

The Environmental Sensor Station Subsystem should collect latitude and longitude information for portable environmental sensor stations equipped with GPS. This data should be used by the subsystem to determine the location of portable environmental sensor stations. GPS data should also be collected for probe vehicles collecting environmental data. Additionally, the Environmental Sensor Station Subsystem should collect all available diagnostics data from environmental sensor station field devices. This data should be used to issue an alert anytime a device, component failure, or communications failure is detected. Alerts should be sent to the Work Order and Service Request Management Subsystem.

The user interface should allow the user to change configuration parameters of the environmental sensor station controllers. The user should also be able to create and modify schedules for data collection intervals. Each environmental sensor station should have a unique ID and Name. Environmental sensor stations should appear as icons on the map display that display the status of the environmental sensor station. By clicking on the icon on the map display or a button on a toolbar, users should be able to determine the condition of the device. This includes:

- Environmental Sensor Station ID
- Environmental Sensor Station Name
- Date and time of the last update
- Visibility
- Air temperature
- Road temperature
- Humidity
- Wind speed
- Pressure
- Precipitation

- Volume
- Graphs depicting visibility, air temperature, road temperature, humidity, wind speed, and pressure over a period of time

The map should display road temperatures for the roadway links. This data may be collected either from environmental sensor stations or probe vehicles. This information should be included on the map as a separate layer and should use colors to differentiate between road conditions. Colors other than red, yellow, and green are recommended to avoid confusion with the traffic conditions layer.

5.2.1.3 Over-Height Detection Subsystem

The purpose of the Over-Height Detection Subsystem is to collect over-height vehicle event data from field devices and alert users of potential over-height vehicle events. Because alerts must be issued quickly if a vehicle is over-height, over-height detection systems should not require operators to post messages to field devices. Over-height systems should still operate primarily as standalone systems in that regard. The ATMS should act automatically to activate response plans for the specific over-height event. However, when an over-height detection system in the field is activated, the field device should issue an alert to the ATMS with information stating what response plan was activated.

Alerts should be issued to all users logged in within the geographic area. Upon receiving an alert, a user may act on the alert. At this point, one operator may elect to manage the incident and he/she is automatically passed to the Incident Management Subsystem. If no operator selects to “manage” the event, the alert should go to a supervisor for assignment to an operator.

The Over-Height Detection Subsystem should collect all available diagnostics data from over-height detection field devices. This data should be used to issue an alert anytime a device, component, or communications failure is detected. Alerts should be sent to the Work Order and Service Request Management Subsystem.

Operators should access the Over-Height Detection Subsystem by clicking on an icon on the map display or by clicking on the appropriate box on the toolbar. This should allow the operator to view the status of the over-height detection system field devices including messages posted on DMS.

5.2.1.4 CCTV Camera Subsystem

The purpose of the CCTV Camera Subsystem is to allow users to view video images and control CCTV cameras. VDOT TOCs include existing video systems for camera control, a video switch, video wall, and monitors integrated in operator workstations. The ATMS platform should integrate these components into the ATMS.

The CCTV Camera Subsystem should allow users to control CCTV cameras. The functions controlled by the system include those listed below and all other functions of which the controller is capable. The ATMS platform should be able to control multiple functions of multiple camera controllers simultaneously. For example, several operators should be able to control different cameras at the same time with no apparent delay in the processing commands.

- Pan (Left and Right)
- Tilt (Up and Down)
- Zoom (In and Out)

- Focus (Near and Far)
- Automatic Iris Closure when power fails
- Window Wiper
- Camera Power
- White, brightness, gain adjustment
- Iris open/closure
- Display of the direction the camera is facing
- Automatic movement of the camera and lens to preset positions

A main function of the CCTV Camera Subsystem is to relay commands from users to camera controllers in the field. It also ensures that each camera is under the control of only one user at a time.

The CCTV Camera Subsystem should enable users to create preset scenes for each camera. The scene should comprise of camera position (pan and tilt), zoom, and focus. Each preset should allow an associated text phase. In addition to the preset positions, the CCTV Camera Subsystem should allow the user to establish a series of preset views as a "tour". Each preset view should be shown sequentially to the user when the tour is requested.

Any number of users should be able to control cameras simultaneously. However, only one user at a time should be able to control a given camera. If a user attempts to control a camera that is already under the control of another user, the software should display a message on the second user's screen indicating that another user currently has control of the camera. Supervisors should have the ability to over-ride the lock function of any camera. If an operator has selected a tour and a camera programmed for display within that tour is held by another operator, a message should appear of the operator's screen indicating which camera(s) are under control by another user(s). It should also allow the option of skipping the camera in conflict.

The CCTV Camera Subsystem should collect latitude and longitude information for cameras equipped with GPS. This data should be used by the subsystem to determine the location of portable CCTV cameras. The CCTV Camera Subsystem should collect all available diagnostics data from cameras. This data should be used to issue an alert anytime a device, component failure, or communications failure is detected. Alerts should be sent to the Work Order and Service Request Management Subsystem.

Users should carry out camera control functions using the ATMS platform. An individual camera may be chosen by clicking on a camera icon from the map display, or by selecting the CCTV camera from drop-down list. Users should also be able to select preset scenes or preset tours. The CCTV Camera Subsystem should also interface with video wall systems and provide users with all functions available within the video wall system.

The user interface should provide an easy method for operators to establish preset scenes. These scenes should be keyed to an individual user's logon and therefore should remain constant unless changed by that operator. The user interface should also provide an easy method for operators to control tours. This functionality should provide the ability to allow the user to skip to the next image, go back to the previous image, pause at a current image, and change the default "dwell" time per image.

If camera control software currently exists in a Region, the ATMS platform should provide an interface to the existing software and provide the same "look and feel" as other interface applications within the

ATMS. If there is not existing camera control software in a region, the ATMS platform should provide the functionality described above.

5.2.1.5 GCS Subsystem

The opening and closing of gates involves a sequence of events that should be reflected in the GCS Subsystem. If any event in the sequence is not carried out due to equipment failure or an improper operator response to a system prompt, the sequence should abort unless an operator with the required privileges overrides the malfunction. Override privileges should be limited and should require an additional password. All reversible roadway gate functions should require the operator to enter his/her name and password to proceed.

The GCS Subsystem should command the gates to open and close in response to instructions from users. A user should be able to issue a single command for the system to put the reversible roadway into one of the following nine (9) states:

1. Open northbound, all traffic
2. Open northbound, HOV or HOT only
3. Open southbound, all traffic
4. Open southbound, HOV or HOT only
5. Open westbound, all traffic
6. Open westbound, HOV or HOT only
7. Open eastbound, all traffic
8. Open eastbound, HOV or HOT only
9. Closed both ways

In each case, the system should command DMSs associated with the gates to display the message that corresponds to the state of the roadway (e.g., HOV operations westbound). For example, the DMS message "Open to HOV-2 Only" for signs associated with westbound traffic, and "Closed" for signs associated with eastbound traffic should be coordinated.

Before commanding any set of gates to open, the GCS Subsystem should check to ensure that no gate permitting a conflicting flow is open or has been open recently (except those with the interlock disabled). The minimum time between closing the roadway in one direction and opening it in the other direction should be a parameter that can be changed by the user. If a set of gates is in mixed positions or if the positions are unknown, the system should treat them as open.

Before commanding any set of gates to open or close, the system should prompt the user for confirmation that he has visually checked the entire roadway. The system should also use the Video Incident Detection Subsystem to check for vehicles. A separate confirmation should be required for each set of gates to be closed.

When a user requests the system to put the roadway into condition 9, closed in both directions, the system should close the open gates working from upstream to downstream. After issuing the first close command, the system should immediately prompt the user for visual confirmation at the next set of gates. Thus, if a user responds immediately to each prompt, several sets of gates may be closing simultaneously.

All gate operations should require an additional password. All gate events should be logged with the name of the operator performing the operation, and date and time of the operation.

The GCS Subsystem should collect all available diagnostics data from gate field devices. This data should be used to issue an alert anytime a device, component, or communications failure is detected. Alerts should be sent to the Work Order and Service Request Management Subsystem.

All functions described above should be accessible by clicking on the toolbar or directly on a gate icon on the map display. When a user commands, or approves, the opening of reversible roadway gates, the system waits for confirmation from the user that he has visually checked the roadway and that it is OK to open. When the software prompts the user for confirmation, it should automatically display a sequence of CCTV images covering the entire length of the reversible roadway. These images should begin with the end of the roadway that should be upstream when it opens.

If a camera cannot be controlled and does not happen to be in the desired preset position, the software should try the backup camera and, if that fails, notify the user. No gate sequence should proceed until verification is given by the operator or a supervisor overrides. If a camera is locked by another operator, the operator controlling the gate operation should be notified who has locked the camera.

Each time a gate set opens or closes, the software shows the user who commanded the opening or closing, the signs associated with that gate, so that he/she can see that they are displaying the proper message. If the software can't obtain camera coverage of a sign, it displays the message reported by the system for that sign.

5.2.1.6 RMS Subsystem

The RMS Subsystem should be capable of controlling all components of the RMS. This includes collecting traffic data from traffic sensor stations, operating traffic signals, and controlling message signs or blank-out signs associated with the RMS.

The RMS Subsystem should provide an interface for operators to use the ATMS to turn ramp metering devices on or off and run predefined timing plans. Timing plans should be based on day of the week and time of the day. These plans can be scheduled and run automatically. The RMS should allow users to alter metering parameters and time of day scheduling of ramp meter start and stop times. This includes the ability to change cycle length information for the RMS (e.g., the traffic signal's red and green time).

The RMS Subsystem should also support adaptive ramp metering algorithms. The subsystem should collect traffic data from traffic sensor stations associated with the RMS. This should include traffic data collected on the ramp, on the mainline upstream of the ramp, and on the mainline downstream of the ramp. This data should be input into the RMS Subsystem's ramp metering algorithm. The subsystem should also calculate a timing plan based on current conditions using data from traffic sensor stations. The timing algorithm examines two (2) important pieces of information. The first is bottlenecks forming on the freeway. If bottlenecks form of the freeway, the ramp meter needs to restrict the flow of traffic into the freeway. At the same time, the subsystem must monitor the queue length on the ramp. If the queue length exceeds a set threshold then the ramp meter must speed up allowing more cars to enter the freeway.

When the RMS is activated, the RMS should also send a message to the RMS's DMS or blank-out signs. These messages should indicate that the ramp meter is activated.

The RMS Subsystem should collect all available diagnostics data from traffic sensor stations, traffic signals, and DMS or blank-out signs associated with the RMS. This data should be used to issue an alert anytime a device, component, or communications failure is detected. Alerts should be sent to the Work Order and Service Request Management Subsystem.

Operators should access the ramp meter system by clicking on an icon on the system map (when it is sufficiently zoomed in) or by clicking on the appropriate box on the toolbar. A text pop up box should allow the operator to alter the schedule for metering start and stop times and change the metering parameters (where applicable.)

5.2.1.7 Fog Light Subsystem

The purpose of the Fog Light Subsystem is to control lights embedded in the roadway to mark the edge of the roadway to help improve road visibility. The Fog Light Subsystem should provide a means for users to access, monitor, and control fog lights. Operators should be able to select a fog light station, and turn the lights on and off. Operators should view logs containing a record all of the fog light's status and events. Operators should be able to see CCR readings from any fog light station. This information includes kilowatt, electrical current, volt, and actual brightness values. Any operator action that is taken should be recorded and logged into the Data Store.

The Fog Light Subsystem should collect all available diagnostics data from fog light devices. This data should be used to issue an alert anytime a device, component, or communications failure is detected. Alerts should be sent to the Work Order and Service Request Management Subsystem.

5.2.1.8 LCS Subsystem

The LCS Subsystem should be capable of operating LCS directly and on a time of day basis. The LCS Subsystem should be designed and programmed so that an operator can configure the lane signal controllers individually or in groups by issuing a single command through the software. The LCS Subsystem should support, at a minimum, the following messages:

- "Red X"
- "Yellow Arrow" pointing diagonally down and to the left
- "Yellow Arrow" pointing diagonally down and to the right
- "Yellow X"
- "Green Arrow" pointing down
- Speed Limits (for ATM)
- HOV Diamond Symbol (for ATM)

The figure below depicts sample LCS display messages. Some of these displays support ATM strategies. The LCS Subsystem should also support control of traffic signal heads which are deployed at tunnels. This includes standard three (3) and six (6) lamp traffic signal heads.

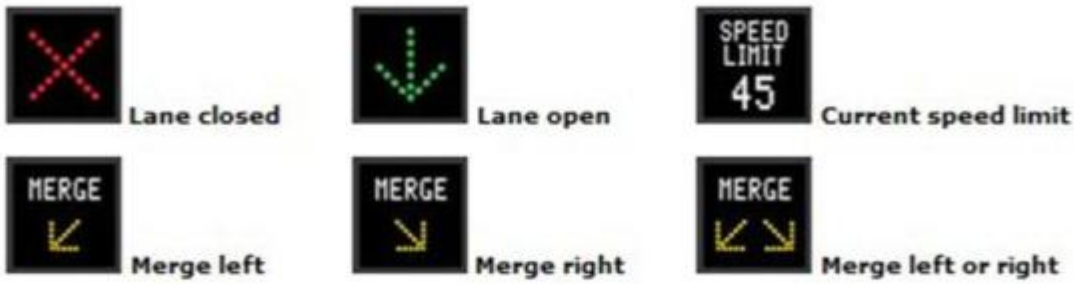

Figure 10: Examples of LCS Display Messages[4]

When a user issues the command to change the message of a LCS, the software should initiate a video "tour" of the lane controlled by the signals. This tour should consist of video images from the CCTV cameras showing the lane. The operator should observe the images to verify that the lane is clear of disabled or abandoned vehicles. At the end of the tour the operator should be asked to verify the signal change and upon doing so, the signal change should occur. The LCS Subsystem should also use the Video Incident Detection Subsystem to check for vehicles. If the operator or the Video Incident Detection Subsystem observes a vehicle in the lane, the signal change procedure can be terminated until the lane is cleared.

The LCS Subsystem should collect all available diagnostics data from LCS field devices. This data should be used to issue an alert anytime a device, component, or communications failure is detected. Alerts should be sent to the Work Order and Service Request Management Subsystem.

The operator should access the LCS Subsystem by clicking on an icon on the map display or by using the toolbar. In either case, a text box should pop up that should allow an operator to change the parameters associated with an individual signal, or a group of signals. Users should also be able to see the status of the messages posted on LCS signs.

5.2.1.9 DMS Subsystem

The DMS Subsystem allows users to develop and send messages to DMS and portable DMS. It also keeps track of the current status of all DMS. The DMS Subsystem should control DMSs in response to user input and schedules stored in the ATMS. Multiple users should be able to control DMSs simultaneously. However, only one user at a time should be able to control a particular sign. If a second user attempts to control a DMS already being controlled by another user, the software should reject the second operator's commands and identify which user is currently controlling the sign. When changing a DMS message, the DMS Subsystem should check the messages against an established list of acceptable and unacceptable words. The acceptable and unacceptable words list should be configurable by supervisors. An alert should be generated when a message has been broadcast for a period longer than a user defined threshold.

The DMS Subsystem should support message priorities. Messages with a higher priority shall be posted on a DMS over a message with a lower priority. This priority is important especially when messages are populated by subsystems such as the Travel Time Subsystem. An example of prioritization for messaging is provided below:

[4] I-66 Active Traffic Management Concept of Operations

1) Emergency
2) Incidents
3) Amber Alerts
4) Construction/Work Zone
5) Weather
6) Special Events
7) Travel Time
8) Ozone
9) Safety Campaigns
10) Test Messages
11) VDOT Hearing

If a user attempts to post a message on a sign and the sign has a higher priority message, the user should be notified that the message will not be posted because of a priority conflict.

The DMS Subsystem should be able to store a library of at least 2,000 messages. The library should enable users to search by a key word. A message in the library may be designated as applicable to all signs, or applicable only to certain types of signs (e.g., regulatory signs or advisory signs). Users should also be able to create new messages. The DMS Subsystem should allow users to:

- Create new messages for the message library or edit messages stored in the library. The DMS Subsystem should be able to handle all ASCII symbols, centering justifying, and alternating messages the same way that the sign controllers do. It should also support full matrix, color images for displaying graphics such as a traffic sign (e.g., speed limit sign). Messages should appear on the user interface just as they would appear on a sign. Upon creating or revising a message, the user should be able to save it to the message library and send it directly to one or more sign controllers for display.
- If a user chooses to send the message to one or more signs, the software should present the user with a list of all signs in the user's geographic profile. The user can select the signs the message goes to. Alternatively, the user should be able to designate signs by selecting icons on the map display.

If a user wants to save a new message in the message library, he/she should specify the signs the message is applicable to (or all signs).

The DMS Subsystem should collect latitude and longitude information for DMSs equipped with GPS. This data should be used by the subsystem to determine the location of portable DMS and verify that the location of the device on the map is correct. Additionally, the DMS Subsystem should collect all available diagnostics data from DMSs. This data should be used to issue an alert anytime a device, component, or communications failure is detected. Alerts should be sent to the Work Order and Service Request Management Subsystem.

Users should access a sign by clicking on a sign icon on the map display or by selecting a DMS from a toolbar. Icons displayed on the maps should be color coded based on the type of message displayed on the DMS. For example, a DMS displaying a HOV message should be green while a DMS displaying a traffic advisory message should be blue. This enables operators to quickly see the types of messages posted on a DMS, from a global view. The user interface should also support the functions described above. Any action taken by an operator with a sign should be recorded and logged in the Data Store.

5.2.1.10 HAR Subsystem

The purpose of the HAR Subsystem is to provide users with an easy-to-use interface with HAR transmitters and beacons. The HAR Subsystem should control the HAR equipment in response to instructions from operators. Control functions that should be supported include:

- **Transmitter Selection** – An operator should be able to select one or more HAR transmitters for message activation, deactivation, or modification.
- **Message Selection** – An operator should be able to select from a library of previously defined HAR messages. The library is discussed in detail below.
- **Message Creation** – An operator should be able to create a message by typing in the message. The subsystem should convert the text message to speech. An operator should also be able to upload an audio file, such as a *.wav or *.mp3 file into the subsystem. By default the messages should include "This is the Virginia Department of Transportation, WPQZ-722" at the end of all messages.
- **Message Activation** – Once an operator is ready to begin broadcasting a message, the software should automatically contact the appropriate HAR transmitter or group of transmitters and activate the message. The operator should have the option of modifying the message duration alert threshold. In addition, the subsystem should activate beacons on HAR Advisory signs. The subsystem should also automatically suggest to an operator appropriate DMS locations and messages to activate in conjunction with the HAR message. Once a message is activated the ATMS should make recommendations to the operator of nearby DMS signs and messages that would match the HAR message.

Multiple users should be able to perform the above functions simultaneously, except that only one user at a time should be able to control a particular HAR unit. If a second user attempts to control an HAR unit already being controlled by another user, the software should reject the second user's commands and identify which user is currently controlling the HAR in question.

A library of messages should be maintained. The library should allow messages to be stored as site specific or general purpose. Messages stored for each transmitter should be displayed to the operator for selection. Alternatively, the operator may choose to record an original message. Operators should be able to specify a name for each message stored in the library. If a user-specified name already exists, the software should notify the user and give him the options of replacing the existing message or selecting a new name for the message he has just created.

The subsystem should support the user in creating and editing HAR messages and schedules. This development should include the following:

- Easily create new messages for the message library. Upon creating or revising a message, the user should be able to save it in the message library and send it directly to one or more HAR transmitters.
- If the user chooses to send the message to one or more HAR units, the software should present the user with a list of all units so that the user can check off which HAR's the new message goes to. Alternatively, the user may designate HAR units by clicking on their icons on the system map. Using a single command, the user should be able to cause the newly created message to be broadcast.

An alert should be generated when a message has been broadcast for a period longer than a user defined threshold.

The HAR Subsystem should collect latitude and longitude information for HAR stations equipped with GPS. This data should be used by the subsystem to determine the location of portable HAR transmitters. Additionally, the HAR Subsystem should collect all available diagnostics data from HARs. This data should be used to issue an alert anytime a device, component, or communications failure is detected. Alerts should be sent to the Work Order and Service Request Management Subsystem.

The operator should be able to access all of the HAR functions described above. The operator should access a particular HAR unit by clicking on the HAR icon on the map display or by selecting a HAR button from the toolbar. The ATMS should record and log all operator actions in the Data Store.

5.2.1.11 VSL Subsystem

The VSL Subsystem should be capable of operating VSL signs directly and on a time of day basis. The VSL Subsystem should be designed and programmed so that an operator can configure VSL signs individually or in groups by issuing a single command through the software. The VSL Subsystem should support posting speed limit messages.

The VSL Subsystem should collect traffic data from traffic sensor stations and use data from other sources such as probe data and third party data, collected in the ATMS. This data should be input into the VSL Subsystem's algorithm. The VSL algorithm should be used to determine when the speed limit may need to be adjusted. Examples of when the speed limit might be adjusted are provided below:

- Weather conditions, such as ice or fog, make driving conditions hazardous. Normal speed limits are set to be safe under usual driving conditions, although safe speeds may be lower than the normal speed limit during adverse weather conditions. Using VSL to reduce speed limits during adverse weather conditions can potentially reduce the number of crashes that occur at those times.
- High levels of congestion result in prevailing speeds that are lower than the normal speed limit. Prevailing speeds in a congested area are lower than the normal speed limit and drivers cannot safely drive the speed limit. Using VSL to reduce speed limits in congested areas can result in speed limits that are more consistent with current travel speeds and could result in less variability in vehicle speeds in congested areas.
- Congestion or an event occurs downstream. Vehicles upstream from a congested area must reduce speed when they reach the congested area. Reducing speed limits upstream of the congested area can both warn drivers that traffic ahead is moving more slowly and help them make the transition to the lower speeds ahead. Using VSL to reduce speed limits upstream of congestion could reduce the number of crashes that occur as vehicles enter congestion-related queues.
- Work zones or Construction activities can make driving hazardous, and high speed traffic in a work zone can be a risk to workers. Reducing speed limits in work zones could reduce vehicle speeds in work zones, which could result in fewer work zone-related crashes and injuries.

The VSL algorithm should recommend a speed limit for individual or a group of VSL signs. Operators should also be able to select a VSL sign and change the speed limit. A supervisor must approve any change to a VSL sign. Each VSL should include approved speed limit messages for signs, configurable by a supervisor. VSL speed limit messages should have a lower and upper threshold for speed limits.

The VSL Subsystem should collect all available diagnostics data from VSL field devices. This data should be used to issue an alert anytime a device, component failure, or communications failure is detected. Alerts should be sent to the Work Order and Service Request Management Subsystem.

The operator should access the VSL Subsystem by clicking on an icon on the map display or by using the toolbar. In either case, a new window should open that allows an operator to change the parameters associated with an individual sign, or a group of signs. Users should also be able to see the status of the messages posted on VSL signs. Any action taken by the operator should be recorded and logged in the Data Store.

5.2.1.12 AVL and Vehicle Dispatch Subsystem

The ATMS should support an AVL and Vehicle Dispatch Subsystem. The purpose of this subsystem is to collect vehicle location data from VDOT vehicles equipped with GPS devices. This functionality does not have to be a fully integrated aspect of the ATMS but can be a closely interfaced function. There are many functions included in this subsystem, but the primary function is the ability to collect vehicle location data. The ATMS should have the ability to collect and consume vehicle location data. It should also allow for the collection of data collected from or on vehicles including engine diagnostics, atmospheric temperature, status of a snow plow, or status of a snow plow's spreader. More detailed functionality may be performed by a closely interfaced system. Vehicle location data updates should be collected and sent to ATMS so operators can track the position of SSP and other VDOT vehicles (e.g., maintenance vehicles, snow plows, signal technicians etc.). This information should be used by operators to assist in dispatching vehicles. For example, this information can be used to dispatch the closest SSP vehicle to an incident. Location data should include latitude, longitude, heading, and speed. Vehicle location updates should be displayed on the ATMS's map display, on a separate layer, to show real-time location of vehicles.

This subsystem should also be leveraged with the Incident Management Subsystem. For existing events, a TOC operator should be able to dispatch a SSP vehicle to an event and relay the location of that event to the vehicle. SSP personnel should have a mobile device such as a smartphone, tablet, or laptop that is remotely connected to the ATMS. Once a SSP has been dispatched by an operator, they should receive an alert to indicate that they should go toward an event. This alert should include an audio notification so the SSP patroller will be aware of the message. They should then acknowledge the dispatch so the operator is aware they received the message. To do this, SSP vehicles need to be equipped with GPS-enabled devices and a device that can receive dispatch information.

SSP patrollers should also be able to create alerts remotely using their mobile device. These alerts should contain basic information including location and roadway direction of an event. These events must still be managed by a TOC operator as the SSP patroller will not have access to the full functionality of the Incident Management Subsystem.

When a SSP arrives at an event they did not create, they should send an update to operators, indicating they have arrived. The SSP update should trigger an event update in the Incident Management Subsystem and log the time when the SSP arrived on scene. While the SSP patroller is on scene they should be able to view the details of the event using a mobile device and will be able to report services rendered and vehicles involved. Changes made by TOC operators to the event will be propagated to the SSP device. When a SSP has finished its work at an event, the application will allow the SSP to record departure from an event so that the SSP can continue patrolling for other events.

5.2.2 Data Processing Subsystems

5.2.2.1 Traffic Anomaly Detection Subsystem

This subsystem should monitor data collected by the Traffic Sensor Station Subsystem for determining anomalies in traffic conditions indicative of an incident or severe congestion. Real-time data should be compared to historical data. Once this subsystem identifies an anomaly, all users logged into the geographic area should be notified. One operator should choose to manage the event and he/she should be automatically “passed” to the Incident Management Subsystem.

When the subsystem detects that the speed on the link has been lower than the threshold level for more than a specified number of polls, an incident alert should be generated. As long as the subsystem detects that the speed on a link is equal to or greater than the threshold, no alert should be generated.

The subsystem should compare real-time link data collected from Traffic Sensor Stations to historical link data. The subsystem should compare the real-time data against a configurable timeframe (e.g., 15 minute intervals, hourly intervals, peak period). The subsystem should also consider the day of the week and the month so that real-time data collected on a Friday afternoon in November is compared to historical data on a similar Friday in November.

The subsystem should store speed and occupancy thresholds for each link. It should accommodate thresholds for different time-of-day and day-of-week combinations. In addition, the subsystem should store system-wide occupancy thresholds for weather conditions such as: rain, snow, fog, and ice. These thresholds are applied automatically when weather conditions warrant, and are not maintained on a time-of-day/day-of-week basis.

The subsystem should automatically transition between occupancy thresholds. Under normal weather conditions, the appropriate time-of-day/day-of-week threshold should be selected by the subsystem. When one of the four weather conditions are detected, or entered by the user, the weather-defined thresholds should be applied to all links.

To account for various types of anomalies in the detector data, the subsystem should incorporate a parameter that should define the number of successive polls required to exceed the current threshold before an incident alert is triggered. This parameter should be for the entire system (not for each link), and should be stored in a configuration file that could be easily modified.

Once an anomaly is detected by the Traffic Anomaly Detection Subsystem, an alert should be generated to a user operating the ATMS in the geographic limits of the alert. At this point, one operator may elect to manage the incident and he/she is automatically passed to the Incident Management Subsystem. If no operator elects to “manage” the event, the alert should go to a supervisor for assignment to an operator.

5.2.2.2 Automated Incident Detection Subsystem

The ATMS needs to support automatic incident detection through data such as video and traffic sensor information. Automatic incident detection leverages data from field devices to alert users of potential incidents (e.g., disabled vehicles, accidents) or events (e.g., congestion) that may impact traffic.

This subsystem should monitor traffic and video data for determining anomalies in traffic conditions indicative of an incident or severe congestion. Real-time data should be compared to historical data.

Once this subsystem identifies an anomaly, all users logged into the geographic area should be notified. One operator should choose to manage the event and he/she should be automatically “passed” to the Incident Management Subsystem.

The Automated Incident Detection Subsystem should receive traffic and video data and feed the data into an automated incident detection algorithm. This algorithm should detect stopped vehicles. For example the algorithm may be based on video analytics, tracking techniques, and trajectory analysis to detect stopped vehicles within the field of view of a camera.

If the algorithm detects an incident, the subsystem should issue both an audible and visual alert to users operating the ATMS in the geographic area of the incident. The subsystem should instantly provide users with the location of the incident, its type, the live video image, and the recording of the seconds preceding the incident. If no operator elects to “manage” the event, the alert should go to a supervisor for assignment to an operator.

5.2.2.3 Parking Management Subsystem

The Parking Management Subsystem should collect parking data from traffic sensors located at VDOT facilities for cars and trucks (e.g., park-and-ride lots). The Parking Management Subsystem should also of collect parking data from other entities such as parking garages operated by transit agencies or truck parking lots. This data should be processed to determine the number of available parking spaces at a parking facility. Parking availability data may be used to populate a message for a DMS or may be made available to the TV&D Distribution Service Center. This would allow VDOT to share parking information with 511 and other public and private entities.

The Parking Management Subsystem should support the ability to implement automated parking information messages for dissemination on DMS. These messages should be sent in agreement with a defined, yet reconfigurable hierarchy of messaging priorities. For example, a message about an incident should have a higher priority than a parking message.

5.2.2.4 Travel Time Subsystem

The purpose of the Travel Time Subsystem is to calculate travel times for freeway and arterial roadway links for posting travel time messages on DMS, supporting performance reports, and providing information to other entities through the TV&D Distribution Service Center. This subsystem also supports the ability to post travel time messages on 511’s IVR and website.

The Travel Time should aggregate data from various data sources including private sector data feeds, traffic sensor station data, and potentially toll tag data to calculate travel times. This may be done by obtaining travel time directly from private sector data sources or by calculating travel times using speed data from traffic sensor stations, or determining travel times from toll tag reader time stamps. Using these data sources, the Travel Time Subsystem should aggregate multi-source data and fuse it to determine a single travel time for a link.

The Travel Time Subsystem should support the posting of travel time messages on DMS. The Travel Time Subsystem should generate travel times for configurable segments, or combination of links, defined by users. Travel times should automatically be uploaded to DMSs. The subsystem should also incorporate data smoothing features necessary to generate accurate travel times.

The Travel Time Subsystem also uses pre-defined and fully configurable "thresholds" and rule-based decision logic for determining maximum and minimum operating conditions and to manage periods when travel conditions are changing. Thresholds include:

- A cap on maximum travel speeds used in the calculation or as part of the final output for each segment's designated speed limits.
- The ability to filter out bad data (e.g., data with low confidence levels received from private sector data sources).
- Identification of data errors or failures to attain travel time data for a continuous period of greater than 15 minutes for any segment. In these cases, the travel time system will automatically notify the operator of an error and remove travel time messaging for that link.

The Travel Time Subsystem supports the ability to implement automated dissemination of all DMS messaging that is in agreement with a defined, yet reconfigurable hierarchy of messaging priorities. The preliminary prioritization of all messaging includes:

1) Emergency
2) Incidents
3) Amber Alerts
4) Construction/Work Zone
5) Weather
6) Special Events
7) Travel Time
8) Ozone
9) Safety Campaigns
10) Test Messages
11) VDOT Hearing

When the selected DMS signs are initially blank, the Travel Time Subsystem should automatically display travel time messages, as a default. When operators post messages with priorities higher than travel time on these signs, the ATMS should automatically replace the default travel time message with the messages posted by operators. When operators take down higher priority messages, travel time messages should automatically be posted back onto these DMS signs.

When operators post lower priority messages, the ATMS should automatically prompt an alert of priority conflict. Operators can overwrite (posting lower priority messages) or accept (not posting lower priority messages) the alert. Similarly, when the non-travel time messages are taken down by operators, the ATMS automatically posts the travel time messages back onto the signs.

Users should be able to identify DMSs for posting travel times to. These travel times should be associated to a user defined travel time segment(s). DMSs may post travel times for one or more than one destination. Examples of DMS travel time messages are provided below.

	T	R	A	V	E	L		T	I	M	E		T	O	:	
I	-	4	9	5		2	0		M	I		A	H	E	A	D
				2	0	-	2	6		M	I	N				

Figure 11: Single Destination Travel Time Message

	T	R	A	V	E	L		T	I	M	E		T	O	:	
R	T		5	0				1	3	-	1	7		M	I	N
I	-	4	9	5				2	0	-	2	6		M	I	N

Figure 12: Multiple Destination Travel Time Message

The Travel Time Subsystem should also support configurable travel time message ranges. This allows VDOT to disseminate a range of travel time instead of a single travel time. The range should vary on a graduated scale, i.e., narrower range at a lower value and wider range at a higher value. The subsystem should allow the range to be capped at a higher value (e.g., 45 minutes and above). Examples of travel time ranges are provided below.

Table 6: Sample Travel Time Message Ranges

Reported Travel Time, Min	Suggested Range	Example*
0-10	+/- 1	**5** will be shown as 4-6
11-20	+/- 2	15 will be shown as 13-17
>20	+/- 3	25 will be shown as 22-28

** The lower value of the range should not be less than the speed limit derivative.*

Users should be able to create travel time segments and associate them to a DMS for posting travel times. If a user chooses to send the message to a sign, the software should present the user with a list of all signs in the user's geographic profile. The user can select the signs the message goes to. Alternatively, the user should be able to designate signs by selecting an icon on the map display.

5.2.3 Event Management Subsystems

5.2.3.1 Alert Management

Event Management Subsystems support the management of traffic, weather, work zones, maintenance, and planned events. The Alert Management Subsystem should prioritize alerts based on the alert type and the characteristics of the alert. The prioritization of alerts may vary from region to region and must be configurable for the local environment and operations. For example, an accident involving a tractor trailer should be prioritized higher than a disabled vehicle. In some regions a disabled vehicle may become a higher priority than it would be in other regions. It should also consider the time the alert was created so that older alerts of a similar type are addressed before new alerts of the same alert type.

The Alert Management Subsystem should allow Supervisors to see the list of queued alerts and the time the alert has been in the queue. The prioritized list of alerts should be presented to Supervisors in a window. The window should allow Supervisors to easily see higher priority events, perhaps using color coding to differentiate between priorities.

Once alerts are in the queue they should be sent to the next available operator for management of the event. This is similar to how phone calls are distributed to dispatchers at a 911 center. Alerts should only be sent to users signed in as TOC Operators and should only be sent to users logged into operate devices in the region where the alert originated. Therefore, a TOC Operator in NRO logged into operate in NRO should not receive an alert originating in SWRO. The Alert Management Subsystem should also be configurable to direct alerts to operators assigned to a given county or roadway.

Once a user receives an alert, they should be given a configurable amount of time (e.g., 30 seconds) to perform any other activities within the ATMS. For example, a user can finish sending a message to a DMS. After the time threshold is exceeded, the ATMS should require the operator to take action on the alert by restricting other activities within the ATMS. Once a user receives an alert, he/she should be required to take any of the following actions on the alert:

- **Ignore the Alert** – Users can ignore the alert
- **Examine the Alert** – Users can examine an alert in detail by displaying the alert in an alert detail screen which provides more information about the alert
- **Generate an Incident** – Users can generate an incident based on the information provided in the alert
- **Update and Associate Incident** – Users can update and associate incidents with an existing incident

Video confirmation is critical in verifying an alert. To assist operators with acting on alerts, the Alert Management Subsystem should automatically pull up the closest CCTV camera based on the location information (e.g., latitude and longitude, mile marker) included in the alert. Users should be able to associate an alert with an event or incident. By associated an alert to an event or incident then events and incidents can automatically be updated as alerts are updated.

5.2.3.2 Incident Management Subsystem

The Incident Management Subsystem should be activated once an operator generates an incident from an alert, or when an operator manually identifies an incident. In addition to traffic incidents, the subsystem should also allow operators to manage weather and congestion events.

Once reaching the Incident Management Subsystem, the operator should see a data entry window to describe the details of the incident (such as severity, number of lanes blocked, HAZMAT conditions, injuries, etc.). If the incident was created from an alert, details from the alert should be populated into the fields in the Incident Management Subsystem.

The Incident Management Subsystem should support operators in the management of incidents. Operators should be provided with pre-defined incident response plans or ATM plans based on the location, type, number of lanes blocked, severity of the incident, and real-time traffic conditions. These response plans are discussed in Sections 5.2.4.1 and 5.2.4.2.

As part of incident response and ATMS plans, the Incident Management Subsystem should support operators in the use of ITS field devices. These devices might include DMS, HAR, LCS, and ramp meters. The system should recommend messages or timing plans for these devices. Additionally, the Incident Management Subsystem should identify the closest available SSP to the incident or event.

Operators should not be limited to pre-defined incident response plans. Operators should also have to ability to implement *ad hoc* plans that can be activated. This allows the ATMS to execute traffic management strategies based on operator judgment.

When an operator begins to manage an incident, the CCTV camera with the best potential view of the incident should be displayed to the operator. At this point, the operator may verify the incident or declare it as a false alarm. If the incident is verified, the operator should continue through the incident management process.

The Incident Management Subsystem should support, at a minimum, the following data entry fields:

- Type of Incident
- Number of Vehicles involved in the Incident
- County
- Road
- Direction
- Number of Lanes Blocked
- Mile Marker (at 1/10th mile increments)
- Detection Source
- Agencies Notified and the Time they were Notified
- Time SSP was Dispatched
- Time SSP arrived at the Incident
- Time Police and First Responders arrived at the Incident
- Time SSP departed the Incident
- Time Police and First Responders departed the Incident

Operators should be able to check the status of an incident and enter information by clicking on an icon on a map or a button on a toolbar. Authorized users should be able to add or change information about incidents. Data entry should support drop-downs to assist the operator in entering data. As an operator enters data, the Incident Management Subsystem Data should reduce the number of items in the drown-down menu based on data entered into previous fields. For example, if an operator enters the road I-95, the county field drop-down menu should only allow an operator to see (and select) the counties that I-95 transverses. The data entry field should also be dynamic for the operator. For example an operator should not be required to enter in the number of vehicles involved if the incident is debris in the road. The incident type should determine what fields are displayed for operators to minimize unnecessary data entry.

5.2.3.3 Work Zone and Planned Event Management Subsystem

The Work Zone and Planned Event Management Subsystem should provide the functionality currently included in LCAMS. This subsystem should support management of planned events. For example, work zones (which are planned events) may be entered in by operators or other users. Users should be able to enter work zones from remote locations such as VDOT Maintenance Division Offices. The system should allow users to “draw” the extent of the work zone on a map and enter details of the work zone or planned event. These details should include the type of planned event, location, number of lanes closed, duration of the planned event (dates and times), the entity responsible for the event, and the point-of-contact’s information (phone number and email).

The Work Zone and Planned Event Management Subsystem should include a database containing the “allowable” times that a roadway segment may be partially or fully closed. A user should not be able to requests a lane closure for a time period outside of the “allowable” time that the roadway segment can be partially or fully closed.

The Work Zone and Planned Event Management Subsystem should also support the ability to identify conflicts between lane closures. A conflict may entail two or more users requesting a lane closure in the same geographic area. A conflict may also entail two or more lane closures that based on their location and time, may severely impact traffic in the area.

5.2.3.4 Work Order and Service Request Management Subsystem

The ATMS should support collecting and sending information to VDOT maintenance and asset management systems through a Work Order and Service Request Management Subsystem. TOC operators often receive information about maintenance activities that they need to send to maintenance staff to create a work order. This information may come to an operator or the ATMS as information from the field device diagnostic data, CSC, a phone call, or the operator may identify the maintenance need when viewing a CCTV camera.

The Work Order and Service Request Management Subsystem should allow a user to enter data about the maintenance activity into the ATMS, including:

- District
- Asset Type
- Route
- Street Name
- Location (Latitude and Longitude)
- Problem Type
- County/City
- Created By
- Creation Date

This information may be available from either field device diagnostics data, a CSC alert, or a CAD alert. If so, data from the alert should populate data entry fields in the Work Order and Service Request Management Subsystem. Once information about the work order is entered into the ATMS, the operator should be able to send a work order or service request to VDOT maintenance and asset management systems, if an interface exists. The subsystem should also support email notices to configurable distribution lists. The user should receive confirmation that the email was received.

It is important to note that the ATMS will not integrate all of the functionality of a maintenance and asset management system. Instead its purpose is to allow operators to enter information about a work order or service request into the ATMS and alert maintenance staff accordingly.

5.2.3.5 Scheduler Subsystem

The Scheduler Subsystem should be used to schedule future response plans for ITS field devices such as DMS, HAR, LCS, and Ramp Meters. Users should be able to coordinate a response for a future event with multiple types of ITS devices. For example an operator can coordinate DMS, HAR, and ramp meters for a future work zone. These response plans would be activated on a set day and time.

5.2.4 Decision Support Subsystems

5.2.4.1 Incident Response Management (IRM) Subsystem

The IRM Subsystem should support pre-defined IRM plans included in the ATMS to assist operators in managing various ITS devices in response to an incident or an event from a geographical impact point of view.

The IRM Subsystem should be a DSS containing configurable response plans that include pre-defined field device states. Based on the location of an incident and the information entered by an operator the

IRM Subsystem should recommend these plans to the operator for implementation. Operators have the option to implement the response plan or modify the response plan before sending messages to field devices. In some cases certain events will trigger automatic responses from the ATMS. Events such as an over-height truck approaching a tunnel are time critical and need action immediately, without waiting for an operator to accept the response plan.

The IRM Subsystem will interact with numerous subsystems composed of several different ITS components. Each subsystem provides specific capabilities required as either input or output to the IRM Subsystem. These subsystems include:

- Traffic Sensor Stations Subsystem
- Environmental Sensor Subsystem
- Over-Height Detection Subsystem
- Incident Management Subsystem
- HAR Subsystem
- DMS Subsystem
- LCS Subsystem
- RMS Subsystem
- Fog Light Subsystem
- AVL and Vehicle Dispatch Subsystem
- VSL Subsystem
- Traffic Signal System

The IRM Subsystem should use information collected from other subsystems and recommend a response plan to an operator. For example, the IRM Subsystem should collect incident data and based on the characteristics of the incident, recommend DMS, HAR, and ramp metering messages and plans. The IRM Subsystem should also use AVL data from SSP vehicles and recommend dispatch of the closest, available SSP vehicle.

The IRM should also receive information from traffic signal systems. This includes signal timing plans and volume and speed data from traffic sensor stations associated with the signal system. This information should be provided as input into the IRM Subsystem. Additionally, the IRM Subsystem should recommend traffic signal timing plans as a strategy for an incident. The ATMS, however, will not implement these signal timing plans, instead provide a recommended timing to users for implementing the timing plans.

The IRM Subsystem should not be limited to traffic accidents. It should also consider response plans for weather events (e.g., fog event, or winter event). Specific responses should be selected based on “operational rules” and specific traffic flow parameters. Only after TOC operator verification, fine-tuning (if necessary) and approval, the response plans should be deployed.

5.2.4.2 Active Traffic Management (ATM) Subsystem

Before describing the ATM Subsystem it is important to define what is meant by ATM. ATM can be defined as dynamically managing and controlling traffic based on prevailing conditions in order to improve safety. These techniques target collisions that result from both recurrent and non-recurrent congestion. ATM is a tool that can maximize safety and improve throughput and may be used as an interim strategy to enhance the efficiency of corridors that may ultimately receive major capital investments. ATM encompasses the following strategies:

- **Speed Harmonization** – to dynamically and automatically reduce speed limits approaching areas of congestion, accidents, or special events. The benefits of speed harmonization are maintaining flow and reducing the risk of collisions.
- **Queue Warning** – to warn motorists of downstream queues and direct through-traffic to alternate lanes. The benefits of queue warning are to effectively use available roadway capacity and reduce the likelihood of speed differentials and collisions related to queuing.
- **Hard Shoulder Running** – to use the shoulder as a travel lane during congested periods or to allow traffic to move around an incident. The benefits of hard shoulder running are to minimize recurrent congestion and manage traffic during incidents.
- **Travel Time Signing** – to provide estimated travel time (and potentially toll information) to communicate travel and traffic conditions. The benefits of travel time signing are to allow for better pre-trip and en-route decisions by travelers.
- **Junction Control** – to use variable traffic signs, dynamic pavement markings, and lane use control to direct traffic to specific lanes (mainline or ramp) based on varying traffic demand. The benefits of junction control are to effectively utilize available roadway capacity and manage traffic flows to reduce congestion.

ATM generally combines the major elements of VSL and queue warning, and also includes lane control measures. Figures 13 and 14 show the conceptual layout of the gantry-mounted over-lane speed displays that are the backbone of the variable speed limits system. The gantries are typically spaced approximately every one-half mile along a roadway. Descriptions of the components are described below.

- Over-lane speed and lane control displays should be situated over the travel lane that the sign is controlling. The over-lane display can either display the speed or lane control markings, or the two can alternate as separate phases of a message. The lane control displays should provide the additional functionality to use this to manage incidents or address maintenance during nighttime hours. In advance of an incident, the LCS can move traffic out of the blocked lane.

- The display situated over each lane should be capable of displaying numbers (such as speed) and various icons (such as a green arrow, red 'X,' white diamond, or yellow arrow). No supplemental message (such as "speed" or "speed limit" or red circle) around the displayed speed will be necessary. The color of the numbers will be white (on a black background) to reflect the regulatory nature of the system.

- General purpose DMS should be on the right side (or in cases where no room is available on the right, the left side) of the gantry, preferably over the shoulder. These DMS will be used to warn drivers of downstream conditions and queuing that is the cause of the traffic congestion and slow moving traffic. Signs that provide additional detail or a supporting message can be placed on the gantry columns. Examples of the type of messages for these signs are ones that describe managed lane uses, posted speed limits, or traffic condition icons.

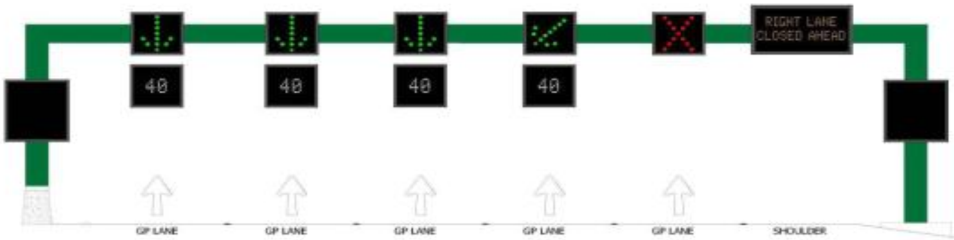

Figure 13: Conceptual Layout of an ATM Gantry

Figure 14: WSDOT Active Traffic Management Gantry[5]

Typically the signs for all general purpose lanes at a given location should display the same speeds. It should, however, be possible to display different speeds above all the lanes, but the typical practice should be to have consistent speeds displayed for all general purpose traffic. Signs over managed lanes (e.g., HOV or HOT lanes) should be able to display speeds that are different from the general purpose lanes.

The ATM Subsystem will interact with numerous subsystems composed of several different ITS components. Each subsystem provides specific capabilities required as either input or output to the ATM Subsystem. These subsystems include:

- Traffic Sensor Stations Subsystem
- Environmental Sensor Subsystem
- RMS Subsystem
- LCS Subsystem
- DMS Subsystem
- VSL Subsystem
- Travel Time Subsystem
- Incident Management Subsystem (with input from the Traffic Anomaly and Automated Incident Detection Subsystems)

[5] Washington State DOT Active Traffic Management Concept of Operations. http://www.wsdot.wa.gov/NR/rdonlyres/73AC9A17-6178-4271-B3A9-91911BD1C8C6/0/FinalATMConceptofOperations.pdf

The ATM Subsystem should include a DSS to support speed harmonization, queue warning, hard shoulder running, travel time signing, and junction control. The ATM subsystem should rely to a great extent on automated operations. Appropriate decision support functions should be implemented such that ATM strategies consider traffic information collected from ITS field devices. For example, speed harmonization decisions should consider actual downstream traffic flows, weather conditions, and lane closures. Specific response should be selected based on "operational rules" and specific traffic flow parameters. The response plans should be deployed only after TOC operator verification, fine-tuning (if necessary) and approval.

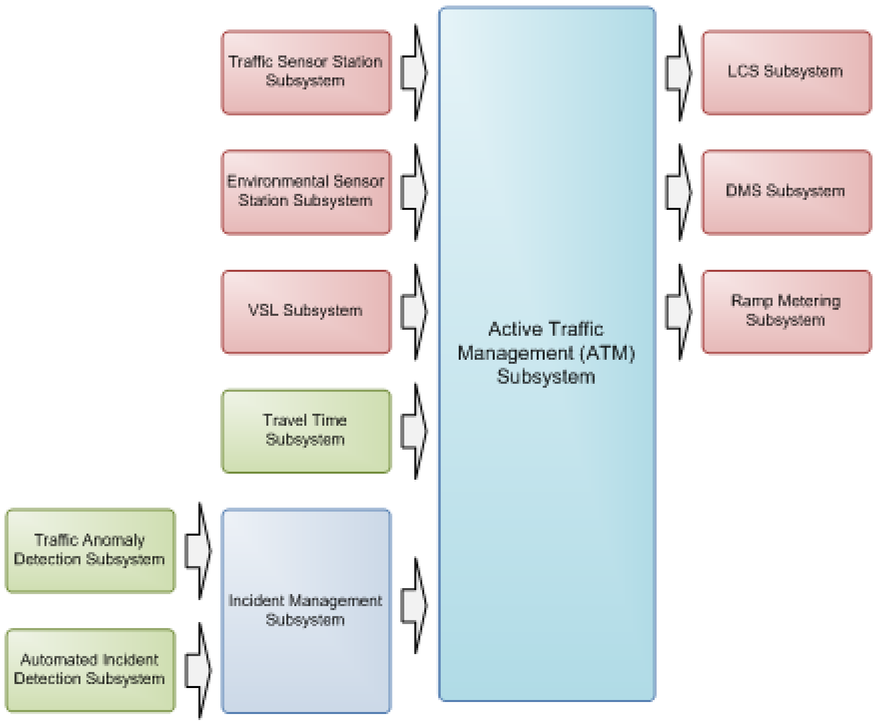

Figure 15: Active Traffic Management Subsystem – Inputs and Outputs

Within the ATM Subsystem, specific combinations of operational and geographic response strategies would be stored. Particular strategies would be selected based on input from other subsystems. Figure 15 shows inputs and outputs to the ATM Subsystem.

5.2.5 Map Display

The ATMS needs to provide a map display with configurable layers and as much detail as possible. All significant roadways must be included. The map display should also support geospatial data. This allows the ATMS to display items such as roadways, boundaries, location of field devices, traffic condition data, and location of events on individual layers that an operator may select. Operators may have as many or as few layers shown on their displays as they consider necessary for the work they are performing.

The map display should be composed of multiple layers, each containing information about a part of the system. All of the data, devices, and other information that has been previously described on the map should reside on configurable layers by the individual user. This will allow users to customize their map to view the information that is important to perform their duties. The map display should be configured such that additional layers may be added in the future as the system expands, or new features are incorporated. Operators shall be able to turn layers on and off according to their preferences and needs. If a user turns features on or off it should not affect the display of any other users.

As a user zooms in using the map, the level of detail provided on the map shall increase. Individual lanes shall be shown when sufficiently zoomed in, on both the mainline and ramps, as shall the locations of field devices and 1/10-mile markers.

5.2.6 Tunnel Management

Each of the six (6) tunnels identified in section 3.3.6, should use the Statewide ATMS Operating Platform for managing traffic at the tunnels. Tunnel TOCs should have the same functionality through the ATMS as any other TOC. For example, operators should be able to enter incidents, work zones, and other events into the ATMS. Operators should also be able to use the ATMS to collect data from and control the following ITS field devices:

- Traffic Sensor Stations
- Over-Height Detection Systems
- CCTV Cameras
- DMS
- VSL Signs
- LCS
- Gates
- Other ITS Field Devices

The Statewide ATMS Operating Platform could possibly control tunnel industrial systems. The control function of tunnel industrial systems may be integrated or may be a standalone system interfaced with the ATMS. These systems include the tunnel's ventilation system and fans, fire suppression, water pumps, and power systems. However, the ATMS should, at a minimum, be able to receive alerts from these systems. Tunnel facilities must also operate locally and independently if any communications to outside systems are lost. During severe weather events and emergency events, the tunnels must remain operational.

Before the new Statewide ATMS Operating Platform can control tunnel ITS field devices and Industrial systems, several issues with the current tunnel field devices and communication infrastructure must be addressed. These issues include the ability to communicate with a vast array of outdated state table driven field devices on a multi-drop copper communications plant using first generation cable television modems as field controllers. Additionally, some tunnel DMSs can only display a limited library of messages because their communication infrastructure only support three (3) or (4) state levels and no direct text communications.

5.2.7 Traffic Signal System Subsystem

The ATMS should be either: (1) integrated with external traffic signal systems or (2) include the ability to operate traffic signals within the ATMS. Within the ATMS, TOC operators should be able to select alternative timing plans within the ATMS or from an external traffic signal system. For example, during an incident the ATMS's IRM and ATM Subsystems should be able to recommend alternate timing plans for operators to implement. Implementation of these timing plans allows close coordination between freeway and arterial traffic management supporting ICM strategies. The ATMS does not implement these timing plans, but only recommends a timing plan that users can act upon. Changing of timing plans would require supervisor or other high-level permissions.

The ATMS should also collect data from traffic signal systems and present this data in the ATMS. This includes data from traffic signal detectors located on arterials as well as diagnostics data from traffic signal devices. This allows users to see traffic data from these devices within a single system.

5.2.8 System Security Subsystem

The ATMS needs to protect itself from unauthorized access by internal and external sources or entities. This protection addresses both cyber-attacks from all external sources and unauthorized entry by outside individuals to sensitive operations areas. The Statewide ATMS Operating Platform assumes a network environment that will support the exchange of information. No specific security (other than encrypted passwords) should be performed by the software. If additional network security is required by VDOT, a careful analysis of how data will be exchanged needs to be made prior to implementing the system.

5.2.9 System Monitoring Subsystem

The system shall provide network monitoring and management for all links between components of the ATMS and its subsystems within the TOC building. This monitoring shall include fiber optics and other media. It should detect and identify location of network failures or stress points (points at which defined capacity thresholds are reached).

Within the TOC facility, monitoring should include but not be limited to: heat and smoke detection, excessive humidity or moisture, power surges or loss, UPS failures or battery low indicators, and any other climatic or equipment status sensor. The ATMS itself shall include state of health indicators and report on critical resources, including memory, processor, and storage usage and performance.

5.2.10 Automated Notification Service

The ATMS shall include functionality for sending notifications via messages such as emails, pages, text messages, and voice messages to appropriate VDOT personnel. This service will allow the ATMS to send messages to configurable groups of users with details of events. This might include providing VDOT staff with information about a major incident, weather event, or maintenance need. This will allow the ATMS to communicate messages that provide short summaries of events entered into the Incident Management, Work Zone Management and Planned Event, and Work Order and Service Request Subsystems. For example, when a major incident is verified the chain of command inside and outside the TOC need to be alerted. The ATMS can quickly reach a distribution list to begin the response.

Distribution lists should be established for varying levels of incidents to ensure that appropriate staff is notified of the incident. These distribution lists should be associated with different types and severity of events. Incident and Event Management Subsystems should recommend distribution lists based on this information. For example, a Duty Officer should not be alerted of a minor event, but needs to be alerted of a major event (e.g., full road closure). The distribution list should also support a subscriber system so the end user can configure what messages they receive and when. For example a VDOT Executive may want to subscribe to only major incident and weather events. This would allow VDOT personnel to receive all the information they want without their specific wants having to be entered into the system by an operator, supervisor, or administrator.

The ATMS should also initiate calls, emails, texts, or pages from field device failures. The system will create a work order or service request, but for certain devices it may be necessary to alert maintenance personnel directly. The events that trigger communications to go out should be configurable.

The Automated Notification Service Subsystem should include text-to-speech capabilities for phone calls and voice messages. The Subsystem should be able to take text with an event description and details and create a digital recording of the event information. The Subsystem should make phone calls and/or leave voicemails to appropriate personnel and play the created message containing the event information.

5.2.11 ATMS Data Store

The software should log and store all significant ATMS events. All actions taken by users in each subsystem should be logged along with the name of the operator taking the action, if applicable. For example, each time a device fails should be logged, each opening/closing of a gate set should be logged, each HAR activation/deactivation should be logged, etc. In addition, once per day, at a defined time, the status of each device in the system (for example, controllers, DMS, cameras, etc.) should be logged in the system log table. A simple interface should be provided to allow the operator to quickly access a portion of the log and view or print the information. A link history table should be logged in the data store. The purpose of this table is to store information collected in the Traffic Sensor Station Subsystem so historical data can be used for other subsystems (e.g., Traffic Anomaly Detection Subsystem).

The ATMS should store all of the data for a configurable amount of time before the system stores the information. For example, the system may store the data for 13 month to insure the system always has one (1) year of data accessible. After this configurable amount of time, the data should be sent to the ADMS.

5.2.12 ATMS Reporting

The ATMS Reporting Subsystem should allow users to create pre-defined and *ad hoc* reports. Pre-defined reports allow users to request reports from a known set that addresses known reporting needs. Ad hoc reporting allows for the configuration of reports using standard data elements using simple data selection mechanisms. This allows operators to present information (e.g., performance measures) from data elements stored in the data store without having to learn another software product (e.g. Crystal Reports).

Users should be able to create reports for various geographic limits. This includes statewide reports or reports for a given Operations Region, county, road, or segment of road. Users should also be able to create reports for a set period of time.

Examples of the types of reports that should be created from the ATMS are described in the table below. In addition to these reports, the ATMS should also be flexible to create other reports using data elements in the data store.

Table 7: Examples of ATMS Performance Measures

Type of Report	Category	Performance Measure
Incident Reports	Number of Events	Number of Events
		Number of Events by Event Type
		Number of Events by Day of Week
		Number of Events by Time of Day

Type of Report	Category	Performance Measure
		Number of Events by Month
		Number of Events by Year
	Alerts	Number of Alerts Examined
		Number of Alerts by Alert Type
		Number of Alerts Ignored
	Event Location	Map Showing the Number of Events by Location (e.g., heat map)
		Map Showing the Number of Event Types by Location (e.g., heat map)
	Safety Service Patrols	Number of SSP Assists
		Number of SSP Assists by Event Type
		Number of SSP Assists by Day of Week
		Number of SSP Assists by Time of Day
		Number of SSP Assists by Month
		Number of SSP Assists by Year
	Event Detection Source	Number of Events by Detection Source
		Detection Source by Day of Week
		Detection Source by Time of Day
		Detection Source by Month
		Detection Source by Year
	Event Response Time	Average Response Time (SSP, Police, and Fire)
		Average Response Time by Event Type (SSP, Police, and Fire)
		Average Response Time by Day of Week (SSP, Police, and Fire)
		Average Response Time by Time of Day (SSP, Police, and Fire)
		Average Response Time by Month (SSP, Police, and Fire)
		Average Response Time by Year (SSP, Police, and Fire)
	Event Duration	Average Duration of Events
		Average Duration by Event Type
		Average Duration by Day of Week
		Average Duration by Time of Day
		Average Duration by Month
		Average Duration by Year
		Number of Events for Different Duration Intervals (e.g., percent of incidents cleared in 10, 20, 30 minutes)
	Event Timelines	Timeline Depicting the Start Time, Time to Verify the Event, Response Times (e.g., SSP, Police, and Fire Response Times), and Duration of the Event.
Traffic Conditions	Traffic Data	Speed from Traffic Sensor Stations (Lane and Link Level)
		Speed from Traffic Sensor Stations by Day of Week
		Speed from Traffic Sensor Stations by Time of Day
		Speed from Traffic Sensor Stations by Month
		Speed from Traffic Sensor Stations by Year
		Volume from Traffic Sensor Stations by Day of Week
		Volume from Traffic Sensor Stations by Time of Day
		Volume from Traffic Sensor Stations by Month
		Volume from Traffic Sensor Stations by Year
		Volume from Traffic Sensor Stations
		Occupancy from Traffic Sensor Stations
		Occupancy from Traffic Sensor Stations by Day of Week
		Occupancy from Traffic Sensor Stations by Time of Day
		Occupancy from Traffic Sensor Stations by Month

Type of Report	Category	Performance Measure
		Occupancy from Traffic Sensor Stations by Year
	Vehicle Classification Data	Vehicle Classification from Traffic Sensor Stations
		Vehicle Classification from Traffic Sensor Stations by Day of Week
		Vehicle Classification from Traffic Sensor Stations by Time of Day
		Vehicle Classification from Traffic Sensor Stations by Month
		Vehicle Classification from Traffic Sensor Stations by Year
	Travel Time Data	Travel Time by Segment
		Travel Time by Segment by Day of Week
		Travel Time by Segment by Time of Day
		Travel Time by Segment by Month
		Travel Time by Segment by Year
Work Zones	Work Zones	Number of Work Zones Entered into the ATMS
		Number of Work Zones Canceled, including Number by Entity (e.g., ITS Maintenance, Maintenance Division, Construction Project, TOC)
		Number of Work Zone Activated, including Number by Entity
		Number of Work Zones Entered by an Entity
		Number of Events by Day of Week, including Number by Entity
		Number of Events by Time of Day, including Number by Entity
		Number of Events by Month, including Number by Entity
		Number of Events by Year, including Number by Entity
Maintenance Reports	Field Device Reports	Number of Devices in the System by Type
		Number of Devices in Failure by Type
		Total Number of Polls per Device
		Number of Successful Polls for Each Device
		Total Number of Failed Polls per Device
		Number of Failed Polls for Each Device
	Server Reports	Server Availability
	Work Orders/Service Requests	Number of Work Orders/Services Requested

5.2.13 Interfaces to Other Systems

5.2.13.1 VSP CAD and Local PSAPSs

The ATMS shall interface with the VSP CAD system. VSP CAD is a system used to initiate public safety calls for service, dispatch, and maintain the status of responding resources in the field. The CAD system is generally used by the VSP emergency communications dispatchers, call-takers, 911 operators in centralized, public-safety call centers, and by field officers using mobile data terminals (MDTs) located in their police vehicles. VSP CAD alerts will be an important incident detection method across the state of Virginia.

The ATMS should integrate VSP CAD messages into the Alert Management Subsystem to create an alert based on the information provided by the CAD system. Upon receiving data from the VSP CAD system, the ATMS should use a look-up table to assign a traffic impact severity level to an event.

VSP CAD messages have a text field that dispatchers can type free form text into. Some of this information, however, is deemed sensitive so VDOT is not permitted to receive that information. As a result, VSP created a “ROADI” field specifically for VDOT. CAD operators can add information to the

"ROADI" to call out information that could be important to VDOT ATMS operators, without passing along sensitive information. The ATMS operators should be able to filter out CAD messages that have no impact on their operation. They should be able to see the "ROADI" and ignore things such as breathalyzer calls. Once the subsystem creates the alert, it should alert the operators to the CAD information the system received. A similar process shall take place if VSP updates a CAD message. The Alert Management Subsystem shall recognize that the data is an update to a previous message and update the corresponding alert. The Incident Management Subsystem should then automatically update the associated event, if there is one, with the new alert information.

In addition to VSP CAD information, VDOT Operations Regions are also pursuing opportunities to receive CAD information from local PSAPs. The ATMS should support receiving CAD data from local police with a similar interface. In the future the ATMS should support sending information to the VSP CAD or local CAD systems as well. State or local police may want VSL information or video from the ATMS to assist them with their duties.

5.2.13.2 CSC Portal

The ATMS shall have an interface to the CSC portal similar to the CAD interface. The CSC should be able to enter data into their system and send messages to the ATMS without having to make phone calls. The ATMS should collect the messages and create an alert based on the information in the message. The ATMS should alert operators to the information from the CSC. If the message pertained to a work order request then the alert should also be sent to the Work Order and Service Request Management Subsystem to generate a work order automatically.

CSC personnel should also have remote access to the ATMS to maintain situational awareness at all times. When the CSC receives a call about an incident they can see if the ATMS is already aware and managing the incident. The CSC can also track events from start to finish allowing them to help the public more.

VDOT's current TV&D project is investigating the ability to collect and consume public data from mobile devices. For example the general public would be able to report events such as potholes or traffic incidents using an application on their smartphone/mobile device. At this time, it is expected that this data will sent to the CSC where it will be filtered. Future integration with the ATMS is possible.

5.2.13.3 Maintenance and Asset Management Systems

The ATMS should interface with the maintenance and asset management systems (e.g. AMS, Land Use Permit System (LUPS)) VDOT operates. The interface should allow the ATMS to send work order messages generated inside the ATMS to the appropriate systems for work order creation and completion. The ATMS should also be able to receive status updates about the work orders so operations personnel can track work orders from start to end. The interface should appear seamless to operators. Operators should not have to send information out or request information about work orders. The information should be in the ATMS for the operator to view only when they need to.

CSC personnel will also have access to view work orders through the ATMS. Once they receive a call requesting maintenance they send the data to the ATMS. The Work Order and Service Request Subsystem collects all available data to send to the maintenance and asset management systems. The maintenance system will continually update the ATMS with the status of all work orders. All approved users of the ATMS can see the status of work orders including remote CSC users.

5.2.13.4 Integrated Corridor Management System (ICMS)

Integrated Corridor Management (ICM) is the set of coordinated actions taken to ensure that the networks within a defined corridor operate at their optimal performance, given the capacity available for each network. The combined application of technologies and a commitment of network partners to work together have the potential to transform the way corridors are operated and managed. Thanks to recent advancements in ITS technologies, there is a tremendous opportunity today to integrate operations to manage total corridor capacity.

With ICM, various institutional partner agencies manage the transportation corridor as a system-rather than the more traditional approach of managing individual assets. They manage the corridor as an integrated asset to improve travel time reliability and predictability, help manage congestion and empower travelers through better information and more choices.

A corridor can have several types of networks including:

- Freeway roadway networks
- Arterial Roadway networks
- Bus transit networks
- Commuter rail networks
- Freight rail networks
- Ferry networks

In an ICM corridor, because of proactive multimodal management of infrastructure assets by institutional partners, travelers could receive information that encompasses the entire transportation network. They could dynamically shift to alternative transportation options even during a trip, in response to changing traffic conditions. For example, while driving in a future ICM corridor, a traveler could be informed in advance of congestion ahead on that route and be informed of alternative transportation options such as a nearby transit facility's location, timing and parking availability.

At the heart of ICM is an ICMS which consists of the set of procedures, processes, data, information systems, and people that support transportation system managers in making coordinated decisions that involve the optimal performance of all transportation networks within a corridor and in executing those decisions in an effective manner. The ICMS includes a decision support function.

To optimize corridor networks, data collection and data processing capabilities need to exist on each of the networks to perform the analysis necessary to optimize the individual networks. Optimizing the corridor, however, requires the ability to collect, process, and evaluate the information from each of the individual networks in a consolidated fashion.

The Statewide ATMS Operating Platform should interface with future ICMS to support corridor operations. The ATMS should share traffic data, environmental data, incident information, and current device status with the ICMS. This information along with data from traffic signal systems and other network systems would then be used by the ICMS to process the data in a manner in which the system manipulates its input to provide useful corridor level results. The ICMS would then provide system-wide outputs used to manage corridor networks. These outputs would feed back into the ATMS and other network systems.

5.2.13.5 Other State and Local Systems

The ATMS software should use C2C standards that provide mechanisms for exchange of two types of data:

- **Status Data** – Data a center "pushes" to other centers. This data may include traffic data, environmental data, incident information, and current device status
- **Command/Control Data** – Data that allows an operator in one center to issue a command to another center to exchange the current state of an ITS device (e.g., an operator can send a request to change a DMS that another center operates)

The ATMS should be configured to indicate what status data should be published and what commands it should be allowed to receive. Additionally, when an operator makes a request of a remote center, the user credentials (e.g., user name and password) of the user making the request will be sent to the receiving center prior to the command being processed – this implies that a remote user must have valid credentials.

The C2C interface should be transparent to the user of the ATMS. When devices are presented on the map display or toolbars, the other center's information is available in a fashion similar to the ATMS's devices. Examples of where C2C data sharing and/or command/control sharing is required include, but are not limited to, the following centers and systems:

- **Northern Virginia HOT Lanes TOC** – A private entity, Fluor-Transurban will own and operate HOT lanes on I-495 and I-95 in Northern Virginia.
- **Metropolitan Washington Airports Authority (MWAA) Bus and Rail Operations Centers** – MWAA owns and operates the Dulles Toll Road in Northern Virginia.
- **RITIS** – The system shares status data between VDOT, MDSHA, District Department of Transportation (DDOT), the Washington Metropolitan Area Transit Authority (WMATA), and other metropolitan Washington D.C. transportation agencies. RITIS is also an integral tool for Metropolitan Transportation Operations Coordination (MATOC) activities.
- **Other State TOCs** – VDOT is interesting in sharing status data (and potentially command/control) with neighboring states. For example, NWRO recently began activities as part of the I-81 Corridor Coalition to discuss cross state coordination along I-81.
- **Local TOCs** – VDOT is also interested in sharing status data (and potentially command/control) with local TOCs. For example, ERO already shares control of CCTV cameras within city limits and has had discussions with City TOCs that operate traffic signals and other ITS field devices.

5.2.13.6 TV&D Distribution Service Center

A centralized Distribution Services Center that makes traffic and video available, in a secure manner, to VDOT's 511 system and other external partners and agencies including the media. Other systems will be able to access data and video through the TV&D Distribution Service, but not command/control of devices. The figure below provides an overview of how data and video will be provided to 511, other systems, the media, and third party resellers.

The Video Distribution Services standardize VDOT's video distribution at the single point of demarcation. This resolves the disparate video solutions at the TOCs and puts the video output into a single, low bandwidth format. This enables scalable video management and opens up opportunities to view video on any platform or by any system. It increases VDOT's current video distribution capabilities from viewing updated snapshots to viewing video feeds over the Internet/Intranet streaming at 15 frames per second. This allows video feeds to be shared with regional and partner video applications in a secure and bandwidth friendly way. That is, stakeholders are not locked into using a vendor-supplied application to view the video.

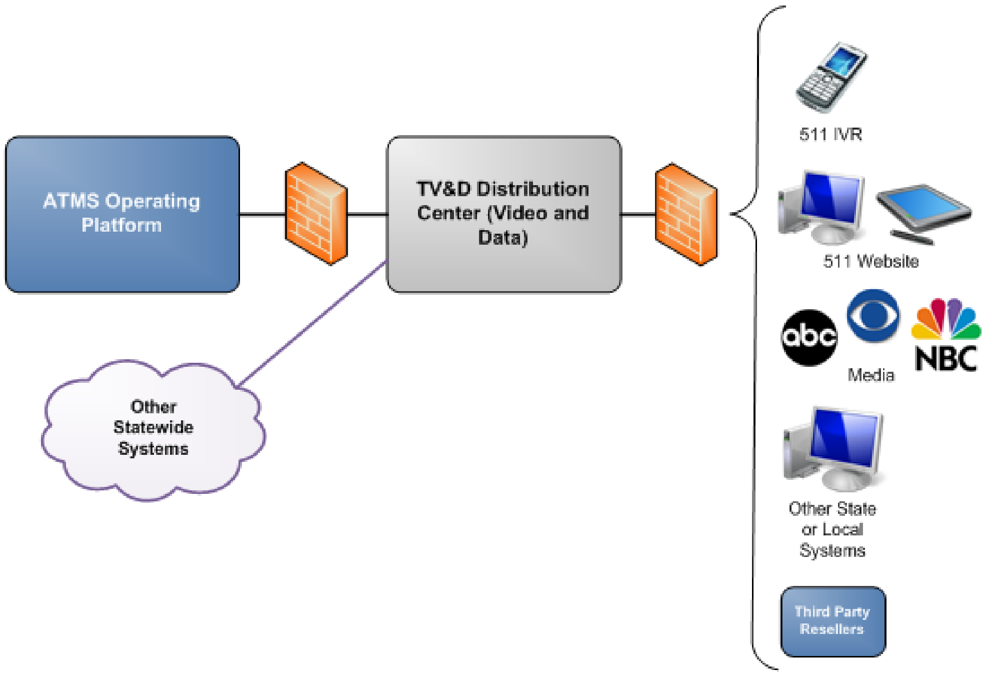

Figure 16: TV&D Distribution Services Center

Data generated by the ATMS and other statewide transportation system will be collected by the TV&D Distribution Services Center. This includes traffic, environmental, and event data. This data is then made available in a secure manner to VDOT's 511 system as well as other external partners and agencies. The ATMS will also be able to collect and consume any data that the TV&D Distribution Center gathers from other agencies. The data will be made available via FTP push/pull from the Statewide ATMS Operating Platform. The data is processed and available via an Active Data Management Database for distribution to external partners and applications.

5.3 Modes of Operation

This section describes the various modes of operation for the new Statewide ATMS Operating Platform. The Statewide ATMS Operating Platform should be operational 24 hours a day 7 days a week 365 days a year. Because of this the ATMS will be in an operational state at all times. The modes it may have, within that operational state, are:

- **Normal Mode –** The ATMS in normal operations mode should have all functionality available. All systems and subsystems are operational and the ATMS can perform all designed functions.
- **Degraded Mode –** In a degraded mode, some function(s) of the ATMS is offline. Many different scenarios can lead to some function being lost including events such as field device power outages or failed communications.

- **Training Mode** – The Statewide ATMS Operating Platform should support a training mode of operation. New operators need training on the ATMS without interfering with the daily operations. Training on live traffic and incidents could possibly compromise safety of travelers. To get the best possible training the ATMS should support a training mode that would simulate the real world conditions and allow trainees to work through scenarios in a controlled environment. The training mode may be a built in mode of the system or a copy of the system that looks and feels real but does not actually perform any live actions on the roadway.

- **Maintenance Mode** – The ATMS should support a maintenance mode. In a maintenance mode some deliberately turned off functionality is under control of maintenance. It is in a sense a controlled degraded mode, but if the functionality is needed it can be returned to the ATMS. Maintenance mode should not have any effect on any other functionality of the system. For example, if a gate controller is in maintenance mode, it should not affect the ability of the ATMS to continue normal gate operations.

- **Backup Mode-** The ATMS should support a backup mode. The backup mode should allow the TOC to operate the ATMS if the connection to the central system fails. The backup mode should take over automatically to resume functionality of collecting and sharing data, controlling field devices, and managing events.

5.4 User Classes and User Profiles

The ATMS should support five types of user classes: (1) guest, (2) field personnel, (3) operators, (4) supervisors, and (5) administrators. The System Security Subsystem should enforce these user roles based on user credentials when logging on. The Subsystem should also support different permissions levels within a user group. These permission levels should be configurable by a system administrator. The user classes are described below:

- **Guest** – Guest users have read-only access to the ATMS. This group of people does not need any access to control devices. They are simply monitoring the system or using it to view traffic and event information. For example the VDOT upper staff can have access to the ATMS to view what is happening, but they are not on the control floor and do not need any device control or data input capabilities.

- **Field Personnel** – Field Personnel users are maintenance, SSP, or other staff working in the field that may need to enter information into the ATMS. For example an SSP driver may want to enter an incident into the ATMS or update an incident while on the scene. Maintenance personnel may want to close or update a work order or view diagnostic data from a field device. This user class can view all information in the ATMS as well as enter data but they do not have control of any functionality. Some members of this class may be restricted to data entry and have only partial viewing of the system. These users may be contractors and construction crews that only need to enter and view work zone information.

- **Operators** – Operators are the primary users of the ATMS. Operators have daily interaction with the ATMS managing incidents, controlling field devices, monitoring travel conditions, and disseminating traveler information. Operators monitor CCTV cameras, VSP CAD, traffic sensors, environmental sensors, and Safety Service Patrol for events that occur on the roadways. Once an operator discovers a verified event, the operator begins the appropriate response leveraging the tools within the ATMS. Operators are also the primary users of traffic management devices such as DMSs, GCS, LCS, and HAR. Operators record and log all activity with the ATMS. Operators are the main data entry personnel into the ATMS. They do not have access to capabilities above and beyond the normal day-to-day operations within the TOC.

- **Supervisors** – Supervisors have all of the capabilities of an Operator plus other access rights. Supervisors have more control over the ATMS and may override events or operators actions in the system. Supervisors may also edit stored information such as allowable sign message words, incident response plans, or field device timing plans. Supervisors are responsible for all operations in the ATMS and oversee all of the Operators. They may also have access to special ATMS supervisory functionality to help the monitor all events happening within the system.
- **Administrators** – The System Administrator is the person that sets up, configures, and maintains the ATMS. System Administrators have the highest level of access to the system and can configure it to meet the needs of the other user groups. They can also perform any action in the system that an Operator or Supervisor would do. The System Administrator also is responsible for all the TOC hardware and servers that the ATMS relies on to function.

These user classes should have the ability to access the ATMS remotely as well as from the TOC. Remote access will allow users to enter data from the field from their laptop, tablet, smartphone, or other mobile device.

5.5 Support Environment

VDOT will require turn-key maintenance and production support from contractors. This support is similar to the support for the existing system. However, since the new Statewide ATMS Operating Platform will be a common system, maintenance and production efforts should be consolidated resulting in cost saving to the Department. Key support functions are described below.

5.5.1 Production Support

Contractor support will be required to restore the ATMS to an operational state as soon as possible after a failure. Critical failures should require continuous work by the contractor during and after business hours until the incident is resolved. Non-critical failures should require continuous work during normal VDOT business hours until the incident is resolved. Contractors should be responsible for responding to critical calls within 15 minutes. All failures should be logged by the contractor.

5.5.2 Maintenance Support

The Statewide ATMS Operating Platform will also require contractor support for all delivered software. Servers, network, and communications related to the ATMS will be maintained by VDOT. Contractor maintenance support should entail:

- **Preventive and Scheduled Maintenance** – This includes preventive and scheduled hardware and software maintenance activities required to ensure the operational stability of the ATMS.
- **Routine Software Updates and Upgrades** – This is needed to maintain system security, reliability, and supportability. All dependent software and firmware should be upgraded in a timely fashion.
- **System Monitoring** – The system needs to be monitored for performance and errors related to the ATMS.
- **Maintenance and Support Documentation** – This includes System Maintenance Plans, System Log Book, Monthly Maintenance and Activity Reports, Root Cause and Resolution Reports, and Design Documents.

- **System Security** – Contractors should be required to report all security breaches to VDOT.

5.5.3 After Hours On-Call Support

Because of the criticality of the system, the Statewide ATMS Operating Platform will require contractor after hours on-call support to restore the ATMS after a critical failure occurring outside of normal business hours. VDOT defines business hours as 6:00 a.m. to 6:00 p.m., Monday through Friday. For after hours on-call support, the contractor should be required to restore the system to a functional state within four (4) hours of notification. The goal of on-call support is to get the system operational as soon as possible after a critical failure.

5.5.4 On-Site System Support

The Statewide ATMS Operating Platform will need on-site support at each TOC. This support should include:

1. **System Administration Tasks** – This should include tasks such as system back-ups, back-up verifications and restoration testing, security monitoring and reporting, system performance monitoring, hardware and software upgrades, system failover testing, and other actions to ensure optimal performance and availability to users.
2. **Field Device Problem Management** – The ATMS will employ field devices managed by vendors other than the ATMS vendor. On-site System Administrators should be responsible for working with VDOT staff and vendors when issues arise with field devices.
3. **Development of Maintenance Plans and Documentation** – On-site support staff should be responsible for ensuring documentation is complete and that logs of maintenance activities are kept up-to-date.
4. **End User Support** – On-site staff should assist TOC operators in diagnosing and remedying issues they may encounter. These issues may include software or hardware problems, or questions related to how the system works.

5.5.5 Enhancements, New Initiatives, and Special Events

The Statewide ATMS Operating Platform will require enhancements and new initiatives. VDOT expects its support contractor to provide knowledgeable staff that can deliver high quality deliverables for these enhancements and deliverables. Additionally, these initiatives should be executed in accordance to industry-recognized development lifecycle process. The contractor should also use industry standards in developing these deliverables.

5.5.6 Change Management Board (CMB)

One of the key justifications for the Statewide ATMS Operating Platform was to have a common source code base for VDOT. This allows for software development to be paid for a single time and then be deployed a number of times. With this approach, solid Configuration Management is mandatory to ensure the software is properly maintained.

A CMB that regularly meets to discuss enhancements and issues must exist. This board should include representation from each of the Operations Regions as well as VDOT Central Office staff. The board should:

- Review change request details to determine if the change can be cleared for implementation as is, or if changes or improvements should be made prior to implementing the change.

- Determine if change management procedures are being followed (including testing).
- Analyze the change request for conflicts.
- Analyze the change request to ensure security is appropriately reviewed, and tested if needed.
- Ensure the communication plan provides appropriate communication to regional staff and users.
- Make recommendations for changes or improvements to the change request. As an example, the CMB may recommend a change to the schedule due to resource conflicts.
- Communicate with management until the change is cleared for implementation.
- Make recommendations on the prioritization of changes.
- Manage a calendar of changes, including recurring changes such as annual events.
- Perform an evaluation after implementation of the change and provide recommendations for improvements if needed.

6 NEXT STEPS

VDOT's Statewide ATM Operating Platform will continue following the Systems Engineering Process discussed in Section 1.2. The next step in the process is to transform the desired capabilities, identified in Section 4.2, into verifiable functional requirements. These requirements will define what the system will do but not how the system will do it. Working closely with stakeholders, the requirements will be elicited, analyzed, validated, documented, and base-lined.

This ConOps document will also be included as an appendix to a RFI. The purpose of the RFI is to collect written information about the capabilities of various ATMS suppliers. The RFI will also be used as a solicitation sent to a broad base of potential suppliers for the purpose of conditioning supplier's minds, developing strategy, building a database, and preparing for procurement of the Statewide ATMS Operating Platform.

APPENDIX A – ACRONYMS

ADMS	Archived Data Management System
AMS	Asset Management System
ATM	Active Traffic Management
ATMS	Advanced Traffic Management System
AVL	Automatic Vehicle Location
C2C	Center-to-Center
CAD	Computer-Aided Dispatch
CCS	Central Computer System
CCTV	Closed Circuit Television
CCR	Constant Current Regulator
CMB	Change Management Board
ConOps	Concept of Operations
COTS	Commercial Off the Shelf
CRO	Central Region Operations
CSC	Customer Service Center
DDOT	District Department of Transportation
DMS	Dynamic Message Sign
DSS	Decision Support Service
DTT	Downtown Tunnel
ERO	Eastern Region Operations
ESS	Environmental Sensor Stations
GCS	Gate Control System
GIS	Geographic Information System
GPS	Global Positioning System
GUI	Graphical User Interface
HAR	Highway Advisory Radio
HMO	Highway, Maintenance, and Operations
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
HRBT	Hampton Roads Bridge Tunnel
IEEE	Electrical and Electronics Engineers
ICM	Integrated Corridor Management
ICMS	Integrated Corridor Management System
INCOSE	International Council of Systems Engineering
IRM	Incident Response Management
ISP	Information Service Provider
ITD	Information Technology Division
ITS	Intelligent Transportation System
IVR	Interactive Voice Response
LCAMS	Lane Closure Advisory Management System
LCS	Lane Control Signal
LUPS	Land Use Permit System
MATOC	Metropolitan Transportation Operations Coordination
MDSHA	Maryland State Highway Administration
MMMBT	Monitor Merrimac Memorial Bridge-Tunnel
MDT	Mobile Data Terminal

MTT	Midtown Tunnel
MWAA	Metropolitan Washington Airports Authority
NFPA	National Fire Protection Agency
NRO	Northern Region Operations
NWRO	Northwest Region Operations
ODU	Old Dominion University
OSD	Operations Security Division
PSAP	Public Safety Access Point
ROD	Regional Operations Director
RFI	Request for Information
RITIS	Regional Integrated Transportation Information System
RMS	Ramp Metering System
RTIMIS	Real-Time Incident Management Information System
RWIS	Road Weather Information System
SCD	System Context Diagram
SSP	Safety Service Patrol
SWRO	Southwest Region Operations
SYIP	Six Year Improvement Plan
SyRS	System Requirements Specification
TOC	Transportation Operations Center
TOTTS	Transportation Operations Technology Support Services
TTF	Transportation Trust Fund
TV&D	Traffic Video & Data
VDOT	Virginia Department of Transportation
VICADS	Video Image Control and Display System
VSL	Variable Speed Limits
VSP	Virginia State Police
VTRC	Virginia Transportation Research Council
WMATA	Washington Metropolitan Area Transit Authority
WSDOT	Washington State Department of Transportation