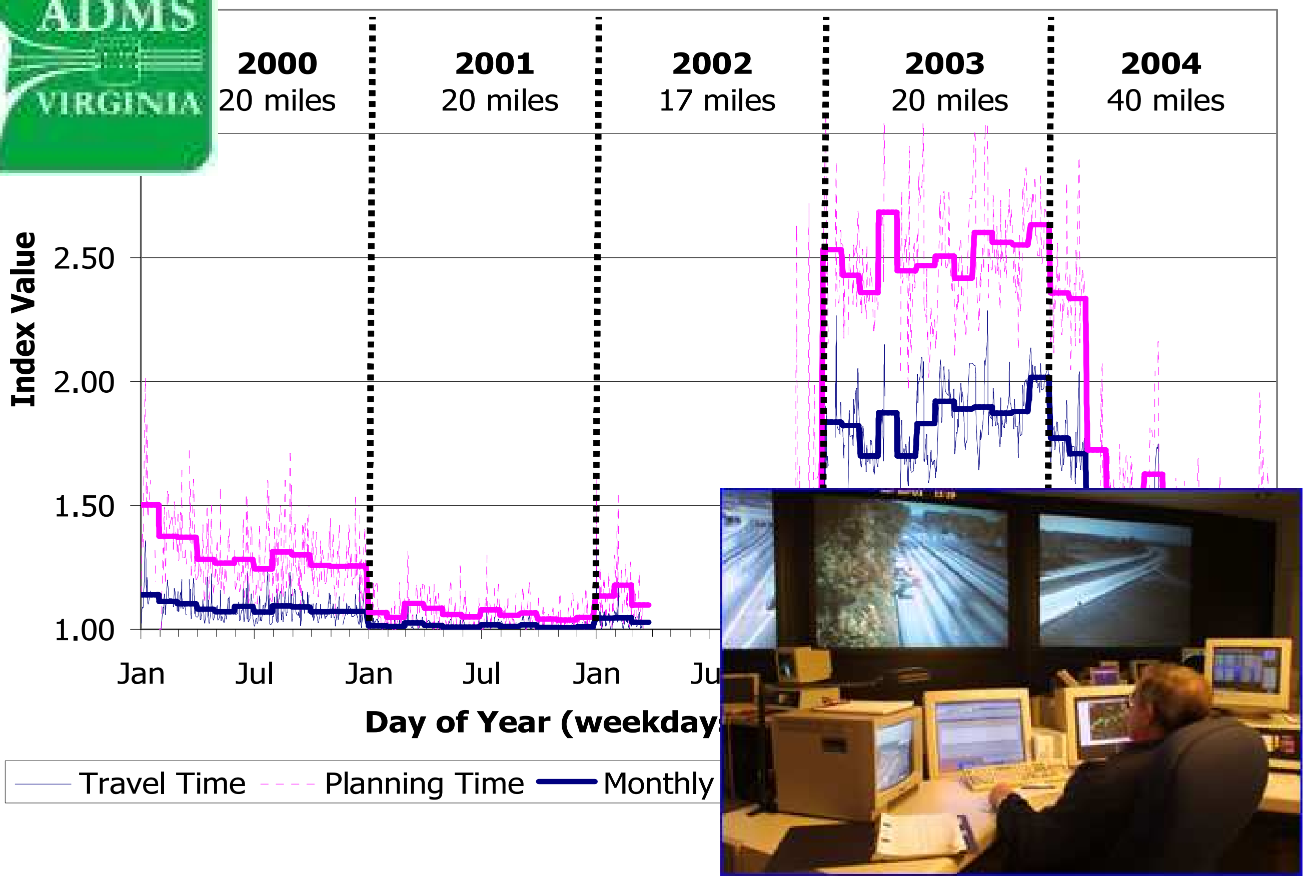

NATIONAL EVALUATION OF THE TMC APPLICATIONS OF ARCHIVED DATA OPERATIONAL TEST – ADMS VIRGINIA

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Table of Contents

EXECUTIVE SUMMARY

Overview

In 2002, FHWA awarded a field operational test to the Virginia Department of Transportation entitled (VDOT) *Traffic Management Center (TMC) Applications of Archived Data Operational Test*. The intent of the operational test was to use archived data to effect transportation operations and management decisions. However, because an ADMS has value to a wide variety of stakeholders (14, as identified in the *ADUS Standards Strategic Plan),* the scope of ADMS Virginia was expanded to include applications for transportation planners as well as operators. The operational test was to build on the current state of the practice in ADMS design.

With regard to operations, algorithms supporting various Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS) functions were to be considered. Performance measurement of TMC functions was also emphasized in the RFA. Since performance measurement overlaps with the activities of transportation planners, their inclusion in the development process was a natural extension of the project's scope.

A team led by VDOT's ITS Division was selected to undertake this operational test. The project was named ADMS Virginia and this term is used throughout this report to reference the project. VDOT led the effort with a team that included the University of Virginia (UVA) Center for Transportation Studies (CTS) and George Mason University (GMU). UVA subcontracted the software development part of the project to Open Roads Consulting, Inc. (ORCI). The equipment necessary for the project is hosted at the Smart Travel Laboratory (STL), a joint facility of VDOT and UVA that is located on the campus of UVA.

The project design and deployment process was divided into four phases or "builds" with each successive build providing incremental support of the preceding services, rather than a single system at the end of the project period. The build approach was used to identify important features of the system and the interface, and to apply the institutional and technical lessons learned in the early builds to later builds. Builds 1-3 concentrated on developing a fully operational ADMS for the Hampton Roads area, with each successive build adding new functions. Build 4 entailed the expansion of the ADMS to the Northern Virginia District of VDOT (NoVA), which is located in the Washington, D.C. Metropolitan area. Builds 1 through 3 completed the requirements of the original scope of work for the FOT. At the completion of Build 3, sufficient funds remained to support a fourth build. A proposal was submitted to and approved by FHWA to extend the project scope and end date to develop Build 4, extending the system to incorporate data from NoVA. The system functionality developed in Builds 1-3 was the same for both regions.

Operations Centers

Northern Virginia Smart Traffic Center

The Northern Virginia Smart Traffic Center is a high-tech communications hub situated in Arlington near the Pentagon. Controllers in this Traffic Center oversee more than 100 miles of roads. The system operates ramp meters, dynamic message signs (DMSs), highway advisory radio (HAR), and supports incident management activities.

The Center also monitors the usage of HOV lanes. Gates and gate groups are used to reverse HOV lanes to accommodate the traffic flow heading north and east in the morning and south and west in the afternoon.

Hampton Roads Smart Traffic Center

The Freeway Traffic Management System installed at the Hampton Roads Smart Traffic Center originally consisted of an extensive computer controlled, fiber-optic based communications and control network installed along 19 miles of the area freeways (I-64, -264 and I-564), 38 closed circuit television cameras, over 60 dynamic message signs strategically positioned across the entire Hampton Roads region, Wide-Area Highway Advisory Radio System, and Freeway Incident Response Teams patrolling over 70 miles of interstate in the region.

Phase 2 expansion of the Traffic Management System (TMS) was completed in March 2004. Phase 2 added 31 miles of coverage on the peninsula and southside interstates (I-64, I-264, and I- 564) with 80 additional cameras and other roadway detectors.

Phase 3 expansion is currently underway. When completed, the total system inventory for the STC will include over 275 cameras covering 113 miles of Hampton Roads freeways.

<u>Smart Travel Lab at UVA</u>

The Smart Travel Lab is a state-of-the-art facility that supports research and education in the rapidly emerging area of ITS. Using the latest information technologies, analysis, and modeling techniques, researchers in the lab are developing prototype systems and applications that promise to improve the effectiveness of ITS. It is a joint effort between the Department of Civil Engineering at the UVA and the Virginia Transportation Research Council (VTRC). The Lab serves as the direct connection to transportation management systems operated by the 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 initiative, known as the Smart Travel Program.

<u>Purpose of Evaluation</u>

The primary purpose of the evaluation is to assess how well the ADMS Virginia project met its objectives, namely:

- How well the approach chosen for ADMS Virginia development resulted in a successfully operating system.
- How it supported TMC uses of archived data in order to effect improved operations.
- How ADMS Virginia was used to improve the functions of non-operations stakeholders.

<u>Summary and Lessons Learned</u>

- ***From a development perspective, ADMS Virginia is an exemplary archived data management system that can serve as a model for the rest of country.*** The Evaluation Team found the physical design of the system to have all of the main features of an ADMS as defined by FHWA, the National ITS Architecture, and current ITS standards. The relatively long list of users from outside of Virginia exploring the system's capabilities is another indication of the ADMS's successful deployment. In some cases, ADMS Virginia has broken new ground on the methods used to process and present data, including:

- Serious attention to *post hoc* data quality control, including the flagging of erroneous, suspicious, or missing data
  - An advanced imputation algorithm to adjust for missing data
  - Providing users with metadata, both about the archive structure and about processing steps (quality control and imputation)
  - Fusion of traffic, incident, and weather data so that they are geographically consistent
  - Repackaging of archived data into user-defined formats, such as AADT reports and simulation model inputs

- ***Professional software engineering and Information Technology principles aids ADMS development***. The ADMS Virginia development team chose a highly structured approach to design and implementation that worked extremely well in terms of delivery (on-time and within budget). Highlights of this process that can be adopted by ADMS developers elsewhere include:
  - User requirements process – heavy and early involvement of stakeholders
  - Incremental "Builds" – which allowed users to see early versions of the system
  - Structured programming, common web-based tools
  - Metadata provision
  - Map-based interface
  - Searchable help
  - Documentation

- ***Data quality and availability are the overriding features of an ADMS that will promote its usage.*** Potential users of an ADMS must have confidence in the quality of data before they will actively use the data for their applications. The Evaluation Team heard statements to this effect from most of the interviewees.

- ***Having event data in addition to traffic data stored in an ADMS enhances its usefulness.*** For the most part, the term "archived ITS data" is generally considered by the transportation profession to be traffic data from roadway detectors (volumes, speeds, and occupancies). However, fusing traffic data with event data (e.g., incidents, work zones, weather, and sporting events) – and even analyzing event data on their own – can have significant benefits for system operators and planners. HRSTC is using incident data to evaluate its incident response plan. ADMS Virginia also includes weather and special event data, and while the system does not currently include applications for them, future applications are likely to take advantage of them.

- ***From a planning perspective, a common drawback of currently deployed ADMSs (including ADMS Virginia) is the limited amount of highways covered by surveillance systems.*** Regional planning efforts require performance information on major highways throughout an area. In most cities, ITS is typically only deployed on major freeways. Expansion to all freeways and at least signalized arterials would provide additional information for planning purposes. A related issue is how to combine performance measurements from ITS with performance data from models – there is a concern that they may not be entirely compatible.

- ***TMC standard operating procedure manuals and operator contract stipulations must be considered during the ADMS design process - implementation of the system will likely require operators to engage in new activities.*** For example, because staffing of the Hampton Roads TMC is contracted out, the contract staff perform only those tasks assigned to them in that contract, or that can be directly measured as part of the evaluation of their performance (this is not a shortcoming of using contractors, which in the Hampton Roads case appears to work very well). New activities are time consuming and staff levels are negotiated under a particular workload assumption. Reporting on freeway performance has not been assigned to the TMC contractors, and is not used as a measure of the contractor's performance. Consequently, reporting on freeway performance cannot be automatically expected and may likely require a contract modification or some other change to the work agreement.
- ***If a software application (including an ADMS interface) is not part of the TMC software and displayed on the main console, its use is very limited.*** TMC operators are extremely busy when managing traffic in real-time. Any additional workload such as accessing an ADMS must be fully integrated into their normal operating software rather than an adjunct system. Similarly, the software must be capable of assembling information very quickly and with a minimum of input/query structure from the operator.
- ***Even with system availability and system performance concerns, ADMS Virginia stakeholders see a high potential for using the system in their applications.*** In Northern Virginia, system availability and the slowness of queries were the major impediments to usage during the evaluation period when the interviews were conducted. However, both these issues were addressed in Build 4.1 after the interviews were performed. The potential of the ADMS is not only recognized by end users but also by VDOT management, who are funding the maintenance and expansion of the system. The planners at HRPDC and the VDOT operators in Northern Virginia all expressed excitement at the ***potential*** of the ADMS, meaning that it may take a little time before that potential can be realized. This led the Evaluation Team to the following observation:
- ***It is likely that productive use of ADMS Virginia will have to wait for it become more fully populated with data and for users to gain experience with what the ADMS can do.*** In that sense, it may make sense to re-visit the evaluation in another 12 months to see what has changed.

1. INTRODUCTION

1.1 ARCHIVED DATA MANAGEMENT SYSTEMS

Archived Data Management Systems (ADMSs) are information management systems with decision support capabilities that implement the requirements found in the Archived Data User Service (ADUS). ADUS is one of 33 user services identified within the National ITS Architecture (henceforth, "the Architecture") that were created to document (in somewhat general terms) what an ITS application should do from the user's perspective. A broad range of users are considered, including the traveling public as well as many different types of system operators. User services form the basis of the Architecture development effort.

ADUS was developed as an addition to the original Architecture as a way to capture for later use real-time information used for ITS control strategies. One of the features of ADUS that distinguishes it from other user services is the large number (14) of stakeholder groups. These stakeholders include public transportation agency personnel (e.g., planners, air quality analysts, researchers, transit operators, and safety administrators) as well as private sector groups. By using archived ITS data, data collection costs for stakeholder applications can be reduced. Further, the detailed nature of ITS-generated data allow for more accurate analyses and make possible many applications that could not have been undertaken except at substantial cost. Figure 1 displays several examples of how a single subset of archived data – travel monitoring data – support ADUS stakeholder functions. ADUS relies on other ITS functions to provide data. This requires that close coordination be achieved with other ITS standard efforts.

One of the stakeholder groups identified in the development of ADUS is operations personnel. They are crucial to the success of ADUS in that they control the collection of data that form the basis of the archives. Moreover, operations personnel are also major beneficiaries of ADUS. Early ADUS documents postulated that archived data would promote improved operations by helping to determine control strategies (e.g., timing of ramp meters and traffic signals; deployment of incident management equipment, etc.) and in evaluations of programs. While these original purposes remain valid, it is becoming increasingly clear that operations personnel will accrue additional benefits from ADUS as ADMSs become more widespread and grow in sophistication.

Several recent events have greatly increased the importance of ADUS for ITS deployments. First, the need to do ***Federal performance benchmarking*** as a way to track program effectiveness has been identified by FHWA. Second, related to Federal benchmarking is the provision of detailed data for ***operations planning.*** Operation of the transportation system has become the primary focus of many transportation organizations including FHWA and ITE. ADUS provides the highly detailed data necessary to do operations planning at a high resolution level (such as evaluations, performance measurement, and deployment adjustments), especially considering the expense of dedicated data collection efforts. Third, closing the Advanced Traveler Information System (***ATIS) data gap*** and producing the ***next generation of ATIS products*** requires ADUS. A sound and detailed historical record of system performance is needed for ATIS purposes, especially as products become more sophisticated. For example, short-term congestion forecasts are seen as a highly marketable product, but these must rely on analysis of historical congestion trends to be credible.

As a user service, ADUS is a concept rather than a tangible system. As noted previously, an ***ADMS*** is the system that implements the concepts embedded in ADUS. At its core, an ADMS is an information management system that is actively maintained following

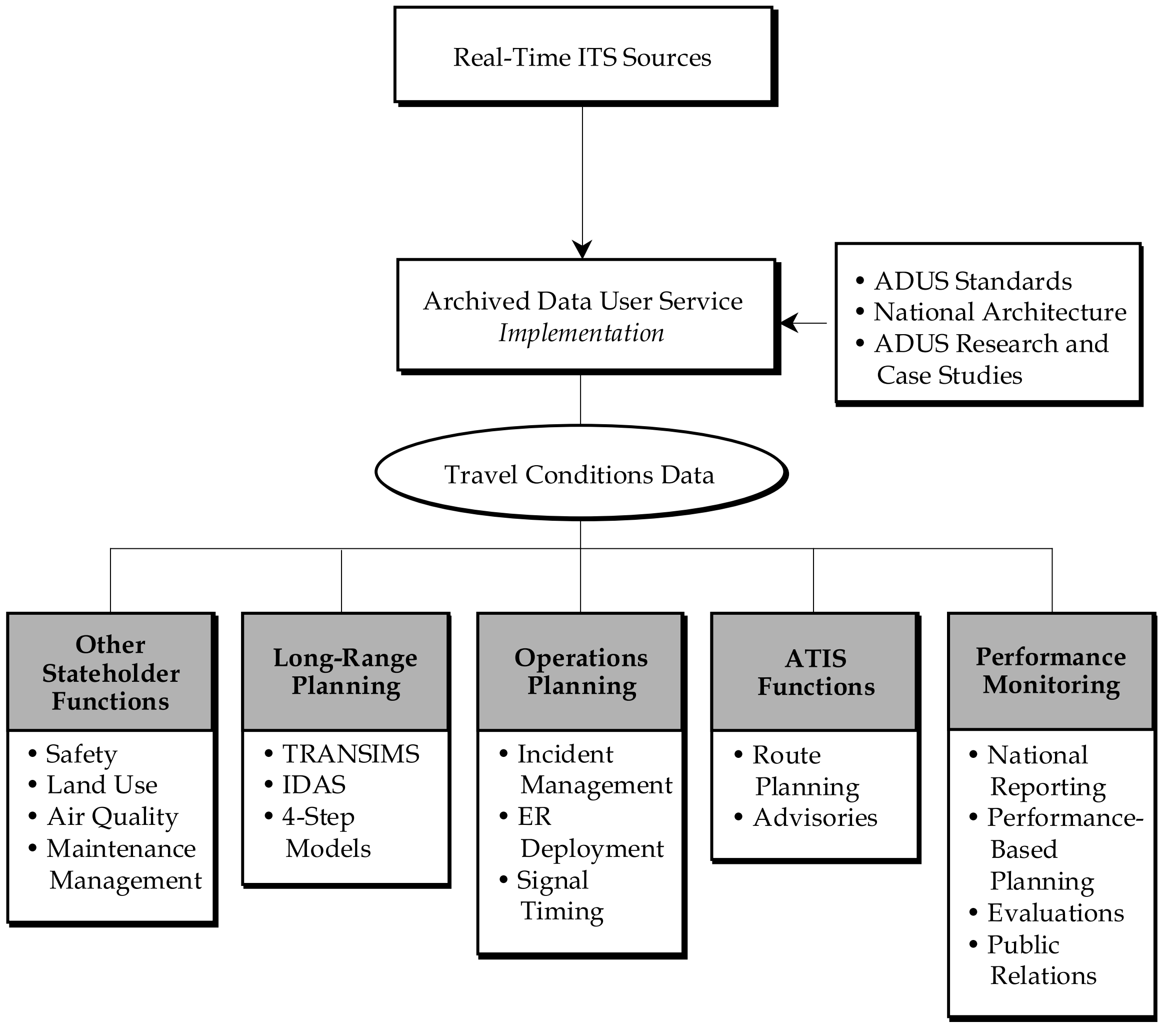


Figure 1 Archived Travel Monitoring Data Serve the Applications of Multiple Stakeholders

standard information technology principles. Advanced forms of ADMSs may include applications that achieve the functionality of a decision support system, but their primary purpose is to collect, process (including quality control, aggregations, and data transformations), store, and disseminate data for a wide variety of existing and emerging applications.

1.2 BACKGROUND ON THE TMC APPLICATIONS OF ARCHIVED DATA OPERATIONAL TEST

1.2.1 Project Goals

In 2002, FHWA awarded a field operational test to the Virginia Department of Transportation entitled (VDOT) *Traffic Management Center (TMC) Applications of Archived Data Operational Test*. The objective from the original Request for Application (RFA) was stated as:

> *The objective of this operational test is to study how transportation management center (TMC) operational practices and procedures can benefit through the applied use of archived data from highway-based and/or transit-based ITS sources. This effort will consider how specific TMC functions can be enhanced through performance measures and analytical techniques enabled through archived data. The results of this operational test will be used to support the development of guidance for applying archived data to enhance transportation management center operations, practices and procedures.*

The intent of the operational test was to use archived data to effect transportation operations and management decisions. However, because an ADMS has value to a wide variety of stakeholders (14, as identified in the *ADUS Standards Strategic Plan)*, the scope of ADMS Virginia was expanded to include applications for transportation planners as well as operators. The operational test was to build on current state of the practice in designing ADMSs.

With regard to operations, algorithms were to supporting various Advanced Traffic Management Systems (ATMS) and ATIS functions were to be considered. The RFA stated:

> The ATMS and ATIS functions that may be supported include, but are not limited to, the following:
>
> - Performance measurement
> - Arterial performance measurement using transit-based archived data
> - High-occupancy vehicle (HOV) lane management
> - Signal system management
> - Ramp metering management
> - Incident management
> - Work zone operational impacts measurement
> - Weather-based traffic management response
> - Special events management
> - Disaster/emergency response management
> - Travel-time prediction along route segments
> - Travel-time prediction between points
> - Travel-time reliability predictions

- Transit reliability and performance assessment

Performance measurement of TMC functions was also emphasized in the RFA. Since performance measurement overlaps with the activities of transportation planners, their inclusion in the development process was a natural extension of the project's scope:

> [The project should…] Determine how the operational performance of the TMC changes as the archived data are applied. Although each TMC has unique operating characteristics, the operational performance can be gauged by establishing performance criteria. Examples of performance criteria may include, but are not limited to, the following:
>
> - Travel-time reliability
> - Travel-time prediction error
> - Percent reduced congestion in particular locations
> - Percent reduced vehicle crashes
> - Reduced response time to incidents
> - Increased average speed during peak periods

1.2.2 Project Development

A team led by VDOT's ITS Division was selected to undertake this operational test. The project was named **ADMS Virginia** and this term is used throughout this report to reference the project. VDOT led the effort with a team that included the University of Virginia (UVA) Center for Transportation Studies (CTS) and George Mason University (GMU). UVA subcontracted the software development part of the project to Open Roads Consulting, Inc. (ORCI). The equipment necessary for the project is hosted at the Smart Travel Laboratory (STL), a joint facility of VDOT and UVA which is located on the campus of UVA.

ADMS Virginia was deployed starting with the Hampton Roads area. The Hampton Roads participants in the process included:

- The Hampton Roads Smart Traffic Center (HRSTC)
- The Hampton Roads Planning District Commission (HRPDC)
- The Hampton Roads Transit (HRTransit)
- The VDOT Central Office, Mobility Management Division (MMD) and Air Quality Planning.

The project deployment was divided into four builds with incremental support of the above services, rather than a single system at the end of the project period. The build approach was used to identify important features of the system and the interface, and to apply the institutional and technical lessons learned in the early builds to later builds. Builds 1-3 concentrated on developing a fully operational ADMS for the Hampton Roads area, with each successive build adding new functions. Build 4 entailed the expansion of the ADMS to the Northern Virginia District of VDOT (NoVA), which is located in the Washington, D.C. Metropolitan area. Builds 1 through 3 completed the requirements of the original scope of work for the FOT. At the completion of Build 3, sufficient funds remained to support a fourth build. A proposal was submitted to and approved by FHWA to extend the project scope and end date to develop Build 4, extending the system to incorporate data from NoVA. The system functionality developed in Builds 1-3 was the same for both areas.

The four builds of the project may be summarized as:

Build 1

- Completion of the core STL infrastructure
- Included detector and incident data collected at the HRSTC
- A simple, non-graphic interface will be provided for these services
    - Historical data query at user-selected levels of aggregations
    - Data Quality Assessments; Abnormality Checks; and Data Imputations

Build 2

- Completion of the graphical user interface -- a map interface improved the user-friendliness of the system, allowing input and output through “point and click” selections on the map
- Added data from the traffic monitoring systems (TMS) continuous count stations and weather databases
- Addition of services:
    - Mobility Measures of Effectiveness
    - Traffic Fundamentals
    - Evacuation Planning Support
    - Air Quality Modeling Support

Build 3

- Completion of the final system with all the required interfaces
- Added weather data from additional locations and arterial signal system data from City of Norfolk
- Addition of services:
    - Transportation Planning Support
    - Incident Management Support
    - Transit Support
    - Modeling/Simulation Support – added the ability to download data in a format compatible with the DynaMIT simulation model input requirements

Build 4

- Adoption of the ADMS to the Northern Virginia District of VDOT (NoVA)

UVA directed the software development effort with Open Roads providing the software engineering. Highlights of the development approach used by the project team included:

- A systems engineering approach was applied that included defining system requirements by a stakeholder involvement process (Figure 2). Formal requirements documents were produced for each build.
- Rapid prototyping was employed to allow the stakeholders and developers alike to try and test the system during development, well before the final release.
- Stakeholder involvement was identified as an important aspect from the beginning, and they were repeatedly requested to provide ideas, review documents/demos, test prototypes, and report any abnormal findings.

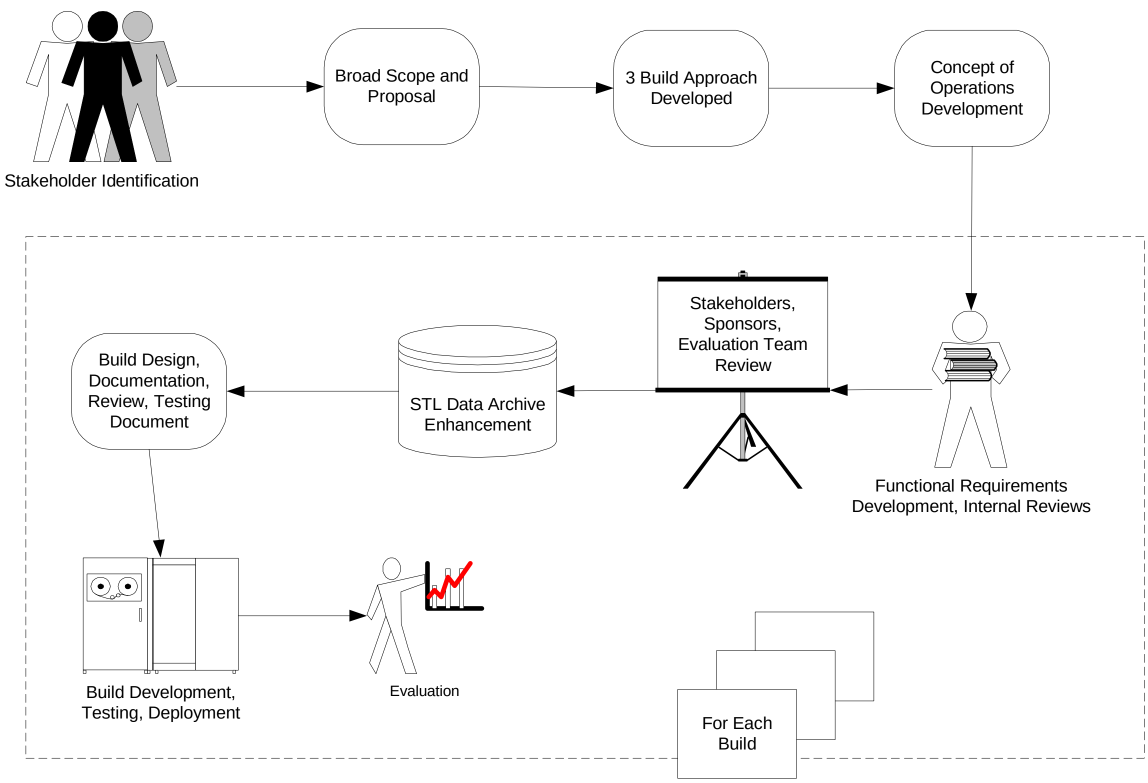


Figure 2 Systems Engineering Approach used in ADMS Virginia Development

Source: *ADMS Virginia Draft Final Report*, December 1, 2004

1.1.3 Operations Centers

1.1.3.1 NoVA District of VDOT

The Northern Virginia Smart Traffic Center is a high-tech communications hub situated in

Arlington near the Pentagon. Controllers in this Traffic Center oversee more than 100 miles of roads. The system operates ramp meters, dynamic message signs (DMSs), highway advisory radio (HAR), and supports incident management activities.

The Center also monitors the usage of HOV lanes. Gates and gate groups are used to reverse HOV lanes to accommodate the traffic flow heading north and east in the morning and south and west in the afternoon.

Loop detectors and pavement sensors that are embedded in the roadways prompt an automatic incident detection system that alerts Traffic Center controllers when and where there is likely to have been an incident. This equipment also gathers speed volume and occupancy data.

The Northern Virginia Smart Traffic Center Operators equipment inventory includes:

- 109 cameras
- 222 variable message signs
- 24 gates on I-66 HOV lanes for use during peak travel hours
- 21 gate groups on I-95/I-395 for reversible HOV lanes
- 25 ramp meters for inside the beltway on I-66 and I-395
- 30 lane control signals
- 23 vehicle classification stations
- 177 controllers with sensors and loop detectors

1.1.3.2 Hampton Roads Smart Traffic Center

The Hampton Roads region, located in Southeast Virginia, presents numerous challenges to the ongoing evolution and maintenance of a safe and effective transportation system. The region consists of ten cities (Chesapeake, Franklin, Hampton, Newport News, Norfolk, Poquoson, Portsmouth, Suffolk, Virginia Beach, and Williamsburg) and six counties (Gloucester, Isle of Wight, James City, Southampton, Surry, and York), with a current population of over 1.5 million people – an increase of 40% in 27 years. Over 100,000 military personnel live and travel in Hampton Roads, serving the Army, Navy, Marines, Air Force and Coast Guard. The area is also a prime vacation destination. On any given summer day, tourists can increase the region’s population by as many as 100,000 people, and 85% are traveling by motor vehicle. Along with major tourist attractions, the region has the best natural deepwater harbor on the U.S. East Coast. More than fifty international shipping lines and over 400 commercial freight carrier companies operate in Hampton Roads, resulting in high volumes of commercial freight traffic. Over 560 thousand tractor-trailers arrive and depart from the three international marine port terminals annually.

I-64 is the primary Interstate route in the region; its eastern terminus is located here. Several Interstate “spur routes are also located in the area:

- I-264 provides east-west travel from Chesapeake to Virginia Beach.
- I-464 provides north-south access.
- I-664 provides and additional water crossing on the west side of the region.

- I-564 provides access to the Norfolk Naval Station.

The region’s limited number of waterway crossings, high population, increasing influx of tourists, waves of military personnel traveling to and from the numerous military bases, and high volume of freight movement cause traffic incidents and delays on a daily basis around Hampton Roads.

The Freeway Traffic Management System installed at the HRSTC originally consisted of an extensive computer controlled, fiber-optic based communications and control network installed along 19 miles of the area freeways (I-64, -264 and I-564), 38 closed circuit television cameras, over 60 dynamic message signs strategically positioned across the entire Hampton Roads region, Wide-Area Highway Advisory Radio System, and Freeway Incident Response Teams patrolling over 70 miles of interstate in the region.

Phase 2 expansion of the Traffic Management System (TMS) was completed in March 2004. Phase 2 adds 31 miles of coverage on the peninsula and southside interstate (I-64, I-264, and I-564) with 80 additional cameras and other roadway detectors.

Phase 3 expansion is currently underway. When completed, the total inventory for the STC will be over 275 cameras covering 113 miles of Hampton Roads freeways including I-64 from Lightfoot to Bowers Hill, I- 264/I-64/I-664 interchange; I-264 from Bowers Hill to Park Avenue, Virginia Beach; I-664 from Bowers Hill interchange through the Monitor Merrimac Memorial Bridge Tunnel to I- 64 interchange, Hampton; and I-564 from Terminal Boulevard, Norfolk to Gate 3 and 3A Naval Base.

1.1.3.3 Smart Travel Lab at UVA

The Smart Travel Lab is a state-of-the-art facility that supports research and education in the rapidly emerging area of ITS. Using the latest information technologies and analysis and modeling techniques, researchers in the lab are developing prototype systems and applications that promise to improve the effectiveness of ITS. It is a joint effort between the Department of Civil Engineering at the University of Virginia and the Virginia Transportation Research Council. The Lab serves as the direct connection to transportation management systems operated by the 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 initiative, known as the Smart Travel Program. The mission of the Smart Travel Lab is to:

- Conduct applied ITS research and development
- Provide technical support to VDOT’s Smart Travel Program
- Develop and deliver innovative education and training programs.

The foundation of the laboratory is an OC-3 connection to the Commonwealth of Virginia's wide area network known as "Network Virginia." This connection is used to continuously transmit data and video from four Virginia Department of Transportation (VDOT) traffic control systems. These systems include:

- The Hampton Roads Smart Traffic Center (HRSTC), an freeway management system in Southeast Virginia that monitors and manages traffic on I-64 and I-264
- The Northern Virginia Smart Traffic Signal System (NVSTSS), a signal control system that manages nearly 1,000 intersections in the region.

- The Northern Virginia Smart Traffic Center (NVSTC), a freeway management system that monitors and manages traffic on I-95, I-495, and I-66.
- The Richmond Smart Traffic Center (RSTC), a freeway management system that monitors and manages traffic on I-64 and I-95.

1.3 PURPOSE OF EVALUATION

The primary purpose of the evaluation is to assess how well the ADMS Virginia project met its objectives, namely:

- How it supported TMC uses of archived data in order to effect improved operations.
- How ADMS Virginia was used to improve the functions of non-operations stakeholders
- How well the approach chosen for ADMS Virginia development resulted in a successfully operating system.

The next section of this report outlines specifics about the evaluation approach.

2. DEVELOPMENT OF THE EVALUATION STRATEGY

2.1 REVIEW OF ADMS VIRGINIA DOCUMENTS

The Evaluation Team reviewed and commented on many of the documents produced during the course of ADMS Virginia's development. These included:

- TMC Applications of Archived Data Operational Test, Modified "Build" Methodology & Schedule, January 24, 2003
- Concept of Operations, ADMS Virginia, March 17, 2003
- Build 1 - Functional Requirements Document, ADMS Virginia, April 01, 2003
- Build 2 - Functional Requirements Document, ADMS Virginia, July 16, 2003
- Build 3 - Functional Requirements Document, ADMS Virginia, December 16, 2003
- ADMS Virginia Draft Final Report, December 1, 2004

Many more documents were developed by the ADMS Virginia team that were not reviewed with formal comments by the Evaluation Team.

2.2 EARLY REVIEW OF ADMS VIRGINIA DEVELOPMENT

The interim documents produced by the ADMS Virginia team as well as the Build approach to system development allowed the Evaluation Team to review the functionality at several different stages. The first major review of ADMS Virginia progress was held on March 26, 2003. The purpose of this meeting was to flesh out the types of evaluations that should be performed as a precursor to the Evaluation Plan. The Concept of Operations document and initial contact with the ADMS Virginia team were the basis of this formulation. At that time, neither the Concept of Operations nor the ADMS Virginia team indicated direct use of archived data in operations strategies. The focus appeared to be on planning functions, both traditional transportation planning and operations planning (the latter primarily through the use of performance measurement.) As a result of this meeting, more emphasis was given to supporting operations by the ADMS Virginia team, in addition to maintaining support for planning functions.

2.3 ADMS VIRGINIA FINAL FUNCTIONALITY

The key features of the final system provided the basis for developing the Evaluation Plan and the Test Plans. These are documented as follows.

2.3.1 Data Processing and Management Functions

- Data Structure – a relational data base was constructed. Common location referencing was used to link the various types of data for applications.
- Metadata – metadata on the data stored in the system is provided.
- Quality Control (QC) – *post hoc* QC procedures were developed and are applied to the traffic data.

- Data Imputation – for traffic data that is either missing (not reported from the field) or fail the QC tests, an imputation procedure is used to fill in or replace gaps.
- On-line Query Results – many ADMS Virginia applications include data summarized visually for users on-line via the use of maps and statistical charts
- Output File Formats – the results of queries for data files may be viewed online as an Adobe Acrobat file or downloaded as files in either comma-separated or XML formats. The XML definitions were developed by the ADMS Virginia team.

2.3.2 User Functions and Applications

2.3.2.1 Standard Data Query

This service outputs raw data or aggregates of the raw data at user-requested temporal and spatial levels of aggregation. The format of the output data is available in CSV, XML, PDF, or by plot. Data is available from the Traffic, Incident, Weather, and TMS databases.

Traffic Data Timeline Plot/Map

Plots or maps volume, occupancy, speed, and quality information for a single corridor, corridor section, or station aggregated at selected time intervals.

Station Data Download

Allows user to view or download detailed volume, occupancy, speed, and quality information for selected corridors, corridor sections, or stations aggregated at selected time intervals.

Incident Download

Allows user to view or download detailed incident information.

Incident Plot/Map

Provides user with capability to perform analysis of incident information for defined periods of time. This page allows the user to obtain counts for the types of incidents requested plus detailed incident information. The user can view, download, or plot the data. The data can be plotted by incident type, weather conditions, duration of incident, number of cars involved, number of lanes blocked, or number of incidents that occurred by day. Users can map average, maximum, or minimum duration of an incident.

Weather Download

Downloads weather data from various WBAN(s) (Weather-Bureau-Army-Navy) in the region.

TMS Data Download

Downloads detailed classification, speed, and quality information from the Traffic Monitoring System (TMS) for selected links, time period, and time aggregation.

2.3.2.2 Mobility Measures of Effectiveness

Derives a number of defined mobility measures from the archived data and present these measures in different formats. Users are able to retrieve the following traffic-based mobility measures: speed, flow rate, V/C ratio, speed standard deviation, and VMT.

Mobility Measures - Traffic Download

Allows user to view or download of traffic-based performance measures.

Mobility Measures - Traffic Spatial Plot/Map

Allows user to plots or map traffic-based performance measures.

Mobility Measures - Traffic Timeline Plot/Map

Plots or maps traffic-based performance measures. Measures can be aggregated at selected time intervals.

Mobility Measures - AADT Analysis

Allows a view, plots, or downloads AADT values.

2.3.2.3 Operations/Maintenance Support

Allows users to evaluate current road conditions, data quality for sensor stations, and compare current incidents with past incidents.

Current Conditions

Allows user to view speed and flow rate for the last 5 minutes, by corridor. The user can view current conditions on a plot or map. The user can also monitor active incidents in the region.

Incident Insight

Provides traffic information regarding similar incidents from the past.

Data Quality

Allows users to view data quality for selected stations. User can download, plot, or map % of usable data and % of imputed data.

Traffic Forecasting

Allows user to view short-term forecasted traffic statistics. Forecasts are made 10, 30, and 60 minutes into the future for level of service and volume. Forecasted volumes may be displayed along with either current volume or historical average volume.

Traffic Forecasting Accuracy

Allows user to review the accuracy of forecasted traffic volumes for the last week.

2.3.2.4 Evacuation/Special Events Planning

This service aids the development and implementation of evacuation plans for major disasters such as hurricanes or for local events such as the July 4th holiday.

2.3.2.5 HOV Monitoring/Evaluation (currently NoVA only)

This service provides reports for HOV usage monitoring/evaluation on the I-95 and I-395 corridors. These analyses are available only for weekdays currently.

HOV Daily Report

Allows user to view, download or plot: volume, speed, and quality information for two pre-selected stations (one inside the beltway and one outside the beltway) during the AM and PM HOV Restriction Peak.

HOV Detailed Analysis

Allows a view, downloads, or plots: volume, speed, and quality information for either a Mainline (HOV or RHOV) or Ramp (On or Off) Station Analysis.

2.3.2.6 Transportation Planning and Air Quality Support (currently Hampton Roads only)

Supports air quality analysis needs and long-range transportation planning by computing statistics typically use as inputs to travel demand forecasting and emissions models: volume, speed, VMT, % VMT by hour, V/C ratio, Level of service, peak hour factor average daily traffic.

2.3.2.7 DynaMIT Simulation Support (currently Hampton Roads only)

Allows user to download data structured in the input formats of the DynaMIT simulation model.

2.4 FINAL EVALUATION HYPOTHESES AND APPROACH

2.4.1 Hypotheses

The objectives of the evaluation relate to the use of the data to improve TMC-related and other activities. ADMS Virginia is developing a series of applications around its data archive that support a variety of transportation functions. From these, eight hypotheses and associated goals for the evaluation have been constructed. These are organized into three broad areas, as follows:

2.4.1.1 TMC Operations Planning

Archived data tools enable STC staff to perform more effective Operations Planning

- Goal – improved TMC operations

Use of the ADMS improves system wide travel conditions

- Goal – less total delay and increased reliability

2.4.1.2 Planning Functions

Availability of archived data will improve accuracy of regional planning models

- Goal – improved regional planning

Availability of archived data will reduce cost of regional planning models

- Goal – improved regional planning

2.4.1.3 General Archive Functions

The ADMS provides a mechanism for improving the quality of traffic data

- Goal – improved data quality

The ADMS is portable to other areas

- Goal – provide transferability with a minimum of customization

The ADMS development process has met the needs of the stakeholders

- Goal – exemplary or “model” ADMS design

The ADMS has satisfactorily fused data from different sources

- Goal – applications and queries can access and use disparate forms of data

A summary of hypotheses, goals, measures of effectiveness (MOEs), and required data appear in Tables 1 to 3, followed by a discussion of individual evaluations.

Table 1 TMC Operations Planning MOE's and Data Sources

Hypothesis	MOE's	Data Sources
The Archived Data Tools Enable STC Staff To Perform More Effective Operations Planning (Note: DMS-related Operations activities may be contingent upon the use of the Incident Response Module.)	Change in the time required to post DMS message following an incident.	• System Data • Interviews
	Percent of time that ADMS tools are accessed prior making a DMS change.	• System Data • Interviews
	Perceived change in the time required to post DMS message following an incident	• Interviews
	Perceived usefulness of the ADMS data available to STC operators when considering a DMS change.	• Interviews
	Reported change in the process used by STC operators when considering a DMS update	• Interviews
	Percent of time that ADMS tools are accessed prior making a road closure decision.	• System Data • Interviews
	Perceived change in the time required to plan and implement road closures	• Interviews
	Perceived usefulness of the ADMS data available to STC operators when planning a road closure	• Interviews
	Reported change in the process used by STC operators when considering a road closure	• Interviews
	Percent of time that ADMS tools are accessed prior making a decision regarding HOV restrictions	• System Data • Interviews
	Perceived change in the time required to plan and implement changes to HOV restrictions	• Interviews
	Perceived usefulness of the ADMS data available to STC operators when planning changes to HOV restrictions	• Interviews
	Reported change in the process used by STC operators when considering changes to HOV restrictions	• Interviews
The Use of the ADMS Improves Systemwide Travel Conditions	Travel time index (mean and 95th %ile), buffer time index, delay, incident duration by type	• Archived Data

Table 2 Planning Functions MOE's and Data Sources

Hypothesis	MOE's	Data Sources
The ADMS Improves Accuracy of Planning Models	Perceived usefulness of ADMS tools.	• Interviews
	Reported change in the day-to-day processes of users resulting from the availability of ADMS tools.	• Interviews
	Perceived benefit of ADMS tools	• Interviews
	Perceived user friendliness of ADMS tools.	• Interviews
	Identification of aspects of the ADMS tools that users find effective.	• Interviews
	Identification of user's needs not being met by the ADMS tools.	• Interviews
	Number of ADMS queries made by planners	• System Data • Interviews
	Comparison of ADMS performance measures with similar measures from travel demand model.	• Archived Data • Model Comparisons
	Comparison of ADMS performance measures with similar measures from MOBILE6 model.	• Archived Data • Model Comparisons
The ADMS Decreases Costs of Planning Models	Estimated reduction in data collection costs for model development and calibration	• Interviews • Review of previous data collection efforts

Table 3 Planning Functions MOE's and Data Sources

Hypothesis	MOE's	Data Sources
The ADMS Provides A Mechanism For Improving The Quality Of Traffic Data.	Failure rates tracked over time by corridor for each QC test in the ADMS software	• System Data • Archived Data
The ADMS is Portable to Other Areas	Labor hours needed to customize (actual and/or estimated); extent to which code and concepts can be applied to other installations	• Interviews • Labor logs by personnel category
The ADMS Development Process Has Met the Needs of the Stakeholders	Subjective -- attitudes and opinions of stakeholders: 1. Perceived usefulness of ADMS tools. 2. Reported change in the day-to-day processes of users resulting from the availability of ADMS tools. 3. Perceived benefit of ADMS tools. 4. Perceived user friendliness of ADMS tools. 5. Identification of aspects of the ADMS tools that users find effective. 6. Identification of user's needs not being met by the ADMS tools.	• Interviews
	Quantitative – system usage statistics 1. Number of "current conditions" queries made, by user. 2. Number of "traffic forecasting" queries made, by user. 3. Number of "data quality reports" queries made, by user. 4. Number of "incident insight" queries made, by user. 5. Number of failed/aborted queries	• System Data
The ADMS Has Satisfactorily Fused Data from Different Sources	Perceived ease of integration within the ADMS analytical framework	• Interviews • Analyst Observations

Hypothesis	MOE's	Data Sources
Sources	Perceived ease of integration outside the ADMS analytical framework	• Interviews • Analyst Observations

2.3.2 Evaluation Structure

2.3.2.1 TMC Operations Planning

Hypothesis #1: Archived data tools enable STC staff to perform more effective Operations Planning; and Hypothesis #2: Use of the ADMS Improves System-wide Travel Conditions

The main effect of the ADMS on the TMC will be in the area of Operations Planning. For the purpose of this evaluation, Operations Planning is defined as activities related to the modification or adjustment of existing Operational strategies. It is seen as being a very short-term planning horizon; this contrasts with the longer time horizon undertaken by the traditional transportation planning process. In a broader context, Operations Planning also includes the identification and deployment of new short-term Operations strategies, but the evaluation schedule does not permit enough time for this to be practical.

2.3.2.2 Planning Functions

Hypothesis #3: Improved Accuracy of Planning Models; and Hypothesis #4: Cost of Operating Planning Models

In assessing the ability of the system to improve regional planning, it is also important to identify the effectiveness of the tools to meet user's needs. It is hypothesized that the *ADMS tools will perform satisfactorily for planners and operators*. These MOEs are largely subjective, measuring the perceived usefulness, benefit, and user friendliness of the tools. These measures will be gathered through interviews of various users and stakeholders. These subjective measures will be supported by quantitative measures of the usage of particular ADMS tools by different types of users (e.g., TMC operators, planners, transit operators, traveler information providers, etc.) gathered from the system usage logs. This facet of the evaluation has been rolled into Hypothesis #10 ("The ADMS development process has met the needs of the stakeholders").

2.3.2.3 General Archive Functions

Hypothesis #5: The ADMS provides a mechanism for improving the quality of traffic data

A highly significant concern in the use of archived ITS-generated data is the quality/accuracy of the data. While professionals agree that quality data is required to implement advanced forms of Operations control strategies and for secondary uses, budgets to install and maintain field equipment – as well as the detection of suspect data – are often limited. Basically, ITS-generated traffic data can be of poor quality for a number of reasons.

Hypothesis #6: The ADMS is Portable (Transferable) to Other Areas

The ADMS Virginia project has great potential for sparking ADMS development in other areas. However, the more directly the results can be applied, the greater the influence the Operational Test will have. A number of general issues will be explored as part of this evaluation:

- Does the design appear to be expandable? (Does the location referencing system used work for other archives? Does the reporting system expand easily to account for other geographic locations?)
- Can the hardware expand to meet larger data set requirements? Can the software meet the needs of users if the number of users grows substantially?
- Can the database structure be transferred in whole or in part to other installations? This will depend to a large degree on the nature of data being collected in other areas. Although ITS data standards have been developed (TMDD, P1512), adoption of these standards have been slow.
- Which components of the data structure are best suited to transfer (e.g., metadata versus measurement data)?
- To what extent can the software code be used directly by other installations? Are algorithms, concepts, and output formats better suited to transfer than actual code?

Hypothesis #7: The ADMS Development Process Has Met the Needs of the Stakeholders

The development of ADMS Virginia has followed sound IT practice by adopting a user requirements process in designing the system. The ASTM standard on ADUS recommends this approach.[1] It would be useful for future ADMS deployments to understand how well this process worked. To this end, interviews will be conducted with stakeholders by the Evaluation Team. A general "question guide" will be used but answers will be free-form and not in the same format as a traditional survey. The guide will be developed prior to the interviews and will include such question as:

- Do they use the system? How easy is it to use? Do they need training? Is the training provided sufficient? (What training do they need?) Do the meta-data provided meet their needs? (If not, why not?) Do they feel the system is readily accessible? Do they have confidence in the data stored in the system and/or the results they get out of the system? (If not why not?) Are there specific concerns they have about using the system? How quickly do they get responses back from queries that make of the archive? Does this meet their expectations?
- What analytical capabilities are part of the system? Do the analytical capabilities scale along with the database itself? (For example, as new detectors are added in Hampton Roads, do they change their definition of the "corridors" used for travel time estimation and/or for computing "average corridor volume?")

[1] ASTM E 2259, *Standard Guide for Archiving and Retrieving ITS-Generated Data*

- How many people access the ADMS? (Inside VDOT? External to VDOT? - Describe who those people are, and how they use it.)

- Is the archive functionality the same as planned? What capabilities (output reports, uses) are actually built, and how do they compare with the original design?

- What was the cost and effort that went into designing and implementing the ADMS (documentation, not a formal evaluation)? This involves review of the labor records of those involved in the ADMS development. Several dimensions will be used:

    - Phase of the project: design, implementation, maintenance

    - Labor categories: management, senior software engineer, junior software engineer, senior transportation analyst, junior transportation analyst, stakeholder (for meeting attendance), and clerical.

Hypothesis #8: The ADMS Has Satisfactorily Fused Data from Different Sources

A major challenge for any ITS archive is the fusion of these data and their combined use in advanced applications. A number of questions/issues arise from the ability to fuse data from different sources.

- Does the system effectively integrate multiple data sources? Can an analyst match data from two different data sources efficiently? (For example, can they use incident response data to easily select volume and speed data?) This should be examined both within their analytical framework and the whether they are able to export data in such a way as to allow matching of data from different sources outside of the archive's own analytical framework.

- Is the location referencing system used capable of correlating data collected from two different data sources? What are the issues associated with using that referencing system given the other referencing systems used by VDOT and the other participating agencies (what are the other location referencing systems being used)? How are they integrated, and what does it take to perform/maintain that integration?

2.3.2.4 Data Collection and Management

Interviews

The Evaluation Team worked with STC and other stakeholder staff to identify the appropriate personnel to be interviewed on each topic and to get approval for the interview. Before beginning most interviews, an interview guide was prepared that lists the topics that should be covered and specific questions that should be addressed. These guides were used during the interviews.

Archived Data

The Evaluation Team obtained historical archived traffic data. Metadata is crucial for the analyses envisioned, and these will be obtained as well; this is especially true for estimates of the quality of the data.

System Usage Data (e.g., user sessions for Websites)

The Evaluation Team relied on STL to provide tracking of system usage.

3. EVALUATION RESULTS

3.1 Preface

The evaluation schedule was delayed from what was originally planned. This delay was not at all related to the development progress of the ADMS Virginia system, which was slightly ahead of its deployment schedule. Rather, the delay was prompted by two factors: 1) problems with the data quality and availability from the HRSTC and 2) lack of use on the part of stakeholders (primarily due to the data quality issue). As a result, the decision was made to delay the evaluation, with the hope that additional time would rectify these problems. As it turns out, however, these problems were to plague the evaluation even with the delay, as discussed below.

3.2 Interviews of System Users

3.2.1 Initial Interviews, July 2004

Interviews were held with personnel in the Hampton Roads area in July 2004. The purpose was to uncover basic usage facts about the system and to help structure the remaining evaluation.

3.2.1.1 HRPDC

Two staff planners were interviewed. One was involved in the rapid prototyping of the system and was highly familiar with the functions and interface; he had accessed the system about 25 times prior to the interview. The second planner had accessed the system only a few times. The three primary uses of the system were to 1) obtain volume data for use in a variety of planning functions, especially near the tunnels, 2) tabulate incident characteristics for use with the Congestion Management System, and 3) determine speeds on a limited number of segments. However, all the uses were done in "test mode" – widespread use of the data in planning applications had not been made. (But it was hoped that in the near future, practical use of the data could be made.) The traffic data from the sensors is more likely to be bad (missing) than good. The main problem was the lack of data altogether due to problems with the field data. This requires the user to do a lot of checking on data availability before accessing the data. The coverage (only a limited number of freeway miles) is still not complete enough to be useful on a regional basis. However, the planners liked the concept of having the data directly available to them. They commented that this system is much better than the previous methods of accessing data; in the past HRPDC had to request data from VDOT and wait a couple of weeks to receive it.

The planners were very pleased with the functionality of the system. ("We can obtain data with "three clicks"). Obtaining the same data used to take at least a day, and probably more due to several iterations of data requests. The planner with experience with the system commented that the interface was not intuitive for the first-time or casual user. Menu items are categorized by organizational data source (e.g., STC) not by function (e.g., freeway traffic volumes). The uninformed user needs to search around to find the data source. He suggests a glossary of terms be readily available since he had to ask several times what a table or data set name meant. However, once just a small amount of experience is gained, the system is easy to navigate. This may suggest that a short but formal training course be provided to potential users.

The traffic volume information from ADMS Virginia could be used now on a limited basis, but this can't be done until the data is reliable and the coverage is expanded to region wide. Until then, it is easier to use VDOT's periodic (3 year) short counts. HRPDC's travel demand forecasting model is a daily model (it predicts total daily traffic rather than peak hour or peak period traffic), so hourly volumes and speeds are not yet as useful. However, when reliable data are available, it will make the migration to a peak hour model easier. (Peak hour models are considered a more sophisticated form of travel forecasting and HRPDC intends to convert their model to it at some point in the future.)

HRPDC currently collects travel time data on major highways using the "floating car method." Assuming the data was reliable and region wide, some travel time runs performed by HRPDC could be eliminated. Also, VDOT would no longer need to conduct periodic short counts on freeways. In the short-term, redundant data collection is needed to provide a consistent data source region wide and provide validation for the ADMS data, because the planners were suspicious of the data quality. When the ADMS data could be used, the savings would probably be used to collect data on additional roadways.

Additional data could be used in developing models more sensitive to varying incident and weather conditions for conducting operations modeling (e.g., HRPDC attempted to conduct a previous analysis on the air quality benefits of the incident management system. The analysis was not successful due to the lack of data representing incident conditions). They have considered developing an evacuation model, which will be easier with reliable ADMS data.

Until data is reliably available on a region wide basis, little opportunity exists to use data for regional reporting, such as in the Congestion Management System (CMS). Data may be used for special studies in the meantime. ADMS is also used to fulfill some internal and external requests for traffic data. When reliable, ADMS speed data may be used in congestion reporting and the CMS. Until then, speed data is based on HCM method using periodic traffic volumes.

Advantages of the ADMS to support planning functions include decreased time required to fulfill requests for data and data for special studies. A constant stream of data would provide a more accurate picture of what's currently happening on the system, especially in assessing day-to-day variability. When data quality and coverage improves, the planners intend to access the ADMS several times per month to obtain data for planning applications.

The planners offered their opinion about the value of the ADMS. Planning efforts based on ADMS data would provide for implementation of better solutions and more cost-effective planning activities, but would probably bring about only marginal improvements for the traveling public. However, use of the ADMS's data to evaluate the effectiveness of the TMC and to alter operations strategies should lead to tangible benefits, the planners felt. Evaluation of other special projects would also be enabled.

The planners would like to have data on signalized highways, even it is only continuous volumes. Much of their planning effort is focused on these types of highways. Also, any data that could be used to supply origin/destination patterns would be of tremendous help. This is a key piece of information for the travel demand forecasting model and the only way to get it now is conduct special and expensive household travel surveys.

3.2.1.2 HRSTC

The Lead Project Engineer, Maintenance Supervisor, and IT Department Manager were interviewed. All three individuals were familiar with the system and had been involved in testing and commenting on prototype versions of the system. The system had been used in an exploratory way but had as yet not been used in day-to-day operations or to effect operating decisions. This use included: reviewing speed and volume data as compared with ground counts and reviewing incident data when developing incident response plans.

The same problem with the data quality and availability noted by the planners was also noted by the operators. The lack of data obtained through the sensor system currently inhibits the usefulness of the data. Because the data is unreliable, a second source of data must often be obtained for confirmation. Incident data was useful, and the operators were able to see patterns at selected locations.

Many of the field detection systems throughout the region are unreliable. Loop detectors, which have been used extensively throughout the region, provide the most accurate data when they are working, but are often inadvertently damaged. The equipment inventory system ties all equipment location to a filed cabinet, not necessarily its actual physical location, often resulting in loop detectors being damaged during repair work. Therefore, the Department has recently replaced loop detectors with number of less intrusive technologies including side looking radar and acoustic sensors, so the reliability of the data from existing sensor locations should increase, simultaneously with the expansion of the overall coverage of the system. As the reliability of the detection system increases, the usefulness of the data should increase.

It was noted that VDOT has historically been in the business of collecting the freeway performance data, but hasn't been a significant user of the data. Other entities (e.g., HRPDC, STL, other researchers) have more often been the "customers" of the data and would have better perspective of the data usefulness. The unreliable nature of the sensor data does limit the usefulness of the data. In short, performance measurement was not seen (at this time) as a priority with the HRSTC, although it was recognized that performance measurement was both a useful activity for HRSTC and may eventually be required by VDOT management as part of a department-wide performance measurement effort.

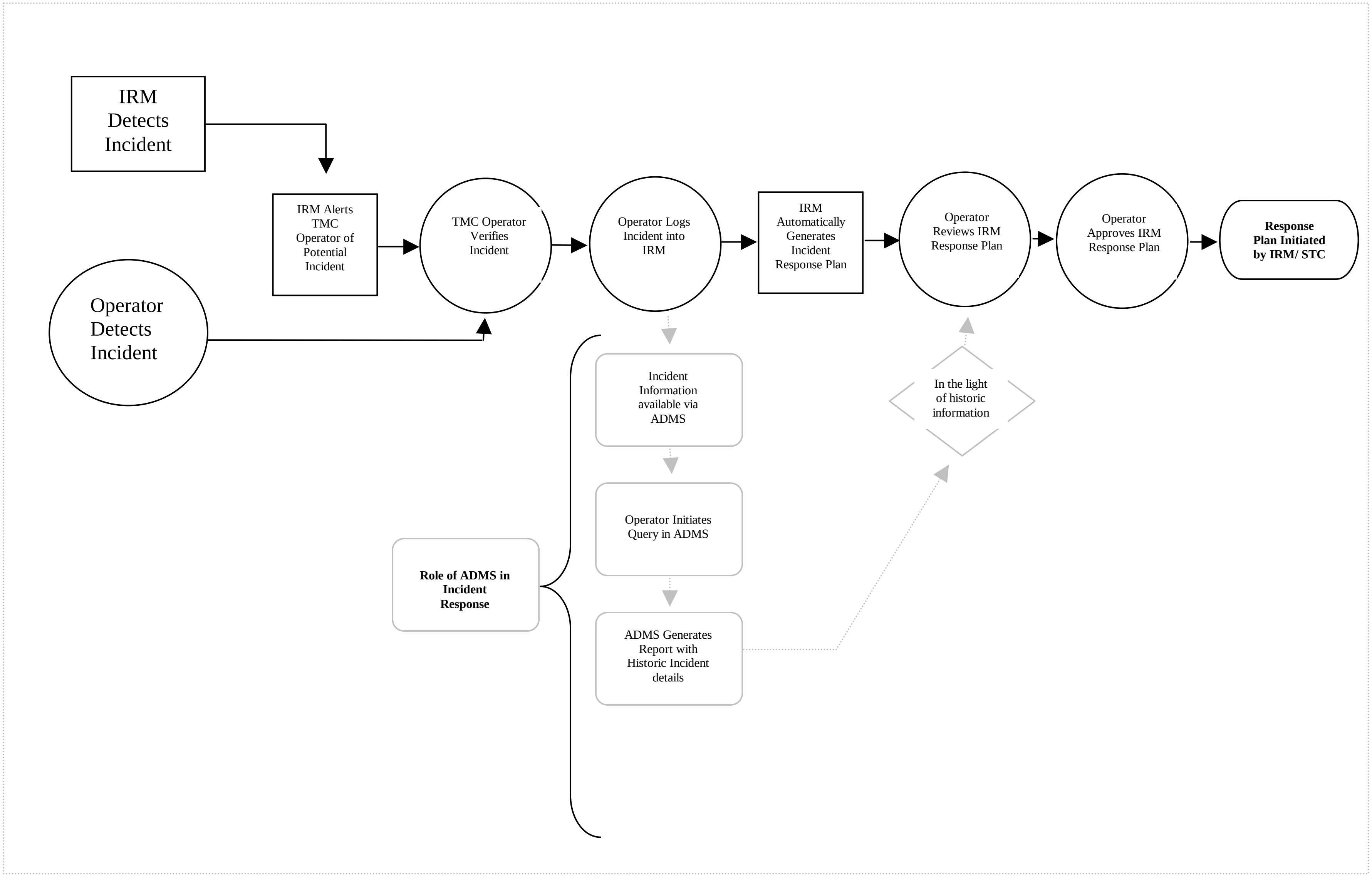
The operators commented positively on the operation of the ADMS as an information system; system is well designed and intuitive to use. The system itself works well, but the poor data quality limits its usefulness. This is desirable because with current TMC functions, the historic incident data is the most useful (for now).[2] The IT Manager speculated that because ADMS Virginia is a completely web-based application there could be interface problems in tying in the ADMS with existing systems, although it had not been tried.

Incident management is probably the most important operations strategy performed by HRSTC. The procedure for incident response is as follows. Once incidents are detected and verified, the response is largely coordinated by the controllers in the TMC. Several Incident Response Plans

[2] The HRSTC is staffed primarily with contractor personnel, with oversight by VDOT personnel. The operations contractor is currently responsible for entering incident data.

have been developed that specify appropriated responses for various types and locations of incidents. The decision to implement one of these response plans or to implement a customized response is left to the discretion of the controllers and shift supervisor. This decision is based on their knowledge of local conditions, available information on the incident, and experience. The operators are trained on the Standard Operating Procedures (SOP) Manual and refer to it for many decisions. The primary sources of information on the actual incident conditions include CCTV surveillance and from direct communication with responders on the ground. A more formal standard operating procedure defines all the decisions regarding operation of the reversible lanes. Regardless of the response, a log is maintained for all implemented strategies during the full duration of time that the incident is actively being managed by the TMC. It is hoped that the ADMS can help in the development of the Incident Response Plans (Figure 3). It is not expected that the ADMS would typically be accessed in real-time by controllers during an actual incident. The rapid speed at which decisions are made during these conditions does not allow the controllers the time to access an additional data source to analyze what conditions were during similar incidents in the past. Decisions need to be made quickly relying on the experience of the controllers. It is possible that the shift supervisor might have the opportunity to perform some of this type of real-time analysis on occasion, but he currently has no plans to implement ADMS use as a part of typical incident response procedures. Any sort of decision support in managing incidents in real-time would have to have immediate turnaround time and be extremely easy to access through the current TMC software.

Figure 3 Potential Role of ADMS in Incident Management Process at HRSTC with Incident Response Module



With regard to evacuation planning, fairly comprehensive evacuation plans/procedures already exist. Once implemented, there aren't that many variables that the TMC has control over. It is possible that the ADMS data might be used in these situations, but it is not clear exactly how they would be used real-time. The data could be used as historical data for event debriefings and evacuation plan refinement, however. (What happened, what worked, what failed, etc.)

In the future, using the ADMS data and/or the traffic forecasting function could be useful to the HRSTC. Communicating expected delay information to travelers is seen as function that should eventually be performed.[3] The ADMS has a much greater potential to be used as an evaluation/planning tool than to be used in the day-to-day functioning of the TMC. Potential applications include use as an "after-the-fact" tool for evaluating the effectiveness of implemented responses. The tool could also be used in the evaluation and modification of the Incident Response Plans or in the development of new operating procedures. More data would be available to supervisors in gauging the effectiveness of the implemented response strategies. Many of the current Incident Response Plans are not greatly sensitive to the level of congestion. The ability to examine incident response in different incident conditions could provide the ability to modify the plans to increase their sensitivity to congestion and other conditions (e.g., weather).

Operators felt there would be little noticeable impact for travelers; however, if the system provided the ability to evaluate and improve the incident response plans, there could be some travel time savings. Also, if the data could be used to provide estimates of expected delay, it is possible that this information could be passed onto travelers through the DMS or through a website.

The ADMS could also be used in training exercises (e.g., providing the ability to examine similar incidents with different responses and compare the resulting impacts). VDOT has discussed with FHWA the use of archived data to estimate and simulate delay and queue length (the DynaMIT simulation model). This led to observation by one of the operators that HRPDC has more uses for the data than the TMC staff.

Making the data available on-line may reduce the amount of staff time required to fulfill data requests from other agencies/organizations. The data is also available to all the ISP's which currently have access to STC cameras and incident information. Currently there are no known users who are performing additional analysis on the data and making any system performance data available to the public, but it remains a possibility.

3.2.1.3 Summary

As mentioned in the Preface, the first round of interviews revealed that the ADMS had not been used much except in an exploratory way. This was primarily due to issues concerning data quality, but also was not clear exactly how or if the ADMS would be integrated into the HRSTC operations. On the other hand, it did appear that HRPDC was planning to use the ADMS to supply data for a variety of planning needs. At this point, it was decided to give the system more time to work out data quality problems and to give personnel a chance to access the system more fully. Also, the transporting of the ADMS to the NoVA District of VDOT offered additional opportunities for the evaluation.

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[3] Note: there are no current plans for this type of traveler information system.

3.2.2 Second Interviews, February 2005

3.2.2.1 NoVA District

Attending this meeting were operations personnel; planning personnel were invited but did not attend. From the NoVA perspective, the evaluation of the system is occurring too soon because personnel had not had adequate time to use the system yet.

A function that NoVA personnel thought would be useful was the ability to monitor HOV lane utilization. At that point, the ADMS did not have a specific report to present data collected from HOV lanes, but ad hoc reporting capabilities did exist. (The HOV monitoring function was being developed at this time and is now operational in ADMS Virginia for NoVA.)

The main deterrent to using the ADMS was the speed of the login and the queries – access time was very slow, measured in many minutes.[4] Sometimes, it was not possible to logon successfully. Even when queries are small, users still need to wait a long time for the results. First time users mentioned that the tool looked cumbersome, but with a little experience, became easy to use and navigate. A short amount of training – perhaps a videotape demo – was suggested as a way to overcome the initial learning curve.

One type of analysis that the ADMS currently does not do is a "timeline" analysis of incidents. That is, how long the various components of total incident duration are: detection, verification, response, on-scene time, etc. Such an analysis, however, requires that the data be accurately collected by operations personnel before the ADMS can store and summarize it. NoVA TMC is not collecting all the data that would be needed for rebuilding incidents, however, they are making improvements towards getting to that point. They hope the ADMS data structure and functions could be modified in the future to accommodate this.

The issue was raised about the effectiveness of the ADMS to support real-time operations. The time involved in retrieving and accessing archived data was seen as a hindrance to real-time use. Operational planning, especially for HOV, was seen as maybe the best application set for the ADMS. But the data has to be easy to access and use. Maps of interstates and arterials with seasonal trends and shifts would be valuable for short-range planning and evaluations. There may be value for offline analysis, especially for transportation planners and operators. However, the value of the data as it is used for real time operations was seen as questionable.

One of the strong points of archived operations data is the fact that since it is continuous, fluctuations in demand and congestion can be seen. However, other than providing data for offline analysis (which the planners and operators would have to develop themselves), the ADMS functions are not that useful. ("There needs to be a better way of looking at the data directly.") Having the data in GIS format or in some customized graphical views would be helpful.

These suggested improvements were relatively new in the minds of NoVA personnel they had not been discussed during the Build 4 user requirements process. This was largely because

[4] The ADMS Virginia developers have been aware of the speed of access/query turnaround time issues and have been working to improve them since this interview was done.

NoVA personnel did not have a good idea of what was possible until they started to use the system.

The heaviest users of the ADMS were foreseen to be planners and engineers involved in planning activities. VDOT planners were asked to experiment with the ADMS, but most of them have not provided any feedback. People in operations on the TMC floor would be light users of the system for the immediate future – their workload is already heavy. Training and internal marketing of the tool could be improved.

Other potential uses that were identified for the ADMS would be performance monitoring reports, especially for incident management. The data could also be used in the data-intensive traffic simulation models. Reformatting the data into the specific input structure for simulation and travel demand forecasting models would be another future enhancement that would avoid post-processing the data by planners. The ADMS would be helpful to determine the timing of lane closures for work zones.

It was noted that VDOT is launching a department-wide performance measurement initiative. As these requirements are pushed down to operations, the value of the ADMS becomes apparent. Having continuous data on system conditions from the ADMS will be very useful. It will be easy to meet internal reporting requirements and there is the potential to slice the data in several ways. One way would be to expand VDOT's Dashboard (which currently only reports construction progress) to include congestion statistics. Again, either the ADMS would have to be modified to provide this function directly, or an offline application fed with data from the ADMS would have to be developed.

The main problem with the ADMS for NoVA was reiterated – the accessibility (logon ability) of the system and the speed of downloads and queries. Solutions suggested by the interviewees were to increase bandwidth or download the data overnight, although ADMS Virginia developers have been working to improve the speed.

3.2.2.2 HRPDC and HRSTC

These two organizations are reported together for ease of discussion. In summary, the evaluators found that little had changed from the time the initial interviews were done. HRSTC had made no operational use of the ADMS. HRPDC still expressed interest in using the ADMS to supply data for planning applications, but with one notable exception, had still only used the system in an exploratory way. The notable exception is that HRPDC is currently using the ADMS to help produce their reports on the incident response program. The details of the discussions with these two agencies follow.

Performance Measurement and Decision-Making

Recent changes within VDOT that reflect the increased importance of improving operational performance of the roadway system have not yet been reflected in active requests for and use of performance statistics for Hampton Roads. Consequently, relatively little use of the ADMS has taken place in these organizations as of the project interviews.

As with many roadway agencies, resources at both HRPDC and HRSTC are already stretched very thin. Because there has been no formal reporting requirement for performance information on the Hampton Roads freeway network, and until recently, no clear audience for such reports, few resources have been allocated to the use of the ADMS. For example, reporting on facility performance was not a contract task for the contractor staffing the HRSTC. The lack of facility performance reporting is likely to change with the new organizational structure adopted by VDOT and the corresponding increase in visibility of operations within the Department. The new organizational structure, combined with VDOT's increased reporting of performance statistics is expected to increase use of the ADMS in the near future. VDOT's Chief of Systems Operations will become the "primary client" within the Department for this information, thus increasing interest in, and likely resources for, performance measures that can be most effectively produced by the ADMS. HRSTC is a likely candidate for producing these reports, but whether they or some other group (such as HRPDC) are tasked with these efforts is still being determined by VDOT.

The VDOT organizational changes may also result in minor modifications to the ADMS software. While VDOT's new organizational structure will result in the publication of operational performance measures, no specific measures have been determined. Once these measures are selected, the ADMS may need to be changed to quickly and easily produce those statistics. There has been talk of VDOT requesting a quarterly performance report from each District, but the content of that report is currently unknown and the availability of additional data collection resources to support that reporting effort is also unknown.

Organizational changes similar to those being implemented by VDOT that increase the profile of operations have not yet occurred within the transportation agencies in the region. Each of the groups we interviewed noted that in Virginia, funding was passed directly to the seven independent municipalities in the region, and those municipalities select their own projects to receive that funding. The result is that there is relatively little incentive (or funding) to address regional problems, unless the local impacts from poorly performing regional facilities result in problems for specific municipalities. The result is that there is relatively little call at the regional level for a more numerically based, data intensive, regional view of facility performance. Such a reporting system simply doesn't match the political decision-making style of the region. (Perhaps this attitude is best explained by paraphrasing one interviewee's view of the regional project selection process, "If we don't have money for a construction project, we won't study it, and if we have money for the project, we don't need to study it.")

Effect of Policy Decisions

As with many states, there appears to have been relatively little historical interest within Virginia to measure the effectiveness of many transportation policy decisions, or the specific implementations of systems intended to meet policy objectives. To the credit of both VDOT and HRPDC, efforts are now underway to provide more information describing on the effects of many statewide and regional policies on transportation systems performance.

An example of this transition in attitude towards performance measures involves the Hampton Roads incident response patrols. At one point, VDOT cut back funding for incident response patrols as a result of the loss of general transportation funding in the state. The money was restored as a result of an outcry from the public, not an analysis that said roadway performance was suffering from the reduction in response vehicles. However, HRPDC is now producing ongoing reports on the performance of the VDOT incident response program so that the performance of this program can now be quantified.

A lesson learned from our interviews is that agencies that do not actively seek to use or provide information on facility performance are less likely to need, use or benefit from an ADMS. However, the national trend is towards greater levels of accountability in government. We expect this to result in increased need for the types of performance reporting that can be most effectively provided by an ADMS.

Places Where the ADMS Would Be Beneficial

There are several periodic studies done by VDOT/HRPDC that would benefit strongly from the ADMS, if the ADMS contained valid data, and if the staff accessed it. The most obvious of these efforts would be to report on the use and performance of the Hampton Roads HOV system and on the congestion experienced at the two tunnels.

Currently VDOT performs additional, special purpose, data collection (volumes and travel times) on the HOV system and its parallel general purpose lanes in order to examine the performance of the HOV system. If the data in the ADMS were reliable, these tasks could easily be completed without additional data collection (other than vehicle occupancy counting.) However, there is little thought of doing such an analysis, since the ADMS simply doesn't have the data quality needed to perform these studies and the efforts to improve data quality are proceeding slowly.

The ADMS could be a key tool in studying the potential for use of the HOV lanes as a HOT facility. It would also be essential for measuring performance changes on the facility if VDOT were to implement HOT lanes in Hampton Roads. Analysis of the performance changes would be key to effectively managing the operation of the HOT lanes, especially if the HOT lanes involve some aspect of congestion pricing in order to maintain free flow operations during peak periods. The TMC operations staff we spoke to gave little thought to performing these analyses, and the current level of data quality most likely prevents their currently being done with the ADMS. The HRPDC staff had considered the use of the ADMS to examine general tolling options for the region (mostly in conjunction with a proposal to build a third tunnel), but lack the resources to perform such a study (not to mention the problems with data quality.)

The second obvious place where the ADMS would be of significant use is for reporting and managing the delays found at the two tunnel crossings. Such a report would be of significant assistance in obtaining legislative assistance for changing operational policy in the region. Currently, significant delays are caused by the need to shut down both directions of traffic approaching either tunnel whenever an over-height vehicle attempts to use that tunnel. The dual stoppage of traffic creates considerable congestion, but the trucks causing the congestion are not fined or punished. The region would like the state legislature to adopt a fine/fee/deterrent in order to reduce the number of these occurrences. A simple performance report listing the number of times over-height trucks result in temporary roadway closures, and the delays caused by those closures would most likely provide the ammunition needed to pass this change in the Virginia legal code. Analysis of delays caused by over-height truck movements combined with historical traffic volume patterns would also allow TMC personnel to more effectively select appropriate times to actually close the roadway as well as improve the estimates of delays given to motorists when closures are taking place.

Even though tunnel delays are a major public information task of the TMC, no analysis of their size, frequency, or cause has been performed. Again, the lack of accurate sensor coverage seems to prohibit, at this time, this type of routine analysis and reporting. (Note that this is partly a function of the current detector placement, and partly a result of the poor performance of those sensors which do exist.) VMS messages describing expected tunnel delays are currently based on an operator's empirical knowledge of expected delays relative to the length of traffic queues as measured by visual inspection off of the CCTV system. VMS messages are NOT stored, so it is not even possible to get a historical estimate of tunnel delays based on posted VMS messages. Storing VMS messages in the ADMS might allow such a performance report to be produced.

Another place where the ADMS could be used, but where to date no request has been made to use it, is for reviewing traffic management practices that maintain traffic flow into and out of the beaches on weekends. The Virginia Beach area is a key tourist destination, and the reversible roadway operation is used to help bring tourists into and out of the beach area on weekends. No analysis has been performed to determine if the timing of changes in the reversible roadway's direction of operation could be improved, or if historical roadway performance information could be used to provide advanced traveler information to further improve roadway performance.

The ADMS might also be used to help develop the HRPDC Congestion Monitoring report done every three years. Currently that report (based on volume counts and a single floating car run done on each major corridor) is primarily compiled using special data collection efforts. With some forethought and a modest extension of the automated data collection effort, the ADMS might be able to provide much more detailed and accurate congestion estimates for this report, as well as provide for a more routine update of those measurements.

It should be noted that Hampton Roads has a bit of a Catch-22 dilemma when it comes to increased data collection. The region has limited funds for detector expansion, operation, and maintenance, because it can not show the benefit of the use of the added surveillance expenditures. Unfortunately, it can not show those benefits without the additional data that would be provided by the extra detection.

HRPDC is currently using the ADMS to help produce their reports on the incident response program. The current HRPDC report basically lists the number of incidents responded to by VDOT, but does not quantify the congestion associated with those incidents or the benefits from having the incident response program in place.

HRPDC also has begun to produce an annual report on the "state of the region's roads." This report would be a logical place to publish ADMS based roadway performance statistics. The only real issue is whether the ADMS data quality problems will be corrected enough to allow the use of the data in this fashion, and whether the HRPDC can afford to produce the report with the greater level of detail provided by the ADMS.

Potential ADMS Improvements Suggested by HRPDC and HRSTC

For those staff that have used the ADMS to date, data quality and availability issues dominated their view of the usefulness of the system. When pressed for additional information, it became clear that there are two basic groups of users, the casual user, and the routine user.

The casual (or infrequent) user generally found the system to be somewhat slow and intimidating. HRPDC staff that fell within this category indicated that until you were familiar with the system, even getting simple statistics such as AADT values from the ADMS was difficult. A conclusion that may be drawn from this is that making access to finished data products easier is key to encouraging these individuals to use the system more often. This means that more "canned" reports (tailored to specific reporting needs) probably would need to be created, and the user interface may need to be changed slightly in order to make it obvious how to obtain those outputs.

On the other hand, routine users of the system did not find the system confusing. Training and familiarity with the system resulted in the user's ability to easily obtain the data they were interested in (provided that data existed at all.) These users were more interested in obtaining fairly raw statistics and data from the database, but they too expressed interest in speeding and simplifying the interface process for getting key roadway statistics. The operators, in particular, could foresee using the ADMS much more if they had more "easy to obtain" reports. However until these reports became both easier to obtain and more relevant to how their job performance was judged it is unlikely that the operators will access the ADMS routinely.

HRPDC staff also noted that the Phase 2 detectors are now coming on-line, but that the ADMS referencing system has not been kept up to date with those data updates. It is therefore not possible for the "average user" to determine where these new detectors are located. The ADMS may need some additional configuration management support in order to address this problem in the future.

The HRPDC staff was also interested in having more congestion performance related workshops taught in Hampton Roads. And they were also interested in having more training done for staff at the local level.

Data Quality, Validation, and Availability

As noted elsewhere, the lack of data quality is a significant roadblock towards more active use of the ADMS. Most of the Phase 1 detectors do not currently work, and for much of the time when they did work, data quality was highly suspect. The operators interviewed indicated that the data currently being collected has never been validated. None of the groups we interviewed felt it was really their job to perform that validation.

The upcoming performance-based TMC contract may bring some of those duties to the TMC, but there still appears to be disconnects between different divisions within VDOT on who is responsible for (and must fund) the maintenance of surveillance equipment. For example, the Phase 3 detector contract appears to be purchasing acoustic detectors that have traditionally had problems performing accurately at speeds below 30 mph. Consequently, TMC staff is concerned about the performance of the detectors purchased under the Phase 3 expansion, but appears to have no ability to do much about this concern. Just as importantly, there is little budget available for repairing or replacing failed detectors after it becomes clear that a detector has failed.

The TMC currently has little detection on many of the roads that ought to be included in a 'regional freeway performance report.' Cost-effective extension of data collection to those roadways appears to require both additional sensors, and a change in the nature of the sensors used. (For example, detection might be primarily oriented towards collecting travel time data on key roadway segments supported by limited traffic volume data, rather looking to expand the existing point detection system.) Such a change in sensor deployment would require changes to the ADMS.

Other Issues

HRPDC indicated that it would be possible for VDOT to request funding for studies that used the ADMS through the regular HRPDC process. There was considerable speculation about whether CMAQ funds could be used to support this type of analysis. However, funding from this source is unlikely to be available for detector maintenance or repair.

The HRPDC has an ITS Committee that is currently charged with determining where Operations Planning will take place. (Should it be a function of the agency that operates the roadway, or should it be a regionally controlled system.) They are getting good support for this function from VDOT, but the decisions have not been made at this time.

Summary Lesson Learned

Our discussions in Hampton Roads highlighted a key lesson learned. <u>Use of an ADMS and the quality of data included in that ADMS are directly correlated to how actively agencies are using (or are interested in using) performance measures that describe facility operations for decision making</u>.

For an ADMS to be useful, the performance measures such a system produces must be actively used by an agency. If no one actively uses performance measures to make decisions, the quality of the data in the ADMS tends to degrade. The result is that when the ADMS is accessed, data quality issues tend to limit the usefulness of the archive. On the other hand, if the data are routinely used, data quality issues are identified (and fixed) when they occur, because decision makers are relying on, and value, those data.

Historically, facility performance measures have not been actively used in Hampton Roads. Neither HRPDC nor HRSTC had seen reporting on roadway operational performance as "being their job." The result is that data quality in the ADMS has suffered, further degrading the use of the ADMS for other purposes. Both VDOT and HRPDC are in the process of trying to increase their use of facility performance measures. For example, it has been suggested by some parties that VDOT use such measures as one measure of the job performance of the next contractor chosen to operate the HRSTC. If the reliability of roadway operation is used as a factor for judging (and paying) the TMC contractor, then both the contractor and the agency hiring the contractor have a direct interest in accurately measuring and understanding the performance of those facilities. Such an interest will cause the quality of the data to improve, as well as dramatically increase the use of the ADMS as a tool for improving roadway performance.

3.2.3 Final Interviews, May 2005

3.2.3.1 VDOT, Smart Travel Laboratory (STL), University of Virginia

The STL was the ADMS Virginia project coordinator. They performed the functional design of the system and supplied many of the algorithms for data processing such as quality control procedures, imputation, and the travel forecasting procedure.

A formal user requirement process was followed whereby STL and their software contractor (Open Roads) interviewed potential ADMS users. STL felt that the process they followed led to effective system design and would not do anything differently. Initially when they went to the stakeholders with user requirements and design specifications, they received no feedback. It was felt that potential users did not have enough detail to react to, so mockups of the interim builds were provided at subsequent sessions. Giving those examples to stakeholders was essential to getting feedback from them.

The HRSTC is contractor-operated with VDOT supervision. Initially, this was thought to be a potential problem, but this has never become an issue. The HRSTC team there is very well integrated, primarily because URS has had the contract for a long time and work well with VDOT personnel.

STL personnel reflected on the primary users of the ADMS – it is not designed primarily for the TMC operator for use in real-time; the tool is more for planning applications, both operations planning and traditional planning applications. It was observed that in order to be effective ***any*** software application for "on the floor" use at a TMC must be integrated with existing TMC software. That is, it must be part of the same console that operators use – anything else is simply not "ergonomic" or time-efficient to use. Also, query interfaces have to be relatively automatic "point and click" – operators are simply too busy to structure custom queries.

User feedback has been positive. They like the potential that the ADMS affords and are asking for more data, more coverage, and better quality data. The speed of the queries (noted in the February interviews) had been relayed as a problem. This is being addressed in a software update, Build 4.1. The slowness in the speed of queries was related to several factors. Some queries were not structured properly in SQL. Also, the shp files from GIS added to the time needed to run the queries. These map layers in GIS will be available for future applications. There were no complaints about the interface. They were thrilled about getting to the data so easily.

There is a growing interest in archiving data throughout the state. Virginia Beach wants to archive their signal data, but this is only in the early discussion stages. VDOT is talking about a statewide incident log. They would be able to add these sources to the ADMS, should funding be made available. It was observed that ADMS Virginia has demonstrated the value of archived data as a resource for many applications. It has made transportation personnel aware of the vastness of the data available, and it also made them aware that quality matters. There has been more attention on data now than ever before in the history of VDOT – the new performance measure initiative is proof of that. It is likely that the first aspect of performance that will be considered is related to incidents – much data already exist on incidents and there is not same issue of quality and coverage as for detector data.

Build 4.1 also incorporates another feature reported by the NoVA personnel the February interviews. It will allow analysis of congestion patterns on the I-95 and I-395 HOV lanes. VDOT needs to quantify the demand usage on these reversible lanes. Such an application is an example of how the ADMS may be used to support operational planning.

Many data issues had to be addressed by ADMS Virginia that the TMCs would have had to address eventually anyway. Foremost of these was the coordinates of the field detectors, and the naming conventions for the detectors (configuration management). ADMS developers verified locations of the detectors. This rectification will have benefit for the TMCs as well as for ADMS Virginia users. The base maps are from the VDOT GIS division, most of which are in ArcGIS.

Data security is also an issue – in the case of Hampton Roads, the data is put behind a firewall, and the ADMS accesses the data there. NoVA transmits the data via ftp the data to STL every minute, a mutual decision between the NOVASTC and the ADMS team based on aggregation parameters.

The addition of RTMS to the detector inventory should not pose a problem. The RTMS specification says that it has to look like a loop. The structure of the data from RTMS and loop detectors look the same. The inventory file describes what type of detector exists, but the data structure is indistinguishable.

From the outset of the project, portability from the initial deployment (Hampton Roads) was assumed. To enhance portability, the data schema was developed to be consistent with national and VDOT standards (primarily the Traffic Management Data Dictionary). When porting to NoVA, data translation code had to be written to put data into the standard schema, but it was relatively easy to do so. Having this commonality in the underlying data structure (schema) helps to keep performance measures consistent.

The issue of data quality has been the dominant issue in the usage of the ADMS. The QC procedures and quality reports are two ways the ADMS can exert influence on the quality issue, but ultimately it ties back to the status of field detectors: proper installation, calibration, and maintenance of the detectors are the only actions that will improve data quality. These are outside of the control of the ADMS – this function resides at the TMCs. Feedback to the TMCs on data quality status has been initiated in Hampton Roads, but correcting the problems with field equipment and communications that lead to data quality problems has not yet been undertaken (although it is viewed as important).

VDOT has set aside $300,000 annually to maintain and upgrade ADMS Virginia. At STL, there is one full-time database administrator, one part-time database administrator, one part-time documentation person, and one full-time software person. If the ADMS maintenance takes up 1/3 of the time, then maintaining the ADMS may take about one to one and a half persons.

STL personnel gave their insights on lessons learned that can be beneficial to other ADMS developers:

- Involvement of stakeholders early on in the requirements process is critical. Because personnel may not have a good idea of what data exist or what they could be used for, mockups of outputs for the Hampton Roads personnel were very helpful in generating interest.
- The Build approach was very helpful in developing the system. If nothing else, it provided a base system early in the development cycle for users to provide reaction. The builds had very fast turnarounds. The interim builds helped to verify requirements.
- Traditional data providers/collectors (such as traffic monitoring programs) may not want to use data that they do not produce. However, they are more inclined to use it if the data is packaged in some way that is important and useful to them. STL is slightly removed from the data source and data users. They can help get everyone to the table and help them to communicate.
- Professional software development, following standard IT procedures such as user requirements sessions and system requirements specifications – ensures a workable system. STL was very happy with Open Roads – they did things the “right way” (e.g., proper system documentation) and were very responsive to new requirements.

3.2.3.2 NoVA District of VDOT

The Evaluation Team contacted the NoVA district to schedule a final interview. However, we learned that usage of the ADMS had not increased from February. Logon to the system was still a problem. NoVA personnel recommended that we not interview them as the lack of usage would not reveal anything beyond what was learned at the February interviews.

3.2.3.3 Open Roads Consulting, Inc (ORCI)

ORCI provided the software engineering for ADMS Virginia. The interview was structured into several major topics:

- Project Roles and Responsibilities
- ADMS Implementation/Operation
- ADMS Improvements
- Portability

Project Roles and Responsibilities

STL developed the *Concept of Operations*, the detailed system requirements, and also supervised stakeholder input.   ORCI's role was to develop the system but they participated actively in all of the up-front activities and provided feedback during the process. The participation of ORCI in this process was important in assuring that the product addressed the goals, objectives, and requirements of the project.

The original contract called for a single system deployment but the team decided instead to implement the project in three sets of builds. A fourth build was later added for Northern Virginia. ORCI saw the benefits of the multiple build approach from the beginning but had concerns about making such a significant change to the original plan.   While this change involved some risk, the phased build approach turned out to be beneficial. The developers received feedback after each build and were able to improve the product as a result. A robust requirements definition process was included as part of each build. The three key members of the team, VDOT, STL, and ORCI knew each other well and worked together closely. Regular meetings fostered cooperation and helped keep the project on track. Each build had its own set of requirements and was conducted as a separate project, but added incrementally to the work of the previous builds.

The other major change from the original plan was use of a real-time GIS web-based interface. This was implemented in Build 2, to replace the original image map. This has been beneficial to the project and has been well-received.   Real time features include current conditions, active incidents and detector quality reports. Data quality reports have been useful to both maintenance personnel. Planners and traffic engineers also have made use of these reports in order to determine which data sources to use.

All of the planned capabilities have been implemented. Other than the two items mentioned above there were only minor modifications in the original requirements.   As a result of the multiple builds, there were less overall changes in the capabilities vs. the requirements. The multiple builds allowed for the incremental redefining of requirements to meet the stakeholders' needs

STL serves as the primary interface for users. The system does provide an easy way for users to provide feedback or ask questions. These go to STL but may be passed along to ORCI. Planners and traffic engineers have been primary users. There have been more requests recently from consultants doing traffic congestion studies and researchers from out of state. This appears to be a unique resource. The flexibility of the system is perhaps its greatest benefit. The data are available to anyone who wants it and through the query system users can find the information that is useful to them.

STL was responsible for compiling data from the field detectors and developing the standardized database. ORCI was able to develop the interface tools based on this standardized format. In this arrangement, STL took the brunt of the responsibilities related to data quality and shielded ORCI from dealing with these issues (i.e., customizing the system to address these data problems). The availability of this central database allowed ORCI to develop their tools on an agreed data format and promoted the greater portability of the tools.

ADMS Implementation/Operation

Close coordination between the parties was a major factor in the success of the project. The project team had weekly meetings to review progress and these were important in making sure everything stayed on track.   The meetings were especially helpful in handling the shift from a single system deployment to build phases. VDOT, as the ultimate client, was proactive in making needed decisions.

STL had unique expertise that contributed to the success of the project. They had very strong database expertise that they used to develop data conversion procedures and clean up the data. This was combined with strong domain expertise in ITS and transportation. Their ability to address data gaps was important in making sure the system met the requirements and needs of the users.

Rapid prototyping was used to obtain feedback from both stakeholders and the internal team. Some early versions of the software were issued only to the internal team for testing. Some very good input was obtained from both VDOT and STL by doing this. After these reviews the system was tested by a wider group of stakeholders. During the development process, pages would be posted to a website as they were developed to allow team members to review and make comments while the functionality was still being designed. This provided immediate feedback on the appropriateness of the design.

The data quality issues were raised early on during Build 1. The visibility of these issues highlighted the need to address data gaps in the software development process. It also raised the visibility of the detector maintenance issue for VDOT.

ORCI made much greater use of third-party tools than originally anticipated. These tools worked effectively, saved development time and helped to produce a better product.   The implementation through build phases made it easier to incorporate these tools and other new technology as the project progressed. The tradeoff in using these off the shelf components was that ORCI had less control and ability to customize the application. The development team worked closely to weigh the benefits of rapid implementation and lessened resource demands against the loss of flexibility/customized capabilities.

The strong points of the system are its flexibility in responding to different types of queries. The graphics and mapping capabilities are also strong points of the system.

ADMS Improvements

The speed of the system has been a concern for some users. ORCI is looking for ways to speed up the system but there are many variables impacting access time that are difficult to calculate –

most related to external issues of data transfer over the internet. The system currently provides an estimate of query time; however, the time estimates are approximate (e.g., less than 5 minutes) since it is difficult to gauge the impact of these external factors that impact transfer time. ORCI noted that the software was developed using a smaller, fixed database. It would have been helpful to grow the database concurrently with the development effort. Although the fields were identical to the production database and allowed the various analysis capabilities to be successfully developed, the eventual size of the database contained many more records than anticipated. Having a more accurate representation of the final database would have allowed for greater optimization of the algorithms and provided a better indication of query time as the database grew.

ORCI noted that the speed could be improved for some users by developing a series of standard reports. For those users who want the same set of data on a regular basis, standard reports would be faster. Focused, packaged reports may help to attract more usage from operational users, since they need information quickly for decision making. The ADMS is developed using open source, providing the opportunity for these standard queries to be made on a system-to-system basis.

Use of the system for operational purposes was an important goal. ORCI noted that Hampton Roads has been interested in using the data for work zone planning. ORCI also noted that in their installation on the I-81 corridor there is interest in having the TMC central system draw data directly from the ADMS. Automating this capability would provide quick access to data for management decisions, particularly in addressing unplanned events such as incidents and bad weather.

Portability

Portability was the major issues addressed in Build 4, with the installation in Northern Virginia. This has been successfully accomplished due to several factors:

- The availability of a common database and database standards;
- Use of standard and accepted software development practices;
- Use of open source technology; and
- Very thorough and extensive documentation that is available on-line.

One key to successful portability is controlling customization. Ideally all systems would receive the same data so the platform can remain the same. ORCI noted, for example, that Northern Virginia did not initially have weather data so some customization was needed to remove the displays.[5] The team carefully weighed the tradeoff: Is it better to have a standard template for all areas and risk showing blank fields when data is unavailable, or is it preferable to customize the outputs to the specific data availability and limited the reusability/portability of the system. In general, customization was limited in Build 4.

3.2.3.4 Summary of Major Lessons Learned

The standardization of archived data on a statewide basis was seen as having numerous benefits. It permits the query and display systems to be easily ported and provides a common basis for

[5] Weather data has recently been added to the NoVA part of ADMS Virginia

statewide system performance measurement. This also enabled ORCI, as the software developer, to concentrate on their task using a clear set of requirements. They were able to interface with users through a central point, STL, rather than dealing with multiple parties. The high level of technical expertise at STL was critical in accomplishing this. Knowledge of databases and ITS/traffic was important. A lesson for other States is that before funding individual systems to develop stand-alone ADMS, they should consider using University resources to standardize the systems across the State.

The phased incremental approach to software development was very successful for the Virginia ADMS. This approach enabled both internal developers and stakeholders to test the system before its completion and provide feedback. It also enabled the software developers to incorporate new tools and technologies as they became available, without causing delays in the project. Rapid prototyping was also a helpful mechanism in obtaining client feedback.

Weekly meetings of the project team were an important element in success of the project, particularly in the beginning. Small issues were worked out and did not become large problems later on. Frequent contact among the team members meant that minor adjustments could be made with little difficulty.

The flexibility of the query system makes the system useful to a wider range of users. However, some users become impatient with the time it takes the system to execute large queries. Some users may benefit from the development of standard reports.

It is helpful to test the system on the full database, as well as a limited sample of the database. This will provide a better understanding of system response time.

Reports on data quality have been very helpful to the end users. In addition to maintenance personnel, planners and traffic engineers have found that these reports provide a better understanding of the data and help them to focus their queries on higher quality data. This issue should be raised and addressed early in the software development process.

3.3 Evaluation of Hypotheses

For subjective information, this section relies heavily on the results of the interviews documented in the previous section. In these cases, the evaluation refers back to the interviews, but does not repeat the full text.

3.3.1 TMC Operations Planning

3.3.1.1 Hypothesis #1: Archived data tools enable STC staff to perform more effective Operations Planning

<u>*Goal: Improved TMC operations*</u>

Discussion: As shown in the interviews, STC staff did not use the ADMS for operations planning during the evaluation period. Operations planning was cited as the most practical use of the ADMS by STC personnel, but they currently do little in this regard. STC's focus is on real-time management of the system, mainly through coordinated incident management and posting traveler information. A big part of this issue is related to how the STC is staffed – most of the personnel are contractors. VDOT managers expressed positive comments about how this relationship is working and by all accounts day-to-day operations functions are handled very well. However, the contractors are not required under the terms of the existing contract to do any type of operations planning. VDOT has very few staff at the STC, and their duties are consumed by managing and overseeing the contractors. Finally, there was a feeling among STC staff that HRPDC is the group that "studies things" and they would be the proper unit to conduct operational planning in the short-term. However, the relationship between STC and HRPDC with regard to operations planning is still being worked out, so during the evaluation period, neither STC nor HRPDC had used the ADMS for operations planning.

Another major impediment to ADMS use – for operations planning or anything else – was the severe data quality and availability problem. This was cited by the STC as the main reason why the ADMS was not explored ("the data are so incomplete why bother with any analysis for now"). However, given the above discussion, it is not clear if the ADMS would have been used for operations planning even if data quality was high.

3.3.1.2 Hypothesis #2: Use of the ADMS Improves System Wide Travel Conditions

Goal: Less total delay and increased reliability

Discussion: The low overall quality of the data makes it difficult to draw any conclusions from data analysis. When coupled with the fact that the ADMS was not used to effect operations, it is clear that any changes in congestion or reliability levels can not be attributed to ADMS Virginia.

Nonetheless, an analysis of the data was undertaken. The data used came directly from the HRSTC for years 2000-2003. The data for 2004 came via ADMS Virginia. Data were subjected to the quality control procedures used in FHWA's Mobility Monitoring Program.[6] These procedures encompass those used by ADMS Virginia plus several others. Tables 2, 3, and 4 illustrate the history of the data quality problem in Hampton Roads in dramatic fashion:

- The decrease in congestion and reliability between 2000 and 2001 is extremely large and probably due to data problems than any true drop in congestion. A review of VMT changes using HPMS data (Table 4) shows that VMT increased by almost three percent from 2000 to 2001, lending credence to a data quality problem. (Lane-miles were almost constant.
- The availability of data in 2002 was almost nonexistent. Due to the combination of data not being reported from the field and failing QC procedures.
- The extreme increase in congestion and reliability in 2003 is clearly due to a data quality problem. Review of the data and discussions with STL indicated that unrealistically low speeds were being reported from the field. These speeds were still within the range- and cross-checks used by the QC procedures but were felt to be aberrations caused by poor maintenance of field equipment.[7]
- The 2004 data appear more realistic, but are still substantially higher than 2001. However, note that the coverage actually doubled in 2004! It is not known whether the

[6] Htpp://mobility/tamu.edu/mmp

[7] This shows the importance of checking the output of field equipment with spot checks *in the field*. Post hoc QC tests are limited in the data problems that they can catch.

apparent improvement in data quality includes rectifying the aberrantly low speed problem. Nor is it likely to be known without independent field validation of detector measurements.

Corridor	Length	Travel Time Index				
		2000	2001	2002	2003	2004
I-64, EB (I-564 to I-264)	7.90	No data	1.03	1.13	2.16	1.42
I-64, EB (I-264 to Ches. City Line)	3.95	No data	1.01	1.12	1.42	1.41
I-64, WB (Ches. City Line to I-264)	3.90	No data	1.02	No data	1.45	1.28
I-64, WB (I-264 to I-564)	7.95	No data	1.03	1.00	1.38	1.28
I-64 HOV (I-564 to I-64)	9.20	1.03	1.01	No data	1.31	1.23
I-264, EB (I-64 to Va. Beach)	7.55	No data	1.00	1.02	No data	1.21
I-264, WB (Va. Beach to I-64)	7.55	No data	1.00	1.02	No data	1.39
I-564, EB (Naval Station to I-64)	2.40	1.00	1.01	No data	No data	1.61
I-564, WB (I-64 to Naval Station)	2.90	1.18	1.02	No data	No data	1.06
I-64 EB: 8th View St. to I-564	3.69					1.07
I-64 EB: I-664 to S. Willard Ave	3.88					1.31
I-64 WB:I-564 to 8th View St	3.94					1.37
I-64 WB: S. Willard Ave to I-664	3.89					1.06
I-264 EB: Va. Beach to Birdcheck Rd	5.42					1.03
I-264 WB: Birdcheck Rd to Va. Beach	5.39	**No detectors in place during this time period**				1.03
I-664 EB: 39th St to I-64	3.99					1.04
I-664 WB: I-64 to 39th St	4.01					1.07
I-64 EB: Bainbridge Blvd to College Park Blvd	5.27					1.11
I-64 WB: College Park Blvd to Bainbridge Blvd	5.28					1.03

The Travel Time Index (TTI) is a measure of total congestion. It is the ratio of the peak period travel time to the travel time under ideal conditions. A TTI value of 1.2 indicates that peak period travel takes 20 percent longer than under ideal conditions.

Table 2 Trends in the Travel Time Index on Hampton Roads Freeways

<table>
<tr><th rowspan="2">Corridor</th><th rowspan="2">Length</th><th colspan="5">Buffer Index</th></tr>
<tr><th>2000</th><th>2001</th><th>2002</th><th>2003</th><th>2004</th></tr>
<tr><td>I-64, EB (I-564 to I-264)</td><td>7.90</td><td>No data</td><td>13%</td><td>28%</td><td>69%</td><td>69%</td></tr>
<tr><td>I-64, EB (I-264 to Ches. City Line)</td><td>3.95</td><td>No data</td><td>0%</td><td>34%</td><td>43%</td><td>81%</td></tr>
<tr><td>I-64, WB (Ches. City Line to I-264)</td><td>3.90</td><td>No data</td><td>6%</td><td>No data</td><td>49%</td><td>53%</td></tr>
<tr><td>I-64, WB (I-264 to I-564)</td><td>7.95</td><td>No data</td><td>11%</td><td>0%</td><td>50%</td><td>73%</td></tr>
<tr><td>I-64 HOV (I-564 to I-64)</td><td>9.20</td><td>3%</td><td>0%</td><td>No data</td><td>65%</td><td>58%</td></tr>
<tr><td>I-264, EB (I-64 to Va. Beach)</td><td>7.55</td><td>No data</td><td>0%</td><td>4%</td><td>No data</td><td>46%</td></tr>
<tr><td>I-264, WB (Va. Beach to I-64)</td><td>7.55</td><td>No data</td><td>0%</td><td>8%</td><td>No data</td><td>88%</td></tr>
<tr><td>I-564, EB (Naval Station to I-64)</td><td>2.40</td><td>2%</td><td>0%</td><td>No data</td><td>No data</td><td>184%</td></tr>
<tr><td>I-564, WB (I-64 to Naval Station)</td><td>2.90</td><td>55%</td><td>0%</td><td>No data</td><td>No data</td><td>8%</td></tr>
<tr><td>I-64 EB: 8th View St. to I-564</td><td>3.69</td><td rowspan="10" colspan="4">No Data</td><td>13%</td></tr>
<tr><td>I-64 EB: I-664 to S. Willard Ave</td><td>3.88</td><td>65%</td></tr>
<tr><td>I-64 WB:I-564 to 8th View St</td><td>3.94</td><td>68%</td></tr>
<tr><td>I-64 WB: S. Willard Ave to I-664</td><td>3.89</td><td>19%</td></tr>
<tr><td>I-264 EB: Va. Beach to Birdcheck Rd</td><td>5.42</td><td>8%</td></tr>
<tr><td>I-264 WB: Birdcheck Rd to Va. Beach</td><td>5.39</td><td>7%</td></tr>
<tr><td>I-664 EB: 39th St to I-64</td><td>3.99</td><td>8%</td></tr>
<tr><td>I-664 WB: I-64 to 39th St</td><td>4.01</td><td>22%</td></tr>
<tr><td>I-64 EB: Bainbridge Blvd to College Park Blvd</td><td>5.27</td><td>39%</td></tr>
<tr><td>I-64 WB: College Park Blvd to Bainbridge Blvd</td><td>5.28</td><td>8%</td></tr>
</table>

Table 3 Trends in the Buffer Index on Hampton Roads Freeways

Year	Annual VMT (millions)	Pct. Change	Lane-Miles
2000	3,525		653.8
2001	3,622	2.76%	652.8
2002	3,852	6.35%	672.2
2003	3,849	-0.07%	672.1

Source: HPMS Universe data

Table 4 VMT and Lane-Miles for the Norfolk-Hampton Roads Urban Area

3.3.2 Planning Functions

3.3.2.1 Hypothesis #3: Availability of Archived Data Will Improve Accuracy of Regional Planning Models

Goal: Improved Regional Planning

Discussion: For the evaluation period, it can be said that ADMS Virginia did not improve the accuracy of regional planning models. Data quality and coverage problems were noted by HRPDC as the major barrier to use in regional planning models. Even if high quality data were present, the fact that only a small percentage of area freeways are currently covered by roadway surveillance is a limiting. However, HRPDC noted the ***potential*** for improving the accuracy of regional planning models by accessing the ADMS. These include:

- Replacing AADTs based on short-duration traffic counts (usually 48-hour counts factored to account for daily and seasonal variation) with directly measured AADT using continuous data from the ADMS.
- When the HRPDC travel demand forecasting model migrates to a peak hour model (from a daily model), deriving peak hour volumes and speeds directly from the ADMS rather than relying on area wide peak-hour factors.

In addition to providing data inputs for the travel demand forecasting model, HRPDC expects that the ADMS will provide hourly speeds and volumes for the DynaMIT traffic simulation model. The ADMS currently provides these data in DynaMIT input format.

3.3.2.2 Hypothesis #4: Availability of Archived Data Will Reduce Cost of Regional Planning Models

Goal: Improved Regional Planning

Discussion: Because the ADMS had not been used to supply data for regional planning models at HRPDC, this hypothesis could not be tested. However, in interviews, HRPDC staff stated that the direct cost of collecting input data for regional planning models would not be reduced by use of the ADMS. Rather, the ADMS would be used to collect data on the covered highway segments, allowing data collection on additional segments. In other words, HRPDC would expect their data collection costs to remain constant with use of the ADMS, but they would expand their collection coverage. For HRPDC, this would mean primarily conducting travel time runs (floating cars) because VDOT takes traffic counts on the freeways. If VDOT could use the ADMS to collect volume data on covered freeways (rather than having to deploy portable equipment), there would be a direct cost savings.

3.3.3 General Archive Functions

3.3.3.1 Hypothesis #5: The ADMS Provides a Mechanism for Improving the Quality of Traffic Data

Goal: Improved data quality

Discussion: In most TMCs, only cursory review of field detector data is performed – the level of checking is usually only if detectors are communicating with the TMC or not (on or off). Sometimes, field detectors will assign and communicate error codes and the TMC software will check for outlandish values. However, these procedures detect only the grievous errors, allowing more subtle ones to slip by.

STL took the issue of data quality very seriously from beginning of the project and designed into the system a series of sophisticated data quality control checks. STL defined these checks as follows:

1. Maximum occupancy threshold – fail if occupancy > 95%
2. Overall maximum volume threshold – fail if volume > 3100 vehicles/lane/hour
3. Positive volume with zero speed – fail if volume is positive and speed zero
4. Maximum volume threshold with a reported occupancy of zero – fail if occupancy is zero and volume > (volume when occupancy = 2%). This situation appears because occupancy is truncated to an integer and may result in a zero value, when in reality it is not.
5. Average Effective Vehicle Length – this test is applied only to data where all of speed, volume, and occupancy are positive. This test is based on:

   AEVL = 10 * u * h / q where

   AEVL = Average Effective Vehicle Length

   U = speed (km/h)

   H = occupancy (%)

   Q = hourly equivalent volume (vehicles/lane/hour)

   Data fail this test if AEVL >18 or AEVL < 2.7
6. Records containing zeros for all three values (volume, occupancy, and speed) are considered to be "bad".

If data fail the QC tests – or are missing to begin with – the data are flagged and imputation is conducted (see below under Hypothesis #7).

As demonstrated above and discussed by the interviewees, data quality has been a serious problem in Hampton Roads since at least 2002. The data were reviewed for quality using the QC process from the Mobility Monitoring Program; results are shown in Table 5.

Quality Attribute	2001	2002	2003	2004
% complete	35%	6%	39%	46%
% valid	43%	31%	58%	47%
% of VMT covered	9%	17%	18%	28%
% of freeway miles	11%	9%	10%	29%

Notes: (1) Validity is reported as the percentage of submitted data values that passed the quality control rules. (2) Completeness is reported as the percentage of data values available for use. It is calculated as the ratio of total available data values to total expected data values.

Table 5 Quality Control Test Results on Speed Data, Hampton Roads, 2000 – 2004

The results for 2004 are encouraging in the sense that the percent complete is the highest it's ever been in Hampton Roads. They are discouraging in the sense that quality still lags behind that of many TMCs as illustrated in Table 6.

In summary, ADMS Virginia provides the basis for improving data quality by producing information that can be applied by users in their applications and feedback to TMS personnel about the quality of data reported from the field. However, unless that information is acted upon by TMC and leads to improved maintenance of field detectors, data quality will not be improved. In fairness, this activity lies outside of the purview of ADMS Virginia and the evaluators found that the system itself does exactly what it is supposed to do in the realm of data quality.

Participating City	Completeness (%) Analysis Data	
	Volume Data	Speed Data
Albany, NY	38%	37%
Atlanta, GA	57%	54%
Austin, TX	77%	59%
Baltimore, MD	63%	57%
Charlotte, NC	55%	57%
Cincinnati, OH-KY	44%	41%
Dallas, TX	46%	44%
Detroit, MI	61%	62%
El Paso, TX	33%	33%
Hampton Roads, VA	49%	39%
Houston, TX	n.a.	56%
Los Angeles, CA	98%	98%
Louisville, KY	82%	76%
Milwaukee, WI	80%	77%
Minneapolis-St. Paul, MN	83%	79%
Orange County, CA	97%	93%
Orlando, FL		
Philadelphia, PA	89%	88%
Phoenix, AZ	63%	60%
Pittsburgh, PA	77%	74%
Portland, OR	84%	83%
Riverside-San Bernardino, CA	70%	67%
Sacramento, CA	88%	83%
Salt Lake City, UT	44%	38%
San Antonio, TX	67%	66%
San Diego, CA	95%	92%
San Francisco, CA	97%	92%
Seattle, WA	80%	81%
Washington, DC	33%	33%

Source: Texas Transportation Institute and Cambridge Systematics, Monitoring Urban Freeways in 2003: Current Conditions and Trends from Archived Operations Data, November 2004.

Table 6 Summary of 2003 Freeway Archived Data Completeness

3.3.3.2 Hypothesis #6: The ADMS Is Portable To Other Areas

Goal: To Provide Transferability with A Minimum of Customization

Discussion: As discussed, the ADMS was successfully transported to the NoVA District of VDOT with minimal disruption. The success of this transfer relied on the facts that (1) the schema developed for Hampton Roads was a thorough representation of how archived data should be stored and (2) developing custom translation programs to populate the schema. There were some problems with geolocation for some NoVA field equipment, but once these were worked out, the ADMS performed properly. All of the applications developed for Hampton Roads were able to function for NoVA, presumably because the data collected by NoVA was similar in scope to that collected in Hampton Roads.

With regard to the schema, the Evaluation Team found it to be very comprehensive and provided a strong engine for ADMS Virginia applications. One shortcoming that could be easily fixed is the expansion of the incident data definitions and inclusion of data on work zones. In fairness, the expanded data for these events are not currently collected by operators, so the ADMS would have no source of the data. However, in the near future, these types of data are likely to become more important to operators. FHWA has initiated a pilot project that explores collection of data needed to support incident performance measures and evaluation of incident management programs.[8] There is also a current FHWA project exploring work zone performance measures and the data need to support them.[9] The expanded data can include all of the following, but even a subset of them would aid in performance measurement:

Incident Data

Data on the so-called "Incident Timeline" would allow operators greater flexibility in operations planning. Decomposing total incident duration into discrete "sub-events" is very useful for performance monitoring; tracking the duration of the sub-events can help identify areas that require improvement. Specifically, the following points on the incident timeline should be captured:

- Incident Start Time – an estimate of the actual start time of an incident, allowing for gap between when it actually occurred and it was detected. This will be a subjective estimate.
- Incident Detection/Report Time – the time an incident was detected by or reported to the first agency involved in a coordinated incident management program.
- Incident Verification Time – the time that an incident was verified by an agency involved in a coordinated incident management program.
- Incident Response Dispatch Time – the time the first responder was notified of the incident.

[8] *Focus States Initiative: Traffic Incident Management Performance Measures*, http://ops.fhwa.dot.gov/incidentmgmt/

[9] http://ops.fhwa.dot.gov/wz/decision_support/perf_measurement.htm

- Incident Scene Arrival Time – the time the first responder arrived at the incident scene. This does not necessarily have to be the first responder who was dispatched.
- Incident Lane Blockage Clearance Time – for incidents that block lanes or a partial lane, the time that the blockage was either completely removed or moved out of the way (e.g., to shoulder) so that the full width of the lane is available for traffic.
- Incident Clearance Time – the time that the incident has been physically removed from the roadway environment.
- Incident Scene Departure Time – the time the last responder leaves the scene of an incident
- Time of Return to Normal Conditions (optional) – this data element is highly subjective since "normal" conditions may be difficult to determine in the field. For example, if the incident has occurred during the peak period, "normal" conditions might be congestion (queues present). If properly matched to traffic sensor data, this time can be determined analytically.

In addition to the timeline information, it may desirable to monitor what happens to the highway cross-section at the incident scene. This accounts for conditions that may change during the course of clearing an incident. For example, a rear-end collision may block a single lane initially. When responders arrive, they may close and additional lane in order to manage the incident. Finally, once cleared, emergency vehicles may remain on the shoulder for some time. All of these discrete events have a widely different impact on traffic flow.

The data would allow more refined analyses to be performed as well as to track how well responders are managing incident scenes (from the perspective of traffic flow.) The data required for this task is presented below. The data is structured as the times that lane or shoulder blocking events begin. Every time the nature of the blockage changes, a new entry is made. This report suggests these data as optional since some agencies may not have the resources to collect them.

- Begin Time of Blockage
- Number of Lanes Blocked/Right Shoulder Blocked/Left Shoulder Blocked
- Nature of Blockage (emergency vehicles, incident-involved vehicles; debris; solid cargo; liquid cargo; fuel spill)

Work Zone Data

- Work Zone Characteristics -- The actual and planned changes in the roadway environment created by the work zone. Used to measure the extent of work zones in time (duration) and space (amount of existing highway removed for the work zone), and their impact on safety and mobility. Also used in traveler information services to alert motorists to expected work zone conditions. Includes:

    - Work zone type; longitudinal characteristics and extent (including details on transition zones and tapers); duration of work zone characteristics; major cross-section characteristics:

  - Lane condition (width, minor shifts, height relative to adjacent lane or shoulder)

  - Shoulder condition

  - Lane re-direction (description of major changes in lane alignments)

  - Lateral clearance

  - Lane closures, lane narrowing, ramp closures

- Work Zone Activities -- Activities related to traffic management and construction/rehabilitation in a work zone. Used to assess mobility and safety impacts of traffic control plans and motorist guidance as well as improvements in construction planning and execution. Data should include:

  - Specifications in traffic control plans;

  - Times traffic control plans are in effect

  - Traffic control device placement in the field and times used (e.g., pavement markings, DMS and static signage, positive guidance devices, barriers)

  - Construction and rehabilitation field activities (e.g., crew size by task, task duration, equipment used on-scene)

  - Time of day and where in the work zone the work occurred.

3.3.3.3 Hypothesis #7: The ADMS Development Process Has Met the Needs of the Stakeholders

Goal: Exemplary or "Model" ADMS Design

Discussion: On this evaluation point, the Team found ADMS Virginia to be an exemplary deployment of an archived data management system as specified in the National ITS Architecture. It is consistent with ASTM Standard E2259, *Standard Guide for Archiving and Retrieving ITS-Generated Data* on the standard's primary "guiding principles" as shown in Table 7. Several of ADMS Virginia's features are worth highlighting because the Evaluation Team expects these to serve as state-of-the-practice in guiding the development of other ADMSs.

Metadata

The Evaluation Team found the design and use of metadata in ADMS Virginia to be superb. Traditional metadata – what ASTM E2259 calls "archive structure metadata" – is readily available to users – descriptions of data elements and data relationships.

"Processing documentation metadata" was also included in ADMS Virginia. In fact, the Evaluation Team found this to be the first implementation of this concept in an ADMS. This is information about how the data were processed. Documentation on QC and imputation procedures is readily available. More importantly, the “flagging” of data as having failed QC or having been imputed is a major advancement of ADMSs. Finally, the calculation of the “normality index” – specifically develop for ADMS Virginia – is a highly innovative feature that could be use d in future deployments. This index provides users with information on how the currently viewed data deviates form “normal” or “expected” values for that location and time.

The final type of metadata specified in ASTM E2259 is “data collection system metadata” – information about the equipment and conditions under which data were collected. This type of metadata was not included in ADMS Virginia because it was not available (i.e., not collected by operators). Provision could have been made in the data structure for it, but we see no reason why ADMS Virginia should provide this if there is no reasonable chance of data being supplied by operators.

Guiding Principle from Standard	ADMS Virginia Consistency
Reliance on User Needs and Requirements Process	Highly consistent. A formal user requirements process was pursued in the design of ADMS Virginia
Providing for Diverse Needs and Requirements of Different Stakeholders	Highly consistent. A wide variety of stakeholders were identified and involved in the user requirements process
Get Archived Data from Other Centers	Highly consistent. The traditional traffic monitoring data was included in ADMS Virginia
Anticipate a Variety of Data Sources	Highly consistent. Traffic and event data were included in ADMS Virginia
Retention of Original Source Data	Highly consistent. Data as received from field detectors can be maintained by ADMS Virginia
Manage Archive to Account for Data Quality	Highly consistent. An exemplary feature of ADMS Virginia (see text)
Establish and Maintain Metadata	Highly consistent. An exemplary feature of ADMS Virginia (see text)
Process User Requests for Data and Information	Highly consistent. The graphical user interface allows for easy access to the ADMS
Support Analysis of Archived Data	Highly consistent. Many pre-packaged analyses were included in ADMS Virginia’s functionality
Prepare Data for Periodic Government Reporting Systems	Somewhat consistent for traffic data where AADT values are computed, but not directly linked to data formats for other systems (e.g., HPMS)

Table 7 Consistency of ADMS Virginia with ASTM Standard E2259

Imputation

From a user’s perspective, having missing traffic data filled in via reasonable imputation methods is a powerful feature of an ADMS. This is particularly true for volume data, because most traffic measures involve summing volumes over time and space. (In contrast, speeds can be treated as a sample since aggregations typically deal with average speeds.) Testing of various imputation algorithms at STL has been ongoing for some time,[10] and represent the state of the art in this field. Because imputation is transparent to end users, the interviews did not reveal any preferences or experiences with using imputed data, other than users would prefer high quality measurements to begin with. When data are imputed in ADMS Virginia, metadata flags are set, and users have the option in the applications to use or not use imputed data in calculations of statistics and performance measures. These features provide end users with options for computing measures such as AADT – either they can select imputed data and allow the system to compute the measures, or they can download unimputed data and use their own methods for accounting for missing data.

System Development Costs

In addition to the $300,000 annual maintenance and enhancement budget provided by VDOT, the actual development effort (in terms of hours only) is provided in Table 8.

Open Roads Labor Category	Hours			
	Build 1	**Build 2**	**Build 3**	**Build 4**
PM/Admin	131	164	98	39
Sr. Software Engineer	417	108	49	10
Software Engineer	394	502	584	452
Programmer	148	1011	575	324
Total Hours/Build	**1090**	**1785**	**1306**	**825**
Total Hours				**5006**

Tables 8 Software Development Level of Effort for ORCI

User Access

Table 9 shows the number of active users of ADMS Virginia as of May 25, 2004. “Active user” is defined as anyone who has established an account and run at least one query. The table also identifies new users since the release of Build 3.

[10] Conklin, James, *Data Imputation Strategies for Transportation Management Systems*, Masters Thesis, University of VA, May 2003.

User Group	Organization	New User	Active Users
Project Stakeholder	Hampton Roads Smart Traffic Center		9
	Hampton Roads Planning District Commission		3
	City of Hampton		2
	Hampton Roads Transit		1
	VDOT – Central Office		9
	Virginia Transportation Research Council		1
	City of Norfolk		1
	NOVA Safety Service Patrol		1
	NOVA Smart Traffic Signal System		1
Researcher	MIT		2
	NC State University		1
	University of Maryland		1
	Auburn University		2
	UVA – Smart Travel Lab		2
	Texas A&M University		2
	University of Delaware		1
	University of Kentucky		1
External User	Kimley-Horn and Associates, Inc.		1
	P. B. Farradyne		2
	Airsage		1
	DMJM + Harris		1
	ESRI		1
	FDOT		3
	Geodecisions		1
	Illinois DOT		1
	Maryland SHA		1
	Minnesota DOT		1
	Battelle	✓	1
	Mitretek Systems	✓	1
	New York DOT	✓	1
	PBS&J	✓	2
FHWA	FHWA		4
Evaluation Team	SAIC		1
	Cambridge Systematics, Inc.		1
Development Team	UVA – Smart Travel Lab		10
	Open Roads Consulting, Inc.		2
	George Mason University		1

Source: Earnest, Ken, Build 3 – Performance Analysis Report, June 7, 2004

Table 9 User of ADMS Virginia, as of May 25, 2004

There were a total of 77 active users that are categorized into one of six user groups: Project Stakeholder, Researcher, External User, FHWA, Evaluation Team, and Development Team. There were 36 additional users (scattered among the six user groups) that have established an account but have not used the system.

Figure 3 shows the types of queries submitted by users during the initial phases of Build 3. AT least at this stage, the predominant usage is the downloaded of measurement data fro individual traffic detectors. This is consistent with the interviews of planning personnel who said their primary use was (and would continue to be for the short-term), data to feed other applications.

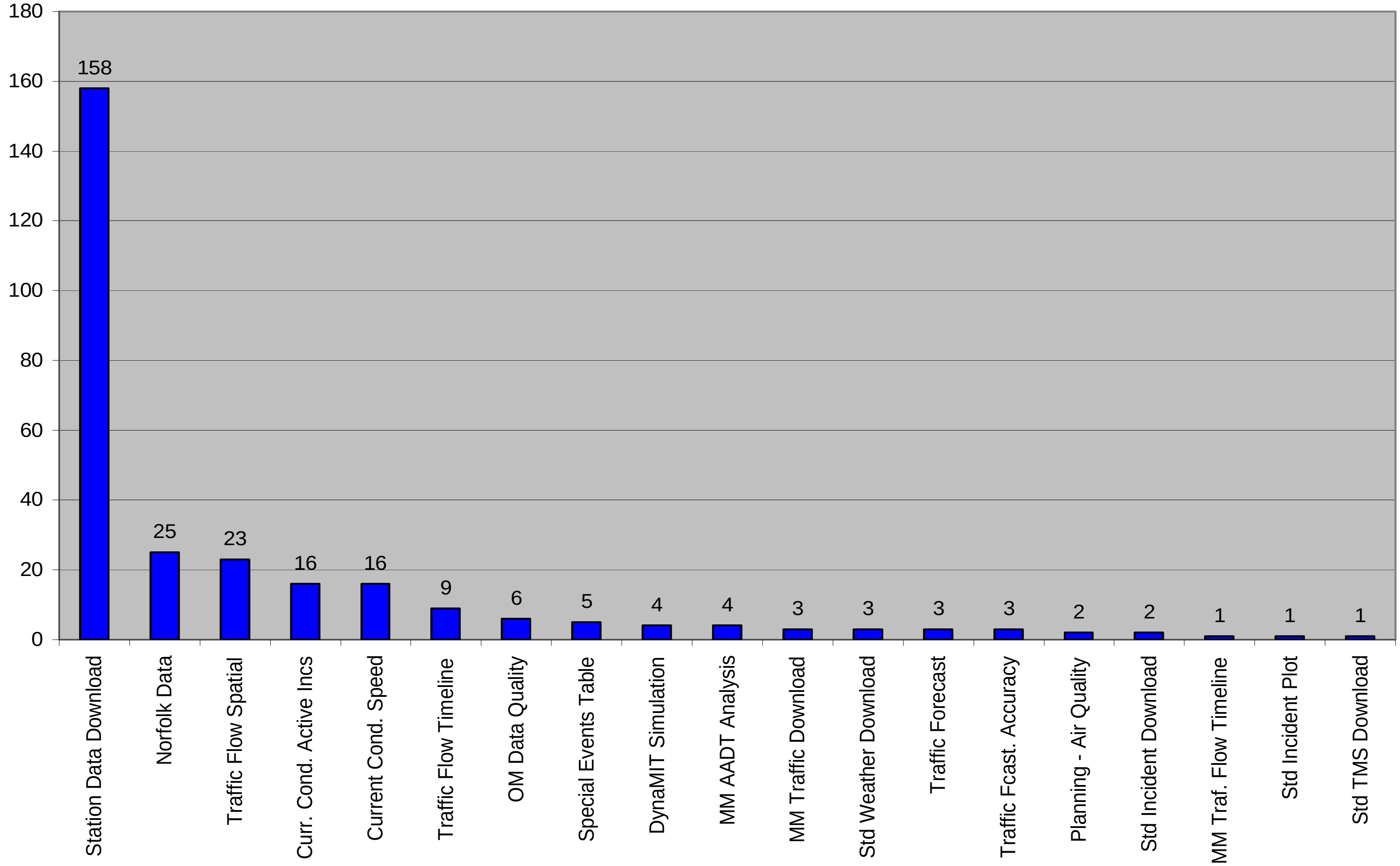

Figure 3 Types of Queries Submitted During Build 3 (4/1/04 – 5/25/04)

3.3.3.4 Hypothesis 8: The ADMS Has Satisfactorily Fused Data from Different Sources

Goal: Applications and Queries Can Access and Use Disparate Forms of Data

Discussion: ADMS Virginia has successfully fused traffic, incident, and weather data into a variety of applications. It has done so by rectifying any potential location referencing problems, as discussed in the interviews in the previous section. The applications that plot or use these different data sources all perform satisfactorily, based on the limited experience of the users (mostly in exploratory fashion rather than for use in planning or operations applications). The successful fusion of traffic, incident, and weather data will allow more complex analyses of system conditions oin the future, such as decomposing total congestion into its component sources and documenting the performance benefit from operations strategies (such as incident management.)

4. EVALUATION SUMMARY AND LESSONS LEARNED

This section summarizes the experiences of the Evaluation Team and provides some thoughts on what was learned and may be applied to future ADMS development.

- ***From a development perspective, ADMS Virginia is an exemplary archived data management system that can serve as a model for the rest of country.*** The Evaluation Team found the physical design of the system to have all of the main features of an ADMS as defined by FHWA, the National ITS Architecture, and current ITS standards. The relatively long list of users from outside of Virginia exploring the system's capabilities is another indication of the ADMS's successful deployment. In some cases, ADMS Virginia has broken new ground on the methods used to process and present data, including:
    - Serious attention to *post hoc* data quality control, including the flagging of erroneous, suspicious, or missing data
    - An advanced imputation algorithm to adjust for missing data
    - Providing users with metadata, both about the archive structure and about processing steps (quality control and imputation)
    - Fusion of traffic, incident, and weather data so that they are geographically consistent
    - Repackaging of archived data into user-defined formats, such as AADT reports and simulation model inputs
- ***Professional software engineering and Information Technology principles aids ADMS development***. The ADMS Virginia development team chose a highly structured approach to design and implementation that worked extremely well in terms of delivery (on-time and within budget). Highlights of this process that can be adopted by ADMS developers elsewhere include:
    - User requirements process – heavy and early involvement of stakeholders
    - Incremental "Builds" – which allowed users to see early versions of the system
    - Structured programming, common web-based tools
    - Metadata provision
    - Map-based interface
    - Searchable help
    - Documentation

- ***Data quality and availability are the overriding features of an ADMS that will promote its usage.*** Traffic data from ADMS Virginia was not routinely used to improve operations in the Hampton Roads or Northern Virginia areas during the evaluation period (incident data are being used in Hampton Roads to assess the incident response program). This was primarily due to inconsistent data quality for much of the Hampton Roads area. VDOT has been aware of the data quality problem and has taken steps to improve field installation and maintenance procedures of detectors. Quality control tests show that quality is improving in Hampton Roads as a result of these actions. Potential users of an ADMS must have confidence in the quality of data before they will actively use the data for their applications. The Evaluation Team heard statements to this effect from most of the interviewees.

- ***Having event data in addition to traffic data stored in an ADMS enhances its usefulness.*** For the most part, the term "archived ITS data" is generally considered by the transportation profession to be traffic data from roadway detectors (volumes, speeds, and occupancies). However, fusing traffic data with event data (e.g., incidents, work zones, weather, and sporting events) – and even analyzing event data on their own – can have significant benefits for system operators and planners. As noted previously, HRSTC is using incident data to evaluate its incident response plan. ADMS Virginia also includes weather and special event data, and while the system does not currently include applications for them, future applications are likely to take advantage of them.
- ***An existing performance monitoring program – or an effort to develop one – would most likely increase ADMS use substantially.*** In Hampton Roads, there was not an ongoing performance monitoring program either at HRSTC or HRPDC during the evaluation period. However, both agencies recognize the value of performance monitoring on its own merits, and in HRSTC's case, VDOT's consideration of an agency-wide performance monitoring program will provide extra incentive to implement a monitoring program. Currently, HRPDC does a limited amount of planning-level activity as part of their Congestion Management System (CMS) program, but detailed operational performance (e.g. HOV evaluation) is not done routinely (when performed, it's done as a special study). Both agencies recognize that the ADMS would be the primary source of data for a performance monitoring program, given the expense of collecting data solely for this purpose. Deployment of the ADMS will support HRSTC's ability to implement performance monitoring in the region.
- ***From a planning perspective, a drawback of currently deployed ADMSs (including ADMS Virginia) is the limited amount of highways covered by surveillance systems.*** Regional planning efforts require performance information on major highways throughout an area. In most cities, ITS is typically only deployed on major freeways. Expansion to all freeways and at least signalized arterials would provide additional information for planning purposes. A related issue is how to combine performance measurements from ITS with performance data from models – there is a concern that they may not be entirely compatible.
- ***State Departments of Transportation, which have traditionally been focused on highway construction and maintenance, are still transitioning into operations***. The Evaluation Team has observed this informally in other parts of the country and VDOT is now pursuing improved traffic management capabilities, but the types of applications that could take advantage of an ADMS (e.g., performance monitoring and advanced route guidance) have not yet been developed. Indeed, there are only a few state DOTs that currently engage in such activities (though their ranks are growing). VDOT personnel in both Hampton Roads and Northern Virginia cited this as something they would need to embrace in the near future (interviewees noted that there is already a top level performance measurement initiative afoot at VDOT) and recognized that the ADMS would be the most useful source of information. In general, as operations strategies become more widespread and sophisticated, their data

requirements will also increase, making the necessity (if not the value) for an ADMS even more self-evident.

- ***TMC standard operating procedure manuals and operator contract stipulations must be considered during the ADMS design process - implementation of the system will likely require operators to engage in new activities.*** For example, because staffing of the Hampton Roads TMC is contracted out, the contract staff perform those tasks assigned to them in that contract, or that can be directly measured as part of the evaluation of their performance (this is not a shortcoming of using contractors, which in the Hampton Roads case seems to work very well). It's just that new activities are time consuming and staff levels are negotiated under a particular workload assumption. Reporting on freeway performance has not been assigned to the TMC contractors, and is not used as a measure of the contractor's performance. Consequently, reporting on freeway performance cannot be undertaken without a contract modification or some other change.
- ***If a software application (including an ADMS interface) is not part of the TMC software and displayed on the main console, its use is very limited.*** TMC operators are extremely busy when managing traffic in real-time. Any additional workload such as accessing an ADMS must be fully integrated into their normal operating software rather than an adjunct system. Similarly, the software must be capable of assembling information very quickly and with a minimum of input/query structure from the operator.
- ***An ADMS can supply the data for operational planning and evaluation of operations programs, but this is a relatively new activity for TMCs.*** The operators of HRSTC currently perform relatively little operational planning; based on the Evaluation Team's experience in other areas, this is very common, but there is slow movement toward engaging in these activities. HRSTC operators are active users of the real-time data available at the TMC, but their viewpoint, when asked about their use of the archives was that the archives are a study tool and that their mission is to operate the freeway system. While at first glance this viewpoint appears to be short-sighted or uninformed, it is in fact a reasonable response given their current contractual relationship with VDOT which focuses on day-to-day operations and not planning for operations.
- ***HRPDC seems to be the group that performs evaluations and studies, but they play no active role in the day-to-day operation of the freeway system.*** Therefore, they do not currently have a direct interest in using performance analysis as a roadway management improvement tool. Instead, HRPDC is primarily concerned with conducting traditional planning studies and meeting the federally required reporting requirements. Given very limited resources, and their need to perform these traditional metropolitan planning organization (MPO) data reporting tasks, their interest in performing studies of operational improvements does not translate into active pursuit of detailed freeway performance reporting. They are interested, however, in using ADMS-derived data to augment their CMS (e.g., incident characteristics and delay), but the current CMS is still at a fairly high level rather than at a detailed operational level. HRPDC is also very interested in moving into the "Planning for Operations" mode, but like most MPOs they are struggling to determine exactly what functions they should be doing in this arena. HRPDC recognizes that data provided by the ADMS would help with many prospective applications possible under the "Planning for Operations" rubric.

- ***Integration of planning and operations functions will not only foster ADMS usage, but will require it to supply required data.*** Feedback should be established between the staff in charge of making day-to-day operational decisions and the staff responsible for performing 'studies' that could give direction as to how those day-to-day tasks (or regional policies) might be modified to achieve better operational performance. The effectiveness of operational procedures should be assessed periodically in order to adjust those procedures. An ADMS is the logical source of data for such activity. FHWA guidance on how to undertake "Planning for Operations" would be very helpful in this regard.

- ***Even with system availability and system performance concerns, ADMS Virginia stakeholders see a high potential for using the system in their applications.*** In Northern Virginia, system availability and the slowness of queries were the major impediments to usage during the evaluation period when the interviews were conducted. However, both these issues were addressed in Build 4.1 after the interviews were performed. The potential of the ADMS is not only recognized by end users but also by VDOT management, who are funding the maintenance and expansion of the system. The planners at HRPDC and the VDOT operators in Northern Virginia all expressed excitement at the ***potential*** of the ADMS, meaning that it may take a little time before that potential can be realized. This leads us to the observation that:

- ***It is likely that productive use of ADMS Virginia will have to wait for it become more fully populated with data and for users to gain experience with what the ADMS can do.*** In that sense, it may make sense to re-visit the evaluation in another 12 months to see what has changed.

- ***Traditional and operational planning – rather than real-time uses – will remain the predominant applications to be supported by ADMSs.*** Until an advanced real-time application that uses archived data is developed, tested, and imbedded into TMC software, the Evaluation Team believes that operational use of ADMSs will be restricted to operational planning. Such an advanced application may come in the form of short-term traffic forecasting, whereby historical information is used alone or in combination with real-time data. The Evaluation Team is aware of only one such application that is not in "research mode" – one of the traveler information components of the *iFlorida* model deployment initiative. However, it is clear that both operators and planners can effectively use an ADMS for planning and evaluation purposes, particularly as part of an ongoing program rather than a special study.

- ***Initial users of ADMS Virginia tend to be "power users".*** The most common queries submitted to ADMS Virginia were for downloads of traffic detector data rather than accessing the "built-in" functions. This may be indicative of the nature of the users – early adapters of new technology typically represent the most sophisticated user cohort, especially in the information technology arena.

- ***Travel time reliability is not currently a focus of ADMS Virginia functions, primarily due to the difficulty converting detector speeds to travel times.*** Although this concept is gaining acceptance among transportation professionals, ADMS Virginia currently does not have any built-in functions that compute reliability metrics, other than the standard deviation of detector speeds. Part of the problem noted by ADMS Virginia developers is the accuracy of transforming spot speeds from detectors to link-based travel times. Simple procedures for doing so exist and are in use in other parts of the country, but the accuracy of such conversions is largely unknown. In addition to the technical accuracy/usefulness of converting speeds to travel times, we believe that stakeholders did not identify reliability as a requirement they needed met. However, the data are present that would allow users to compute travel times using their own procedures, and then to compute reliability metrics from these, if so desired in the future.

- ***Training of end users and internal marketing of an ADMS are needed to foster usage.*** The Evaluation Team found that users experienced a small learning curve when trying to use the system. Some level of training – however small – can overcome this initial learning curve. Also, there did not appear to be an internal champion from a user's perspective for ADMS Virginia. The actual development of the ADMS did have strong advocates/champions, as evidenced by its advanced functionality and its success in deploying ahead of schedule and within budget. But there wasn't a clear champion pushing the potential ***uses*** of an ADMS such as performance measurement, ongoing evaluations, or other forms of operational planning. Securing support among the end users – with regard to what applications the ADMS can actually perform to enhance their job functions – is seen as a way to foster use of an ADMS.