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INVESTIGATION OF SYSTEM OPERATIONS PERFORMANCE MEASURES FOR THE VIRGINIA DEPARTMENT OF TRANSPORTATION

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Supplementary Notes

Abstract

The focus of the surface transportation community has been steadily shifting over the past decade, from one of capital construction and maintenance toward system operations. To support this new focus, new monitoring tools are necessary. The Virginia Department of Transportation's (VDOT's) System Operations Directorate needs to gauge system performance for planning and developing effective future operational systems and strategies.

The purpose of this research was to develop system operations performance measures for VDOT. To do so, the University of Virginia Center for Transportation Studies first identified four categories of measures: traffic, incidents, traveler information, and ITS device reliability. Then, specific measures were identified and developed for these categories. This research report presents these measures along with examples of their use within VDOT. All these measures were compiled into a prototype monthly statewide performance report. VDOT can use this performance report to guide its system operations program, allowing it to focus resources better on activities that best address VDOT's stated goals.

The researchers recommend that the product of this research, the *Virginia System Operations Performance Report* (Appendix A), be used within VDOT's System Operations Directorate to guide future activities. The performance measures provided by the performance report will enable continuous monitoring of VDOT's progress toward stated goals. To ensure that the report is stable and consistent, the report further recommends that VDOT's Information Technology Division maintain the production system developed to automate creation of the monthly reports and that its Operations & Security Division establish a position that is responsible for monitoring and expanding data sources used for performance measurement. This position (the so-called "data watchdog") will serve as the business user expert that interfaces with VDOT's Information Technology Division and all divisions within the directorate.

The benefits expected from this research are significant. Measuring performance is essential to monitoring the activities within the system operations program and determining where resources should be distributed to achieve the goals of the program. A monthly report, developed as a result of this research, will provide access to key performance measures. Such continuous reporting of these measures will help ensure that performance trends will be continuously scrutinized, resulting in improved mobility for all travelers on Virginia's roadways

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ABSTRACT

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INTRODUCTION

Recent years have brought significant changes to transportation agencies. In the past, most agencies, including the Virginia Department of Transportation (VDOT), have been primarily concerned with highway construction and maintenance. However, agencies are now placing a strong emphasis on system operations – actively managing the system in an effort to increase efficiency and improve safety. This has led to the need for meaningful, measurable system operations performance measures to use in guiding this area of activity. While some states have mature system operations performance measures, for example, the Washington Department of Transportation, most are currently struggling to identify appropriate measures and institute a program to collect the data needed to support the measures. When considering the breadth of goals and activities in system operations, along with the expansive scope of required data, it is clear that the development of system operations performance measures is a challenging task.

The University of Virginia's Center for Transportation Studies (UVA CTS) and VDOT have worked together over the past 1 ½ years to identify and develop a set of performance measures to guide VDOT's system operations program. This document describes this effort and presents the resulting, recommended system operations performance measures report. The report begins with a background on VDOT's system operations program. This is followed by a high-level description of the system operations performance report. This description addresses (1) the categories of measures that have been identified as needed to support the program, (2) details on the measures identified and developed to serve in each category, and (3) how the measures may be used to make decisions to guide VDOT's system operations program.

PURPOSE AND SCOPE

The purpose of this project was to identify and prototype system operations performance measures for utilization by VDOT. The project scope focused on relevant data streams currently collected and already available within the state of Virginia. Measures that required new data sources were beyond the scope of the research.

METHODS

It is important to note that in this research effort, UVA CTS worked closely with a VDOT steering committee established to guide development of system operations performance measures. The VDOT steering committee, chaired by Jeff Price, was comprised of the following: Larry Caldwell, Ken Earnest, Scott Cowherd, Mena Lockwood, and Michael Hibbard. The tasks below were conducted to meet the objective of the effort.

1. *Review Literature*: This activity included reviewing operations performance measures used or proposed by other transportation agencies, existing research and reports, and evaluating existing monitoring tools and measures.

2. *Extend, develop, and evaluate new measures and indices*: All new measures were developed considering the data available currently within the state of Virginia, and the usefulness of the measures. All the calculations, data quality issues, assumptions, and parameters have been documented, and provided to VDOT for implementation in a production environment.

3. *Develop Prototype System Operations Report*: Prototype concepts were developed for presenting and reporting the selected measures. Several intermediate prototype solutions were developed and shared with the steering committee for evaluation and feedback. The feedback was continually incorporated into the prototype reports, and evolved into the final proposed system operations monthly report.

RESULTS

Based on the methodology presented above, the research team, with the guidance of the VDOT project steering committee, developed a prototype system operations performance report. This section details the results of this effort.

VDOT System Operations Program

Recognizing the importance of system operations to the future of Virginia's transportation network, in 2004 VDOT created a new business focus – the operation of the highway system. This business focus stands along with construction and maintenance as VDOT's core functions. In 2005, the development of the first *System Operations Business Plan*

was complete – including both a mission statement and four primary goals. The stated mission is to "Actively manage the transportation system to maximize safety, security, mobility, and return on investment for the benefit of customers" (Sorrell, 2005). The System Operations goals (Sorrell, 2005) are to:

- Improve safety
- Improve highway operational performance
- Preserve the infrastructure
- Improve security.

In addition to the VDOT Central Office reorganization that took place as a result of the creation of the System Operations core function, a number of other organizational changes have also taken place. VDOT's field offices have traditionally been organized into nine geographic districts. Recognizing that system operations as a regional activity that crosses traditional district boundaries, VDOT has regionalized its operations functions into 5 regions. Each region is led by a regional operations director who is responsible for traffic engineering, traffic operations and management, and planning for system operations within the region. The 5 system operations regions in VDOT are Southwestern, Central, Eastern, Northwestern and Northern. These were established based on population centers of the state, major travel corridors, and system operations resources already in place.

Identification of System Operations Performance Categories

To begin the effort to identify and develop specific performance measures for system operations, the research team first identified four categories of performance measures: traffic, incidents, traveler information and Intelligent Transportation Systems (ITS) device reliability. These categories were identified based on an examination of significant VDOT activity in the system operations area, as well as a review of previous activity in the area of operations performance measures (Shaw, 2003). Each category is described in detail below.

Traffic

The traffic category is critical and was selected to directly address the second goal of the *System Operations Business Plan*, "Improve highway operational performance". Generally speaking, the measures in this category serve to assess the quality of travel (in terms of travel time, delay, throughput, and travel speeds), and also to measure traffic conditions on specialized facilities such as tunnels, bridges, ferries, and HOV lanes (Sorrell, 2005). The role of such measures in assessing highway performance is evident. For example, only if the current throughput and extent of the traffic delay and congestion are known can cost effective decisions be taken to reduce delay, increase reliability and improve the flow of traffic.

Incidents

The incidents category contains measures that address three goals of the *System Operations Business Plan*: "Improve safety," "Improve highway operational performance," and

"Improve security." Specific areas that can be monitored to measure safety are: number of fatalities, injuries, incidents, and especially crashes (Sorrell, 2005). Fatality and crash rates are already reported regularly by VDOT's Traffic Engineering Division; therefore these existing measures were not addressed in this research. The VDOT management steering committee and the research team decided to concentrate their efforts on incidents. Incident measures address both the safety goal, as well as the highway performance goal (by measuring the quantity of traffic served during incident conditions based on the level of capacity reduction). The first challenge was to agree upon a clear definition for an incident that would be used statewide in order to make the results consistent and more relevant at the state level. VDOT's Incident Management Committee has recommended defining an incident as *"an unexpected event that adversely impacts traffic flow"* and defining the duration of an incident as the time elapsed between first notification until all lanes have been cleared. These are the target definitions for incidents and incident duration, but currently data to support these definitions do not exist for all the areas of the state. The VDOT Incident Management Committee, realizing this fact, recommended allowing each region to move from their current incident and incident duration definitions to the desired definition mentioned above in stages.

Traveler Information

The traveler information category was identified to measure VDOT's ability to better inform travelers, enabling them to make better route and travel time decisions. This helps to accomplish the second and third goals of the *System Operations Business Plan*: "Improve highway operational performance" and "Improve security" (Sorrell, 2005). VDOT uses several technologies to disseminate information to travelers: CMS (changeable message signs), 511 (phone system and website), and public access CCTV (closed-circuit television) cameras. All of the metrics in this category are intended to show how VDOT is currently using these assets, and to quantify the number of people making use of these resources. By analyzing these results, VDOT professionals can recognize the system status of underutilization of existing resources as well as the need for additional resources.

ITS Device Reliability

VDOT owns and operates an extensive set of ITS infrastructure used in day-to-day system operations: traffic detectors, controllers, cabinets, CMSs, CCTV cameras, Reversible Highway Occupancy Vehicle (RHOV) gates, computer hardware and software in the STCs (Smart Traffic Centers – VDOT's transportation management systems), and field telecommunication systems. Given the diversity and large number of devices, keeping track of their availability/reliability, maintenance status and usage level is a daunting task. In cooperation with an asset management program, the performance measures steering committee established the ITS Device Reliability category to present easy-to-understand metrics on the availability of these resources. The information can be readily used to see how well the devices perform, how well VDOT maintains the resources, and also for maintenance scheduling and replacement cycles. These measures are primarily internal to VDOT and used to track maintenance and usage of available resources. These measures tie in the second goal set forth in the *System Operations Business Plan* "Preserve the infrastructure" by ensuring that the required data are available for performance-based monitoring of the system and related infrastructure.

Based on the categories identified and described above, the research team set out to identify and develop specific measures for each, all of which are explained in more detail in the next section.

System Operations Performance Measures

This section details the system operations performance measures identified for inclusion in the performance report. We present all measures, grouped in the categories described above, stressing the new measures that were designed and developed as part of this research effort.

Traffic Measures

Two traffic measures were identified: speed index (SI), which is a measure of the quality of traffic flow, and throughput, which is a measure of the quantity of traffic flow.

While SI is the result of previous research that was published by Evanchik, et al. (2006), this is the first time this measure has been implemented on a statewide level. The speed index as defined for this use is calculated from the data obtained from the continuous count stations (CCS), installed throughout the state, as the ratio of the observed speed to the baseline speed over a month for an operations region. The CCS stations are part of the Traffic Monitoring System (TMS) program and are polled for speed and volume data every 15 minutes.

While the concept is simple, the algorithm used to compute the monthly speed index is rather involved. The observed speed is the average speed at a CCS during a 15-minute data collection interval. The baseline speed is calculated by considering the 85^{th} percentile speed for each 15-minute interval of the year and selecting the 85^{th} percentile of those 85^{th} percentile speeds. This value is considered the speed at which vehicles tend to travel when not impeded by weather, traffic or other conditions. In most cases, 2003 was used as the year for calculating the baseline speed. The exception to this was when equipment or the facility was changed (for example by adding more lanes); then the earliest year with available data in current configuration was used.

The station SI is the observed speed divided by baseline speed and can be less than 1, equal to 1, or greater than 1. The regional aggregation value of the SI (spatial aggregation at the operations region level) is computed as a volume-weighted average of the station SI's from all road systems within the region. The statewide aggregation (spatial aggregation at state level) is computed as a volume-weighted average of the regional SI values. Figure 1 shows an example of a statewide speed index over a 13-month period. Both 24-hour and peak period SI values will be computed for interstate, primary, secondary, urban, and all (road) systems.

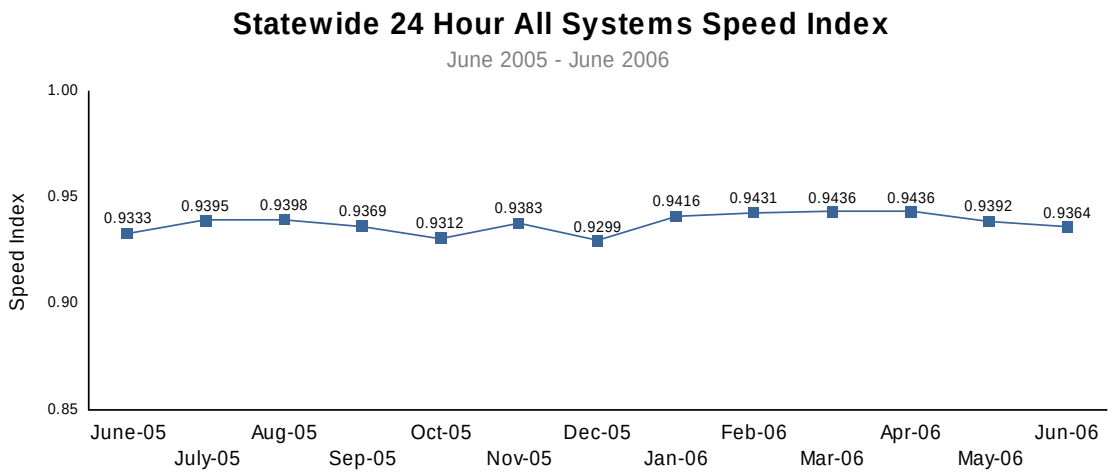


Figure 1: Statewide 24 Hour All Systems Speed Index

One will note the relatively high statewide SI values measured over the last year. This is due to several factors. First, by including 24 hour values, the SI increases because much of the data come from the middle of the night with very little traffic. The research team has addressed this by including SI values for only peak periods. In addition, the data source for statewide SI values is also a contributing factor. CCSs were intentionally installed in areas with very little congestion in order to allow for count data of higher accuracy. Therefore, the SI is likely somewhat biased. However, CCS provides the only source of consistent statewide data at this time. This illustrates a typical challenge a state may face in instituting statewide system operations performance measures.

The research team and the steering committee also acknowledge that SI is not the ideal measure to capture the variability of traffic conditions from the point of view of the traveler, but selected the measure because it can be calculated with available data and does provide an indication as to the levels of congestion by region. In its *System Operations Business Plan*, VDOT expresses its intention to collect and utilize travel time data (Sorrell, 2005), but at the time of this writing, such data were not available. Travel time and travel time reliability measures will be added to the performance report when the data become available.

The throughput measure is calculated as the average daily vehicle miles traveled (VMT) per region. The data sources for this measure are mainly CCSs and coverage count stations. Coverage count stations are locations at which a 48-hour count is conducted every three years. Data collected from these locations are adjusted by known seasonal and day-of-week factors.

As with speed index, the algorithm warrants a short explanation. The algorithm has several sequential steps. First, the link VMT is calculated as the number of vehicles traversing that link (monitored by a traffic count station) multiplied by the length of the link for polling period. The monthly link VMT is calculated as the sum of all the VMTs for that link for the month. The average daily link VMT (ADVMT) is the monthly link VMT divided by the number of days in the month. The ADVMT for a regional road system is the sum of the ADVMT for all the links from that road system. The regional throughput value is computed as the sum of

ADVMT for each road system. The statewide throughput is computed as the sum of ADVMT for each region. Figure 2 shows an example of 13-month statewide throughput trend.

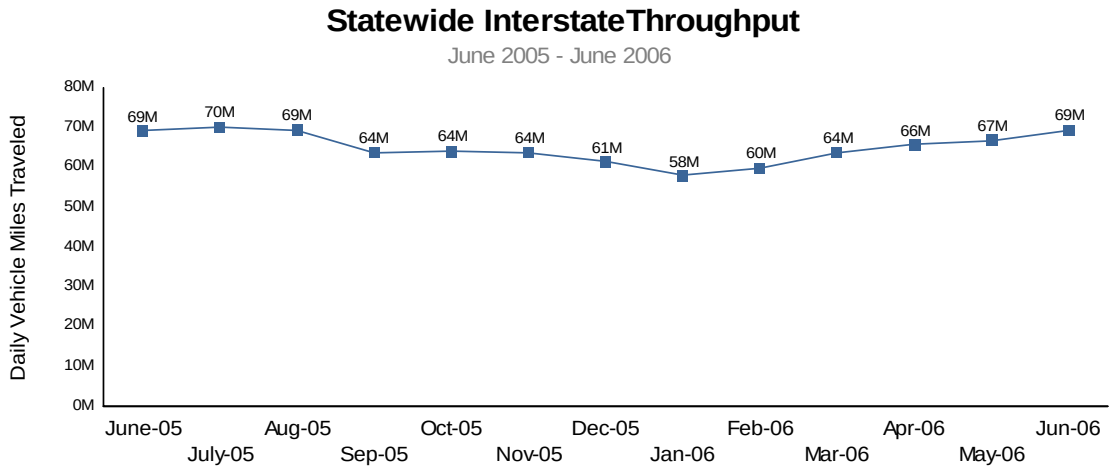


Figure 2: Statewide Interstate Throughput

One will note in Figure 2 that demand remains relatively constant over the year, with some clear seasonal variation (higher demand in summer months than winter months). This measure will be particularly useful to determine how VDOT accommodates any growth in demand over time in terms of congestion and incidents.

Incident Measures

The following metrics are reported for incidents: average and median incident duration, total number of incidents, and incidents by type. Data for all these were obtained from the current Virginia Operational Information System (VOIS), a system developed to coordinate incident management activities on a statewide basis.

Only non-recurring events that have a negative impact on the traffic were considered as incidents. As discussed before in the "System Operations Performance Measure Categories" section, VDOT is working towards implementing a consistent definition of incident duration that would accurately reflect the duration of time an unexpected event adversely impacts traffic flow. Until then, the definition that will be used is the duration of time between the moments the incident was entered in the system by a traffic operator until the incident was marked as closed by the operator. These two timestamps are automatically filled in by the incident management system software from the computer system time. This method has an obvious drawback: it is easy to envision, in the fast-paced, multi-tasking traffic operations center environment, a situation when an operator gets side-tracked from monitoring an incident by another task and, as a result, fails to mark the incident finished until sometime after it was actually completely cleared. This drawback and the rest of the inconsistencies in the incident reporting system will be eliminated within a year, as VOIS II, an upgrade to the existing system, is deployed statewide. Figures 3 and 4 show examples of regional average and median incident duration for June 2006.

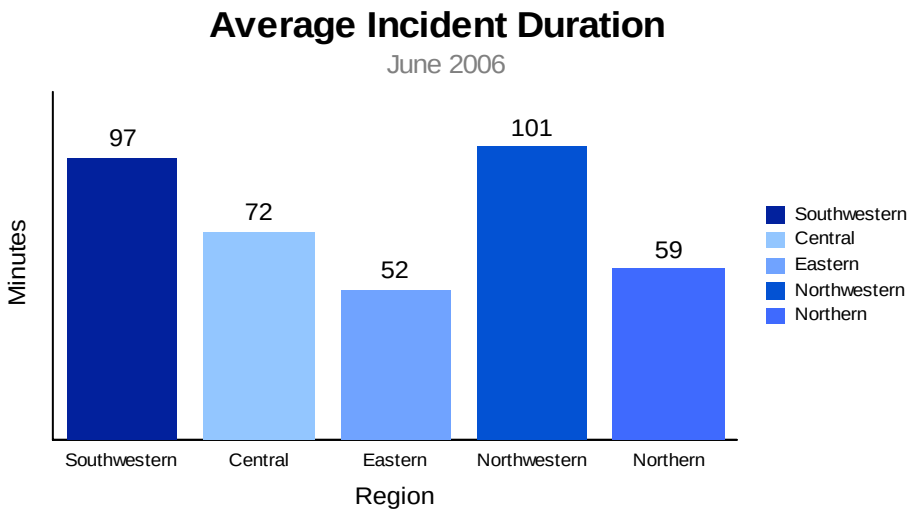


Figure 3: Average Incident Duration

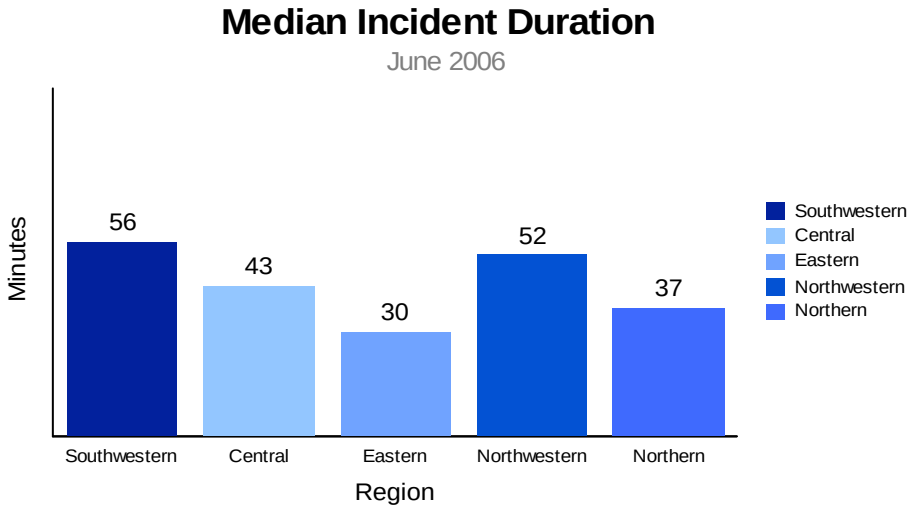


Figure 4: Median Incident Duration

Note the differences in average and median incident duration values for the same region. They are explained by a pattern of many short incidents and few longer incidents that is common to all Virginia's operations regions. Also note the significant variability by region evident in Figures 3 and 4. While some of this variation is due to incident management resources (the Eastern and Northern regions have active STC's and safety service patrols), much of the variation is due to an inconsistent definition of incident and differing approaches by region as to what incidents need to be reported. Tracking these measures will be critical in helping VDOT management identify discrepancies and create more consistent incident management policies on a statewide level.

The total number of incidents is also an important measure, and one that can be easily plotted together with the number of incidents by type statewide and for each region. For comparison purposes, a vertical bar chart showing the number of incidents among the 5 regions is included in the report. When entered in VOIS, each incident is assigned a type by the operator. Although these incident types follow a general pattern statewide, there are differences between regions that are due either to different STC operating procedures or to the different traffic patterns prevalent in their respective regions. Each STC can define and use their own incident types and there is no restriction on the number of incident types they can have. . This creates a challenge when attempting to consolidate incident information statewide. The research team therefore worked to create incident types that were significant at the state level and at the same time to make the charts clearer. As a result, some similar incident types were grouped together. Both absolute figures and percentages are reported for each incident type. Figure 5 exemplifies the break down by type of the incidents in the Central region for June 2006.

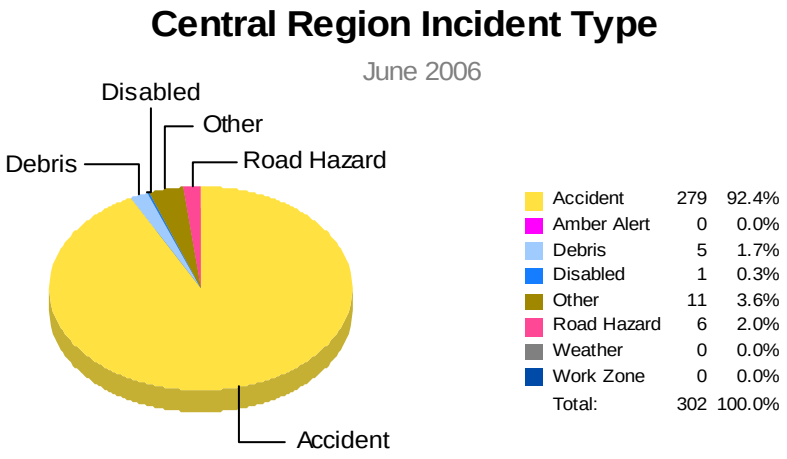


Figure 5: Central Region Incident Type

Traveler Information Measures

For each of the technologies used by VDOT to convey traffic information to the public, the research team developed a set of performance measures to quantify the number of travelers that were potentially impacted (viewed or heard the information) and the overall usage of the resources. These measures are described below.

CMS Messages

For CMS messages, the research team selected the same performance measures as used for incidents (average and median CMS message duration, total number of CMS messages, CMS messages by type), and also designed a new CMS message-specific measure, *CMS Exposure*, that will be explained shortly. The STC CMS logs are the data sources for these measures.

For the average and median CMS message duration, no real challenges were encountered, since the system can accurately record timestamps for the message start and end times. Because of the similarity with the incident duration, no example charts are provided for these measures. However, initial charts have revealed significant differences in durations by region. This again points to the need for VDOT to institute measures for more consistent use of these resources on a statewide basis.

Because none of the STCs assigns a type to the CMS messages they post on the signs, the CMS message types had to be derived from the logged message text itself. To group the CMS messages by type, the research team selected a list of keywords after a thorough analysis of available CMS message data over a long period of time (1 year) and wrote custom software to assign a unique type to each message by looking for keywords. Messages that cannot be assigned any type are flagged at the end and the user has to define new keywords to be able to group these last messages. Since the CMS message text is non-standard and free form, new future keywords are unpredictable and the binning done by the software is not always optimal. As a result, a manual check of the grouping of the CMS messages is performed at the end. Both absolute figures and percentages are reported for each CMS message type. Figure 6 exemplifies the June 2006 break-down of CMS messages by type for the Northwestern region.

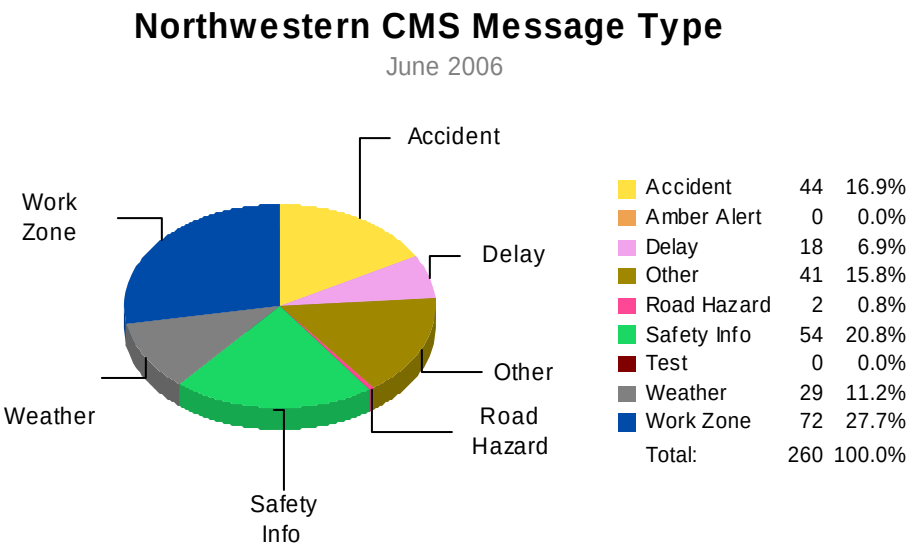


Figure 6: Northwestern Region CMS Message Type

Note that there is not necessarily a "right" split of CMS message types that VDOT management is aspiring to. However, by monitoring the ways in which CMSs are being used, VDOT will be able to determine if, for example, too many safety messages are being displayed that may dilute the effectiveness of the signs under incident/accident situations.

The new CMS message exposure measure attempts to quantify the impact that CMS signs have on the traveling public. If a vehicle travels past a CMS sign when the sign is active (a message is posted on that sign), that vehicle is counted as having been "exposed" to that message. The CMS exposure count is the sum of number of vehicles exposed to all messages posted on all CMS signs where traffic counts could be estimated from "nearby" count stations. A

traffic station is considered “nearby” to a CMS sign if it is not separated by a major interchange or more than one exit. Both upstream and downstream traffic stations are considered and, when both fit the above criteria, the closest one in distance is selected. Since the Central region is the only one for which both data sources needed for this measure, traffic logs and CMS logs, are currently available, the exposure count was calculated only in this area. Based on an analysis of “nearby” detectors, traffic at only 7 out of 14 CMSs from the Central region could be estimated in this way. Because of the small number of CMSs installed in the Central Region, it was feasible to do this matching manually. But the Eastern and Northern regions have roughly 200 CMS signs and 500 traffic stations each, thus a GIS-based method of doing the matching between CMS signs and traffic stations is desirable.

Besides the justified real-world practical interest that VDOT professionals have in this measure, the CMS message exposure is eliciting researchers’ interest because it combines two seemingly different data sources together to create a new value-added performance measure. Figure 7 presents CMS message exposure for the Central region for the month of May 2006.

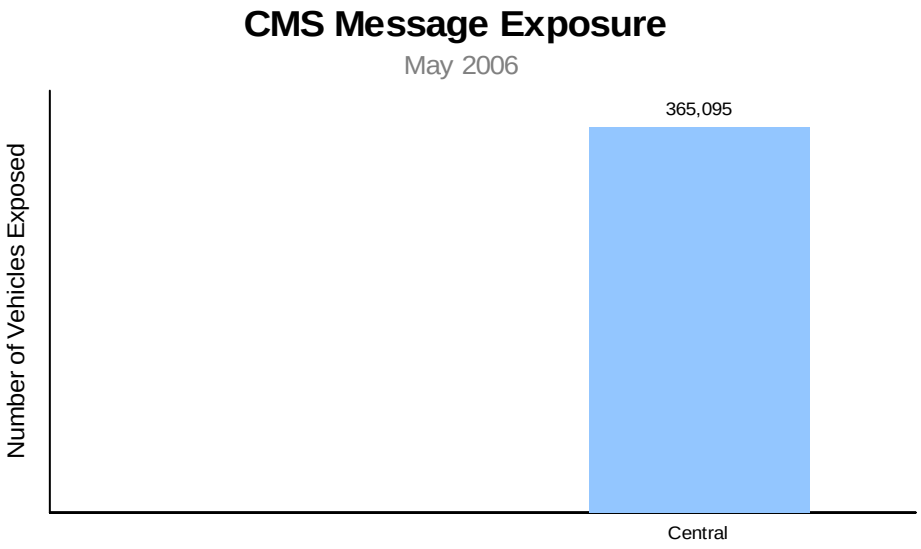


Figure 7: CMS Message Exposure

511 Phone Calls

There are two measures identified that relate to the Virginia 511 phone system, both straightforward: number of 511 phone calls received and 511 phone calls received by type. The data source for these measures is the 511 monthly reports made available by VDOT Operations and Security Division (OSD). The research team encountered no specific challenges for these measures. As an example, the 13-month trend for the calls received by the Virginia 511 phone system is presented in Figure 8.

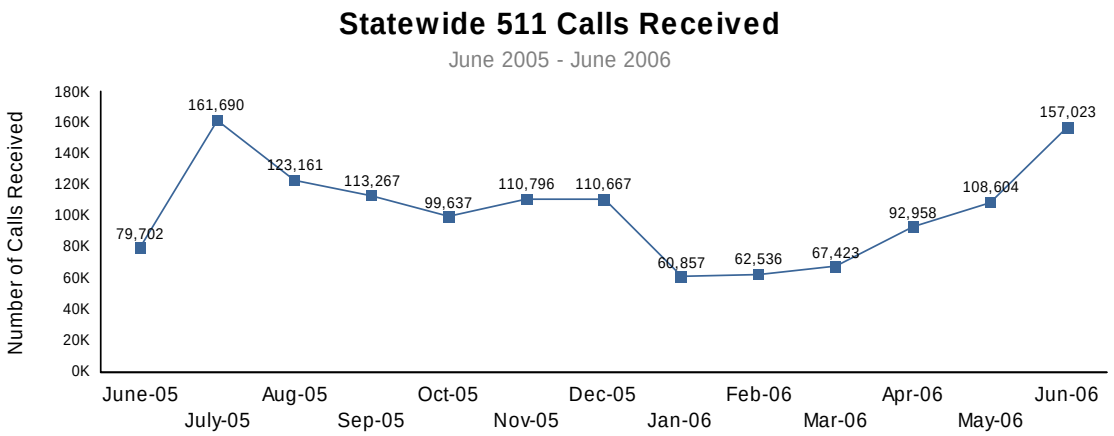


Figure 8: Statewide 511 Phone Calls Received

Figure 8 is particularly effective in showing how VDOT management will be able to use the trend plots in the report. While some seasonal variation is evident in the figure (as with the throughput plots before), note that call volume nearly doubled between June 2005 (nearly 80,000 calls) and June 2006 (over 157,000 calls). This illustrates the fact that this form of information provision is growing in importance.

511 Website Visits

Only one measure is reported for the 511 Virginia website utilization, number of web site visits per month statewide. The data for this measure are also compiled from the 511 monthly reports made available by VDOT OSD. The measure is very simple and similar to the one above, so no charts are included in this paper to exemplify it.

Public CCTV Usage

VDOT uses more than 300 CCTV cameras around the state to monitor traffic. VDOT makes video and still images from these cameras available on the Internet free of charge to the public to inform them of traffic conditions. For all the operations regions in Virginia, video and still images are available on the VDOT website and the TrafficLand (a VDOT contractor) website. Additional media portals disseminate the information in select regions of the state.

Two measures have been selected for inclusion in the report to reflect web viewing of the CCTV cameras: total number of web camera clicks and web camera clicks by portal. A click is registered anytime a user clicks on a camera icon from a map. The measures have been compiled using data from the TrafficLand monthly reports supplied by VDOT OSD. Figure 9 shows the pattern of web clicks by portal for each region. It can be seen that most of the CCTV camera web traffic is from the TrafficLand website.

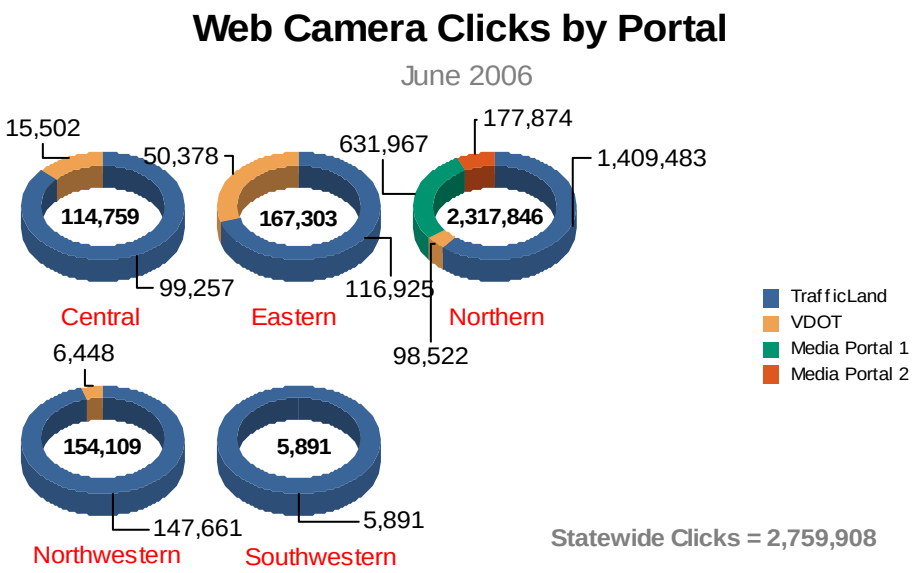


Figure 9: Web Camera Clicks by Portal

In examining Figure 9, it is clear that the vast majority of demand for video imagery is in the heavily congested Northern region. Roughly 84% of the statewide CCTV viewing was of Northern region cameras. This information will help VDOT make decisions in terms of new CCTV investment and in terms of "marketing" the availability of this resource in other regions of the state.

ITS Device Reliability Measures

The measures in this category give VDOT professionals feedback on how well VDOT as an organization is maintaining its core infrastructure for operations. As a start, three types of devices were selected at the suggestion of the VDOT Performance Measures Steering Committee: traffic detectors, CMS signs and CCTV cameras. The Steering Committee and VDOT upper management are interested in simple measures that convey how well these devices are performing. We will examine the reliability measures devised by the research team for each of them.

Traffic Detectors

For STC traffic detectors, the average active detector reliability and the number and percentage of active detectors are reported. Detector reliability is defined as the percentage of time a detector reports reasonable (or feasible) data. Data records from all traffic detectors are archived in a database at the same temporal aggregation level, which is the time difference between two consecutive records for the same detector. A traffic detector is said to report feasible data if the data pass a comprehensive set of data feasibility/quality assessments tests (for detailed information on the data feasibility/quality assessments tests, the reader is directed to Smith, et al. (2007). It is easy to calculate the total number of expected records per detector per month – it is equal to the number of aggregation intervals per day times the number of days in the month. For each detector, the percentage of time it reports feasible data is computed as the

percentage of the total number of feasible data records from the total number of expected records. The average percent of time detectors produced/reported feasible data is the average of the percentages just calculated. These calculations are performed only for active detectors. The designation of "active" is given by STC staff to those detectors that are known not to be milled, under construction or in any other way disabled or unavailable due to unavoidable reasons. As such, "active" detectors are expected to report feasible data.

The second measure, number and percentage of active detectors, is designed to be used by VDOT professionals in conjunction with the first measure to give an accurate idea of how many detectors are known not to be working for legitimate reasons.

As an example, in the month of May 2006, the team determined that one of the VDOT operations regions had 87% of its detectors reported as "active," with 69% of the data from these considered "reasonable." VDOT expects these measures to be very important to improving the quality of system operations. VDOT management is considering target values for detector reliability and availability to use in governing maintenance resource allocation. These measures are also important to help VDOT carefully consider where detectors are absolutely necessary – allowing for better "targeting" of scarce maintenance funds.

CCTV Cameras

The measure identified for average CCTV camera reliability is average percentage of time CCTV cameras produced quality imagery. Again, data for this measure have been obtained from the TrafficLand monthly reports supplied by VDOT OSD. The reports contain the percentage of time each camera produced a good quality image, so the aggregation was straightforward. The image quality is defined by TrafficLand in their monthly report. An example of CCTV camera reliability data by region is presented in Figure 10.

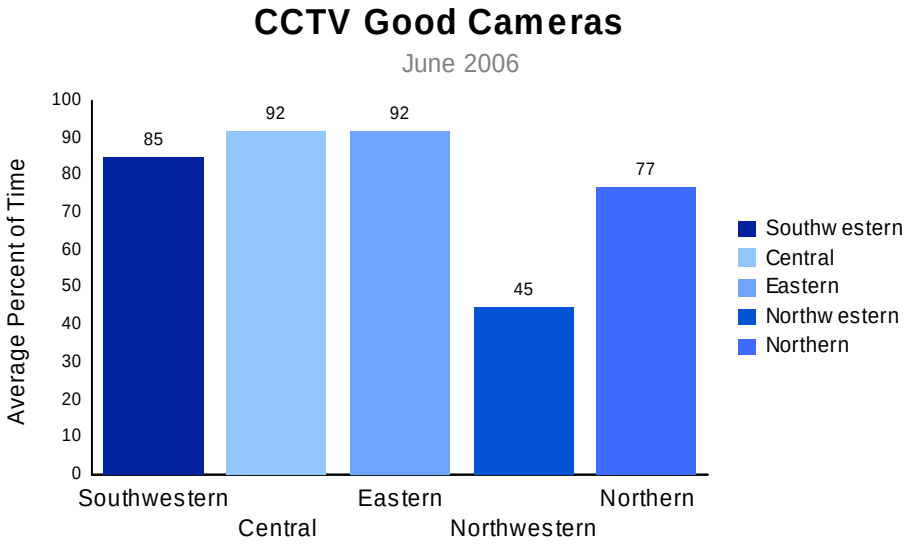


Figure 10: Average CCTV Camera Reliability

Figure 10 illustrates the value of regional data in the report. Clearly in this graph, there is a problem with CCTV reliability in the Northwestern region. This measure makes this quite clear and allows VDOT to identify the problem and take action.

CMSs

Currently, no "true" CMS reliability data are available from anywhere in the state of Virginia. To make up for this data source deficiency, the research team chose to use an average CMS usage measure instead, computed as the average number of days in the month CMS devices were used. A CMS device is considered to have been used in a day if at least one CMS message was posted on it during that day. As with the other CMS measures, the data sources used were STC CMS logs. Figure 11 gives the regional average CMS usage numbers for June 2006.

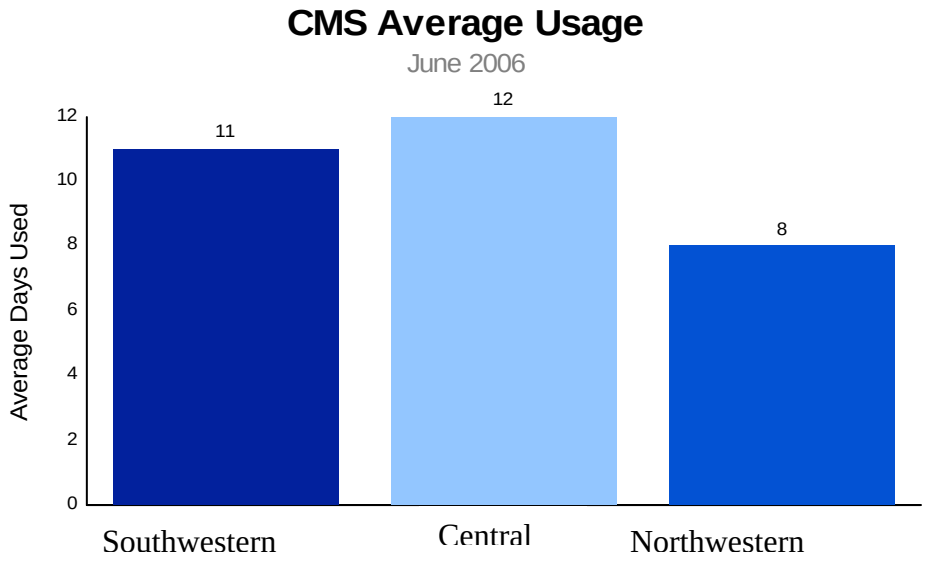


Figure 11: Average CMS Usage

Clearly, CMS Usage is not an ideal reliability measure. Considering Figure 11, it is unknown if the 18 days CMSs weren't used on average in the Central region were due to equipment malfunctions or a lack of information that needed to be communicated. However, this measure will be very useful in tracking how often signs are used on a statewide basis to determine if they are being utilized consistently.

Overview: Virginia System Operations Performance Report

The measures described in the preceding sections were compiled into a comprehensive report, referred to as the Virginia *System Operations Performance Report (Appendix A)*. While it is expected that some subset of measures will be published to the public in the future, the initial goal was to provide measures for VDOT management to use in making decisions regarding the system operations program. The research team and steering committee intends for the *Virginia System Operations Performance Report* to be published monthly, containing information

obtained from data up to and including the previous month. Throughout the *Virginia System Operations Performance Report*, data is presented at the operations region and state level spatial aggregations, and monthly level temporal aggregation. A sample of the report prototype is included in the appendix of this final report. The report has three sections and an appendix:

- The first section presents the highlights of the entire report. This step ensures that the most important information is readily available for senior management to use in making high-level decisions. Tailoring of this section by personnel in the VDOT system operations directorate will also ensure that the data and the performance measures are continually being evaluated by the most appropriate personnel, at the earliest time.

- The second section presents performance measures at the state level. This is intended primarily for use by upper VDOT management, such as the Chief of System Operations and her staff. It presents the statewide situation for the previous month for all the performance measures. In addition, this section reports 13-month trends to showcase performance in a particular area over the past year.

- The third section presents performance measures at the regional level. This is intended for VDOT Central Office managers and Regional Operations directors to let them see how the regions have performed in the previous month. A few important areas contain 13-month regional trends, but as a general rule, it was decided to only report the previous month's data in the regional section. Both the regional and statewide sections present the values for the measures in a user-friendly, graphical format that makes use of plots and charts and other visual elements in a simple and effective way.

- The appendix of the *Virginia System Operations Performance Report* contains measure definitions, data sources, and additional considerations (like aggregation methods, data quality definitions, data availability information, and incident and CMS message types used). This section is essential, allowing readers of the report to clarify their understanding of the measures and numbers reported in the first two sections. This appendix is revised every time there is a change in the data or in the algorithms.

The research team focused on performance measures that were not reported anywhere else by VDOT, thereby stressing the value of the *Virginia System Operations Performance Report* to the reader and eliminating effort duplication. More measures, such as travel times and travel reliability, utilization, return on investment, and HOV-specific measures, should be added as data becomes available for a significant area of the state and as the measures themselves are crystallized. Also, as data become available, the coverage area for current measures will be expanded to include all VDOT operations regions.

Development of Production-level *Virginia System Operations Performance Report*

The project resulted in a complete review of the systems operations performance measurement practices across the country and the development of a prototype statewide monthly report. New measures have been developed in full detail. Beginning in early 2007, the research team has worked with VDOT's Information Technology Division to automate creation of the report based on data in the operations data archive maintained by the division. An automated version is now available.

CONCLUSION

Measuring the performance of VDOT's system operations program requires a large quantity of data from a diverse set of sources. The results from this research project provide guidance for the development of a statewide system operations performance measurement program. The *Virginia System Operations Performance Report* will prove to be a useful tool for VDOT management and transportation professionals for assessing the quality of the service delivered by VDOT to its customers, for conducting internal performance reviews, and for finding areas of business improvement. Based on its utility, VDOT has already created a production-level system to derive performance measures and publish on an internal website on an ongoing basis.

RECOMMENDATIONS

1. *VDOT's System Operations Directorate should use the final product of this research, the Virginia System Operations Performance Report (Appendix A), to guide future activities.*

2. *VDOT's Information Technology Division should maintain the production system developed to automate creation of the monthly reports.*

3. *VDOT's Operations & Security Division should establish a position that is responsible for monitoring and expanding data sources used for performance measurement.* This position (the so-called "data watchdog") should serve as the business user expert that interfaces with the Information Technology Division and all divisions within the directorate.

COSTS AND BENEFITS ASSESSMENT

The performance measures, categories, and report format were developed under this project and do not require any modification by VDOT. To create the capability for automated production of the monthly report, VDOT ITD has already invested a 6-month effort from one employee (FTE) for the automation of the report. In addition, to maintain the entire archive and to manage the changes of the data sources, data models, etc., a new employee in the "data watchdog" position (see Recommendation 3) will be necessary.

The benefits expected from this research are significant. Measuring performance is essential to monitoring the activities within the system operations program and determining where resources should be distributed to achieve the goals of the program. A monthly report, developed as a result of this research, will provide access to key performance measures. Such continuous reporting of these measures will help ensure that performance trends will be continuously scrutinized, resulting in improved mobility for all travelers on Virginia's roadways.

ACKNOWLEDGMENTS

The authors acknowledge Steve Griffin and Jianhua Guo from the Center for Transportation Studies at the University of Virginia for creating the plots, graphs, and charts of the *Virginia System Operations Performance Report;* Ralph Jones from VDOT's Traffic Engineering Division for his work on implementing the speed index and throughput algorithms and producing the statewide and regional numbers for these two measures; and members of the VDOT steering committee for providing useful input throughout the life of the project.

REFERENCES

1. Sorrell, C.S. *VDOT System Operations Business Plan.* Virginia Department of Transportation, Richmond, 2005.

2. Smith, B.L., and Venkatanarayana, R. A New Methodology for Customizing Quality Assessment Techniques for Traffic Data Archives. In *Proceedings of the 2007 Annual Meeting of the Transportation Research Board.* Transportation Research Board, Washington, D.C., 2007.

3. Evanchik, D.M., Best, M.G., Smith, B.L., and Scherer, W.T. Speed Index: A Scaleable Operations Performance Measure Based on Available Data. In *Transportation Research Record 1956.* Transportation Research Board, Washington, D.C., 2006, pp. 14-20.

4. Shaw, T. *Performance Measures of Operational Effectiveness for Highway Segments and Systems.* NCHRP Synthesis 311. Transportation Research Board, Washington, D.C., 2003.

APPENDIX A

NOVEMBER 2006 VIRGINIA SYSTEM OPERATIONS PERFORMANCE REPORT

Virginia System Operations Performance Report

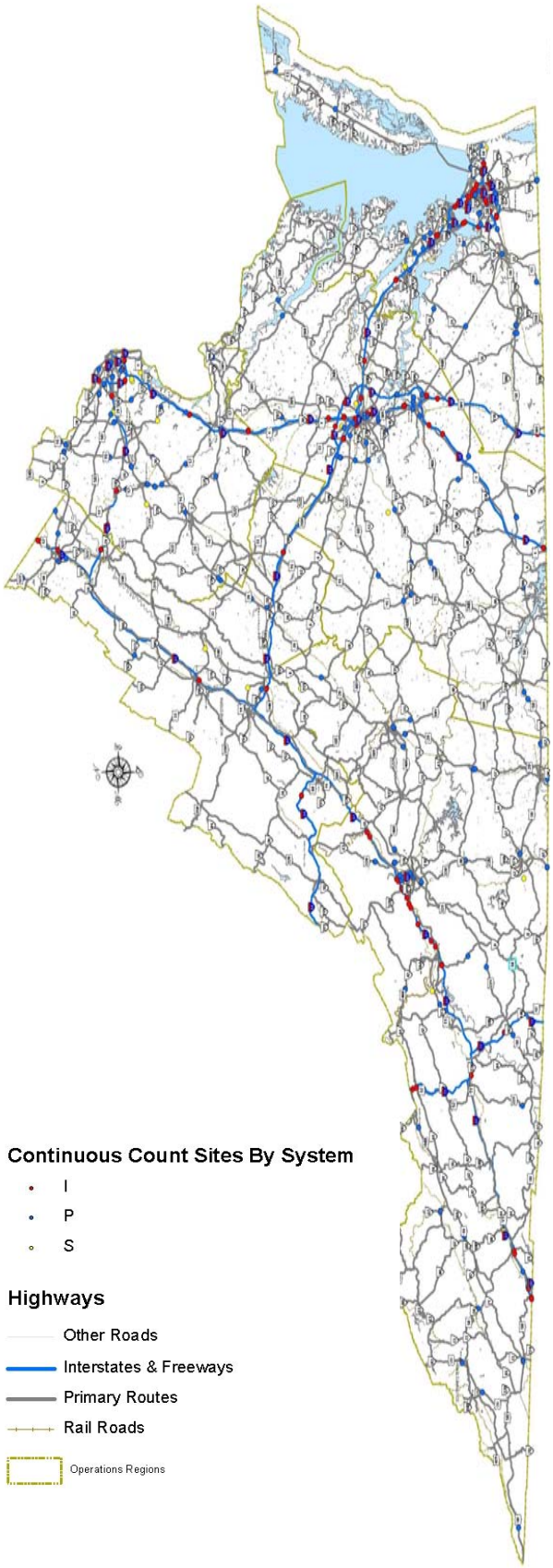
November 2006

Compiled by
Virginia Department of Transportation
University of Virginia – Smart Travel Laboratory

December 21, 2006

TABLE OF CONTENTS

Map of Continuous Count Stations



Highlights

Traffic

- The statewide speed index is fairly constant between 0.85 and 0.86 over the last 12 months. The throughput during the same time period suggests a yearly pattern, with more traffic in the summer months.
- Over the last year, all the regions exhibit similar trends of system throughputs. However, there are some differences in the regional speed index trends.

Incidents

- More than 50% of the incidents are "Disabled vehicles," per STC incident logs. Per VOIS data, Accidents represent nearly 85% of all the incidents. VOIS incidents add up to only about 25% of the incidents reported by the STCs.
- The STC incident logs and VOIS data display some regional differences in capturing different types of incidents.
- Further, the difference between the average incident duration and median duration is much smaller for the VOIS data than the STC data. It appears that the VOIS captures only the major incidents, compared to the STC incident logs.

Traveler Information

- At the statewide, the declining trend in the public usage of cameras nearly parallels the declining trend in the usage of 511 telephone system. In November, there was a sudden surge in the number of 511 calls.
- The 511 website visits stabilized around 29,000 clicks per month for 4 months in a row, before seeing a surge to nearly 47,000 clicks in November.
- As of October, camera usage in the Northern region alone has dropped gradually to less than half the volume in June 2006. The other regions do not show any such significant trends.
- Over the last one year, the trend of 511 calls received across the state closely follows the trend of the traffic throughput. This relationship may suggest that travelers are likely to call 511 and obtain information during travel. The relationship between the actual travel and 511 website visits is not as strong.

Device Reliability

- The average time of CMS messages continue to be larger than the median times. It seems that the CMSs are possibly being used more for larger, longer incidents than for the shorter ones.
- The percentage of active detectors has consistently been above 90% for several months. However, the quality of data has at most been 62% in the last 6 months.

STATEWIDE PERFORMANCE MEASURES

Performance Measure definitions and other metadata are available in Appendix A.

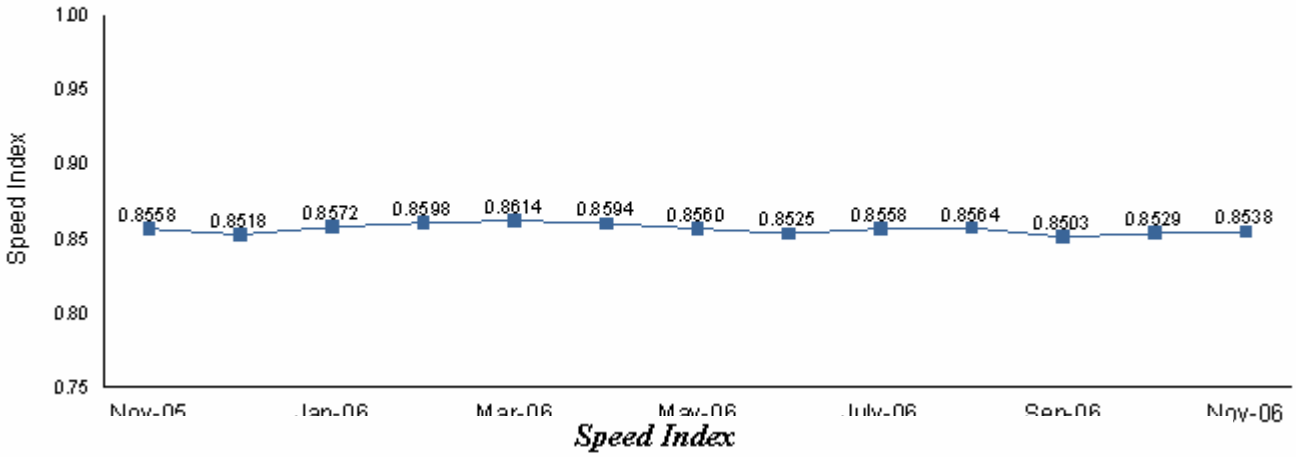
TRAFFIC

Speed Index

Data Source: TMS Continuous Count Stations
From VDOT TED

Note: June and July estimates have been revised.

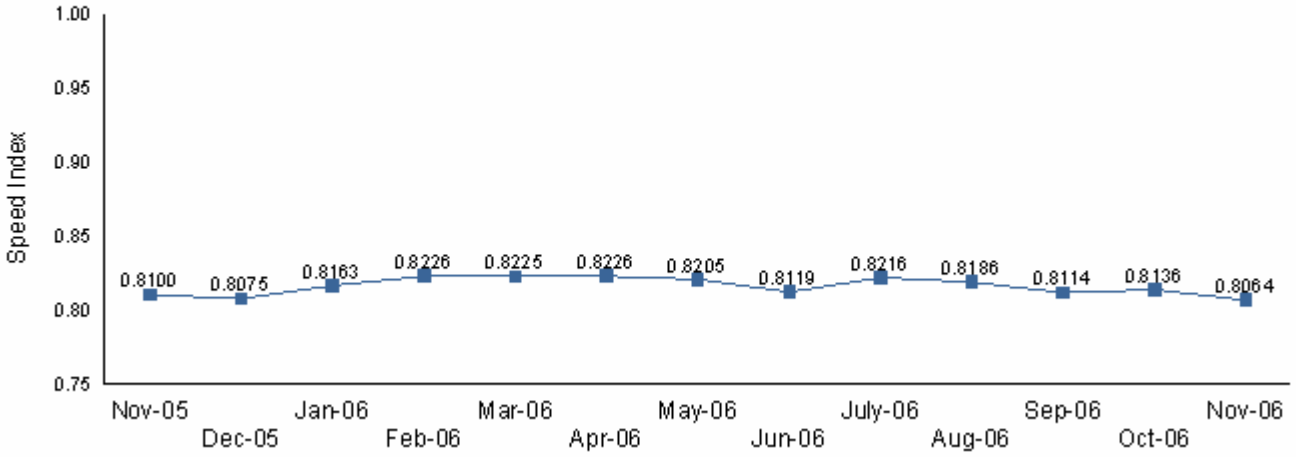
Statewide 24 Hour All Systems Speed Index



Data Source: TMS Continuous Count Stations
From VDOT TED

November 2006 Statewide Peak Hour All Systems Speed Index = 0.8064

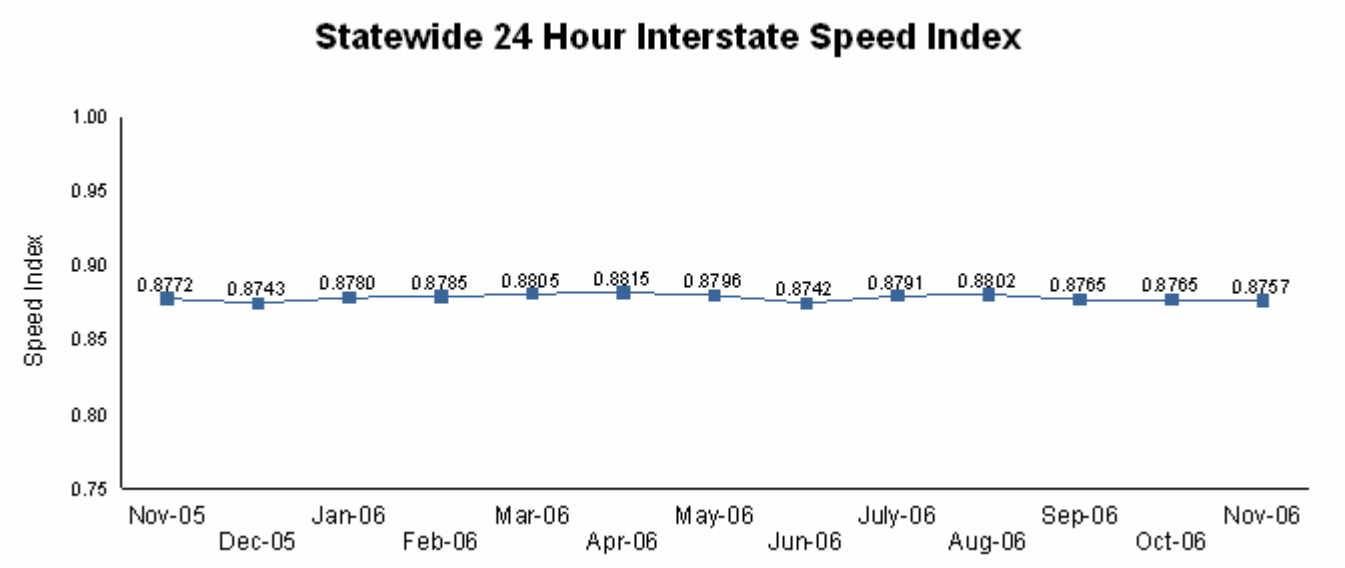
Statewide Peak Hour All Systems Speed Index



Speed Index

Data Source: TMS Continuous Count Stations
From VDOT TED

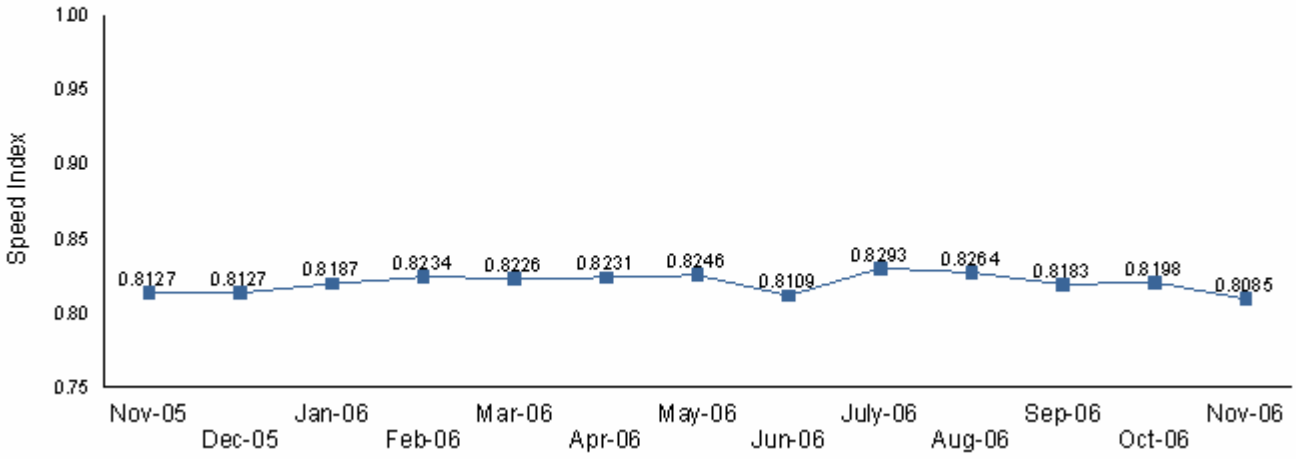
November 2006 Statewide 24 Hour Interstate Speed Index = 0.8757



Speed Index

Data Source: TMS Continuous Count Stations
From VDOT TED

November 2006 Statewide Peak Hour Interstate Speed Index = 0.8085



Speed Index

Data Source: TMS Continuous Count Stations
From VDOT TED

Tables

November 2006 Statewide 24 Hour Speed Index

System

Secondary	Primary	Interstate	Urban	All Systems
0.8353	0.8663	0.8757	0.8374	0.8538

November 2006 Statewide Peak Hour Speed Index

System

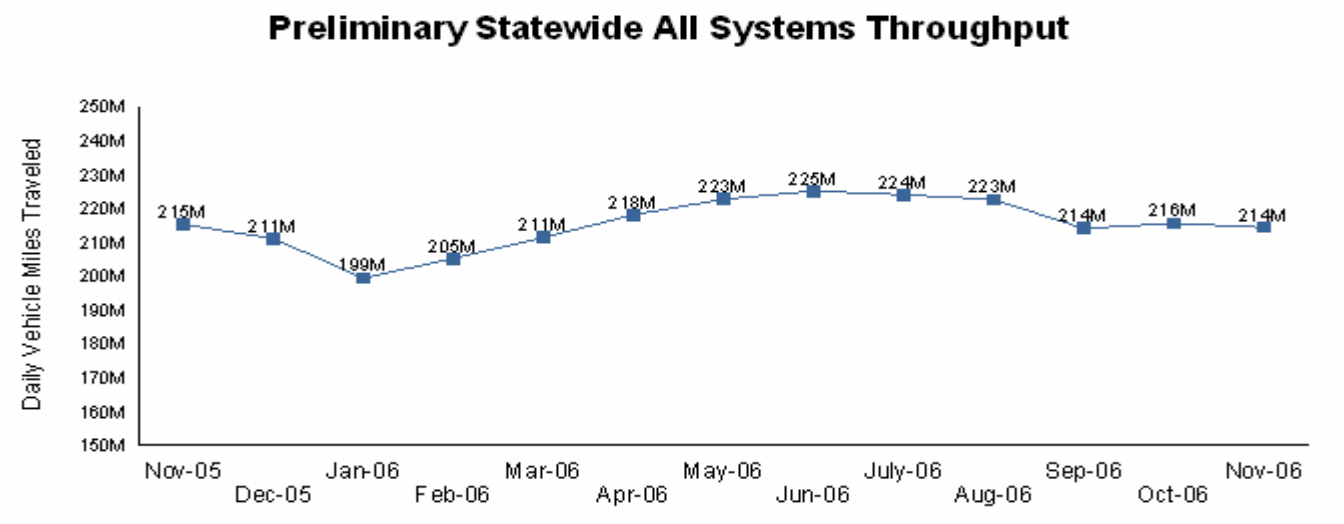
Secondary	Primary	Interstate	Urban	All Systems
0.8031	0.8208	0.8085	0.7963	0.8064

Throughput

Data Source: TMS Continuous Count Stations
From VDOT TED

Note 1: All Current year statewide throughput values are considered preliminary because they are based on monthly data and may differ from the final numbers that are obtained after an annual verification process. Previous year statewide values are not preliminary.
Note 2: June and July estimates have been revised.

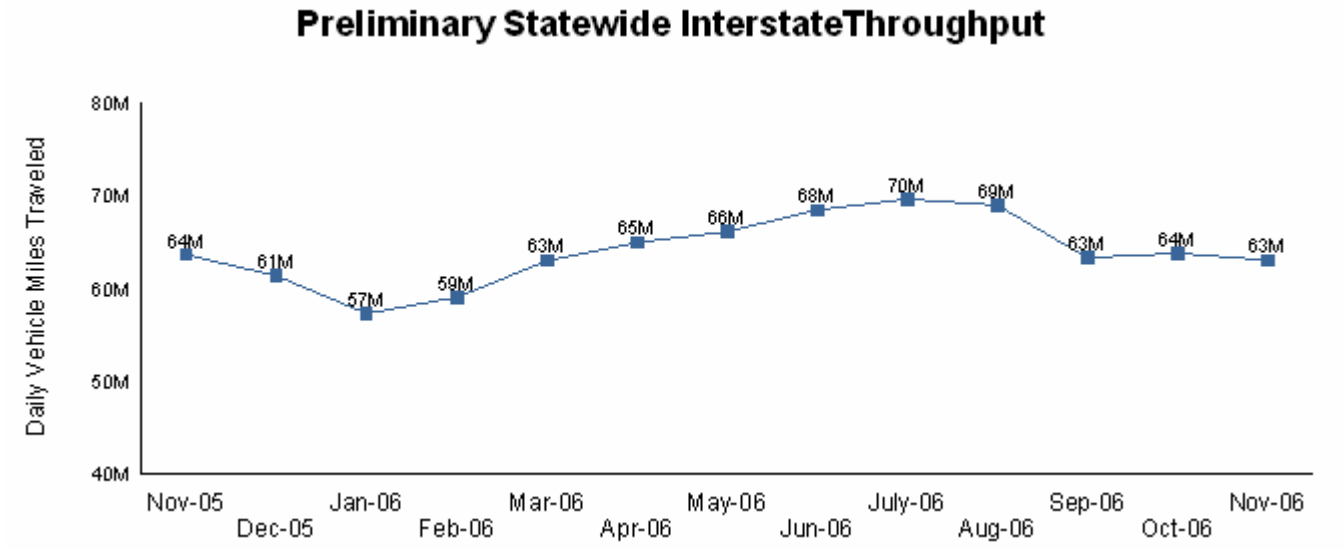
November 2006 All Systems Average Daily Vehicle Miles Traveled = 214,367,223



Throughput

Data Source: TMS Continuous Count Stations
From VDOT TED

November 2006 Interstate Average Daily Vehicle Miles Traveled = 63,057,074



Throughput

Data Source: TMS Continuous Count Stations
From VDOT TED

Tables

November 2006 Preliminary Statewide Average Daily Vehicle Miles Traveled

System				
Secondary	Primary	Interstate	Urban	All Systems
42,754,066	70,934,050	63,057,074	37,622,033	214,367,223

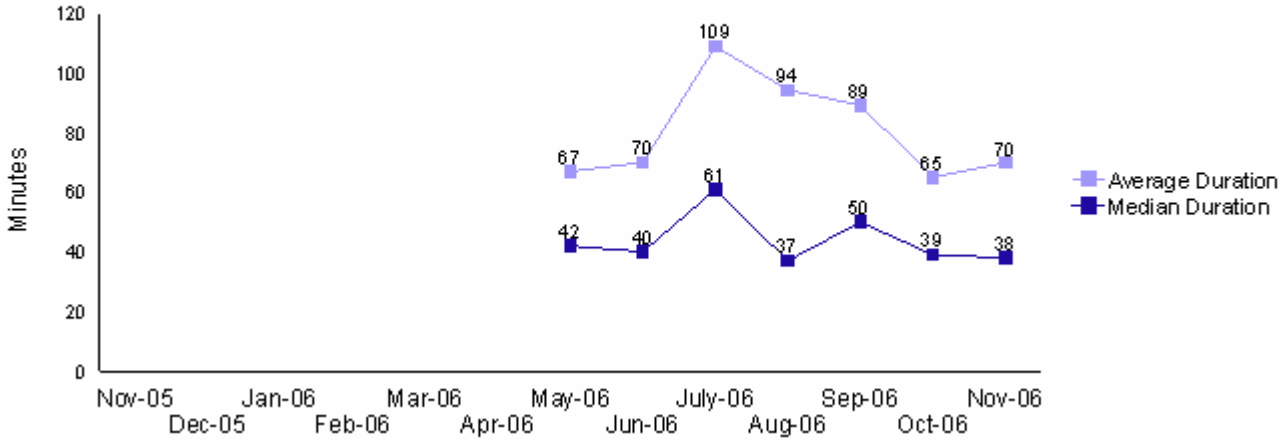
INCIDENTS

Incident Duration

Data Source: VOIS I Monthly Report
From VDOT OSD

November 2006 Statewide Average Incident Duration = 70 minutes
November 2006 Statewide Median Incident Duration = 38 minutes

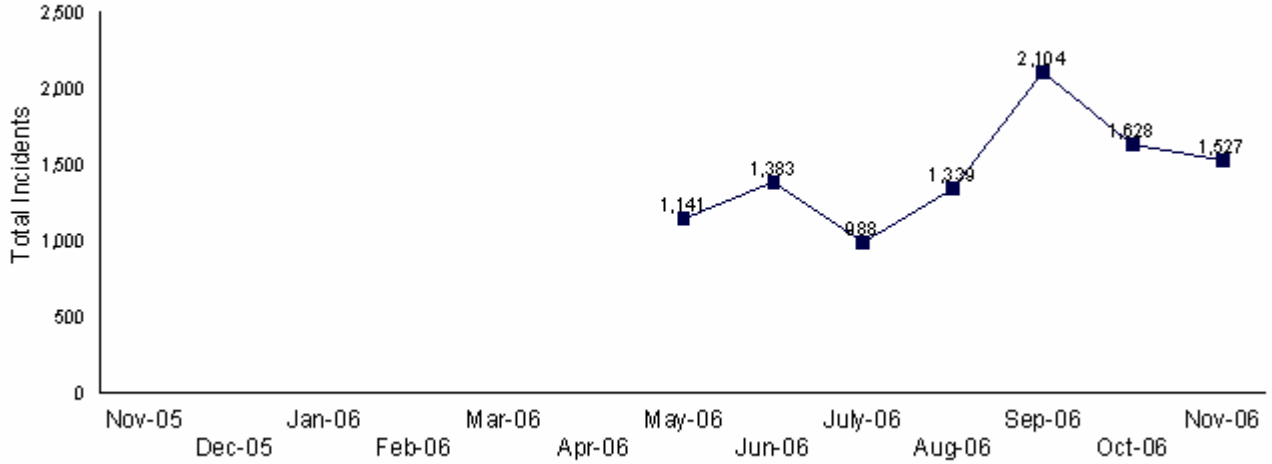
Statewide Average and Median Incident Duration



Total Incidents

Data Source: VOIS I Monthly Report
From VDOT OSD

StatewideTotal Incidents

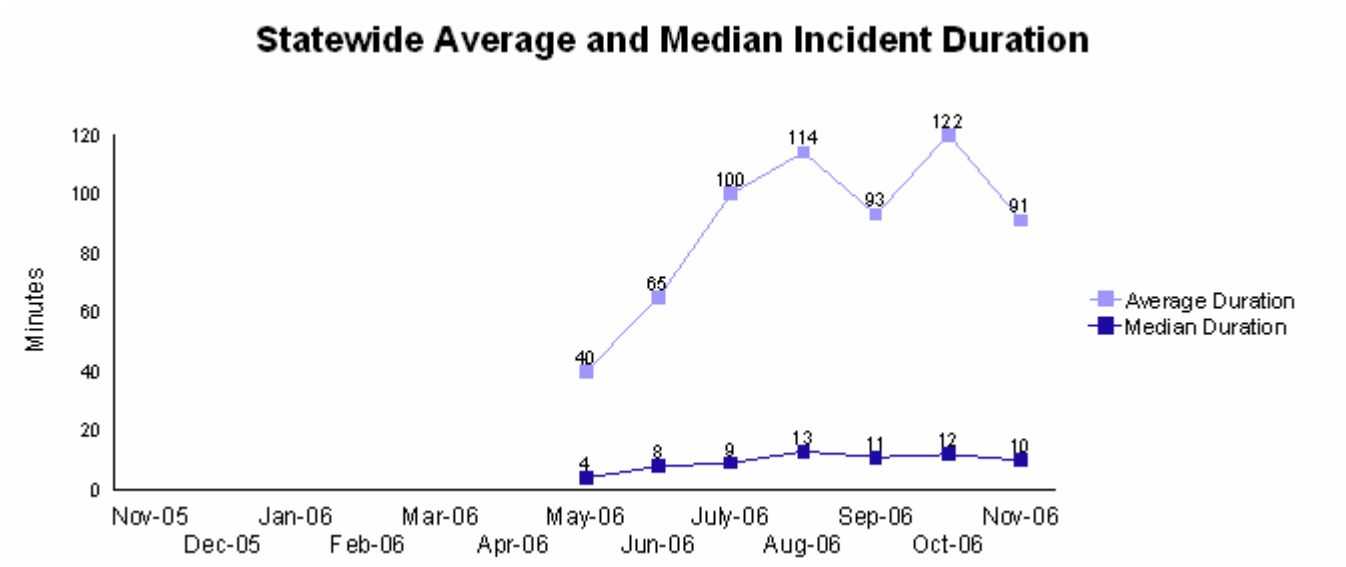


Incident Duration

Data Source: STC Incident Logs

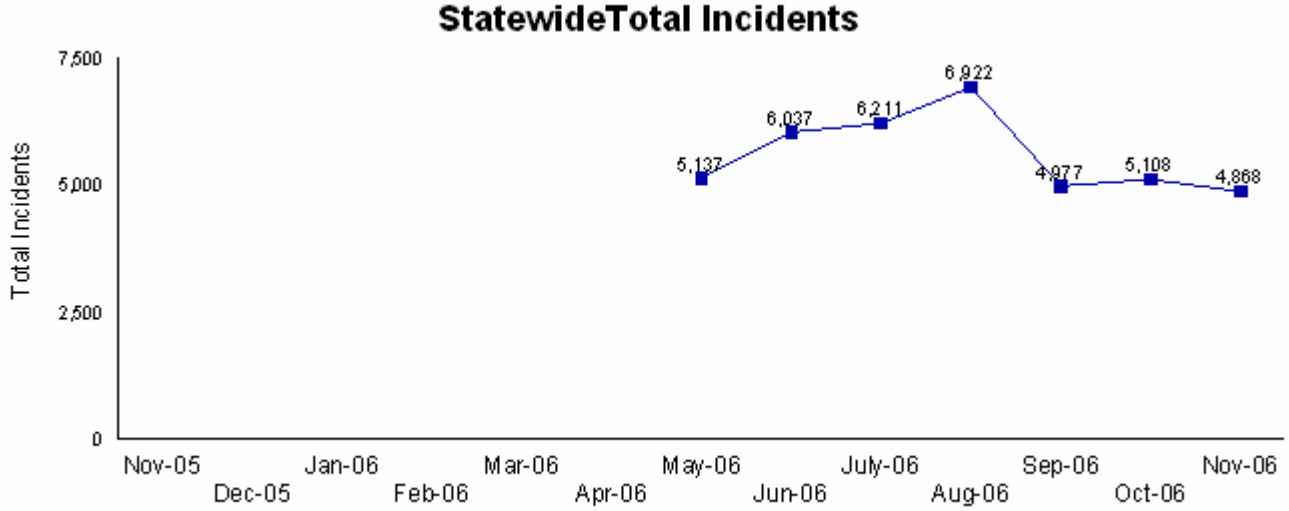
Note: September through November incidents reflect only Hampton Roads, Richmond and Staunton STCs

November 2006 Statewide Average Incident Duration = 91 minutes
November 2006 Statewide Median Incident Duration = 10 minutes



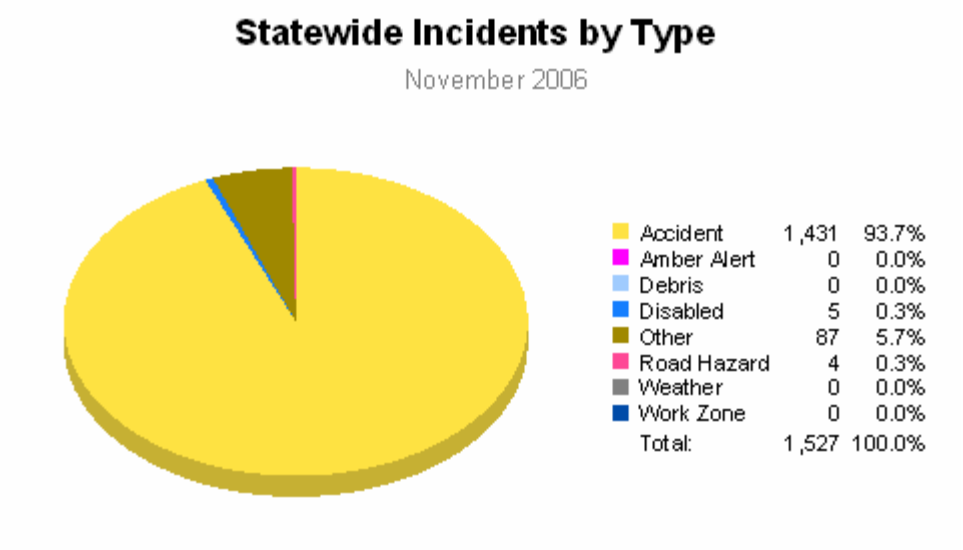
Total Incidents

Data Source: STC Incident Logs



Statewide Incidents

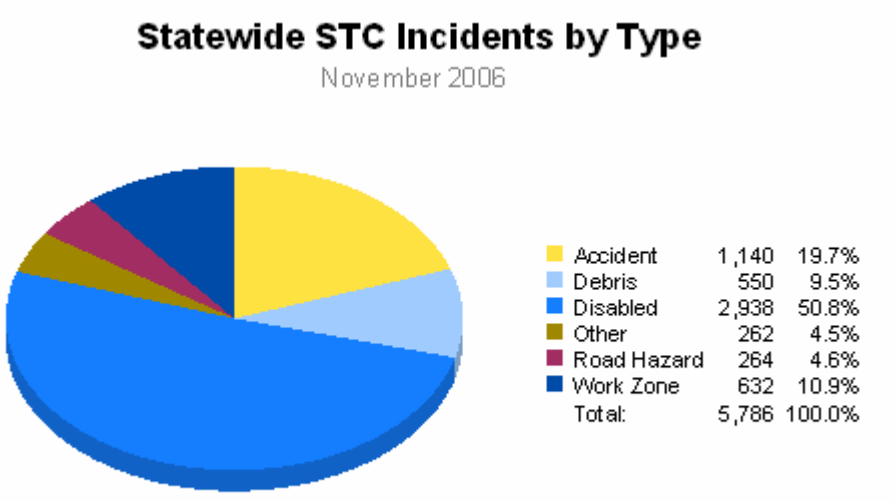
Data Source: VOIS I Monthly Report
From VDOT OSD



STC Statewide Incidents

Data Source: STC Incident Logs

Note: September through November incidents reflect only Hampton Roads, Richmond and Staunton STCs



TRAVELER INFORMATION

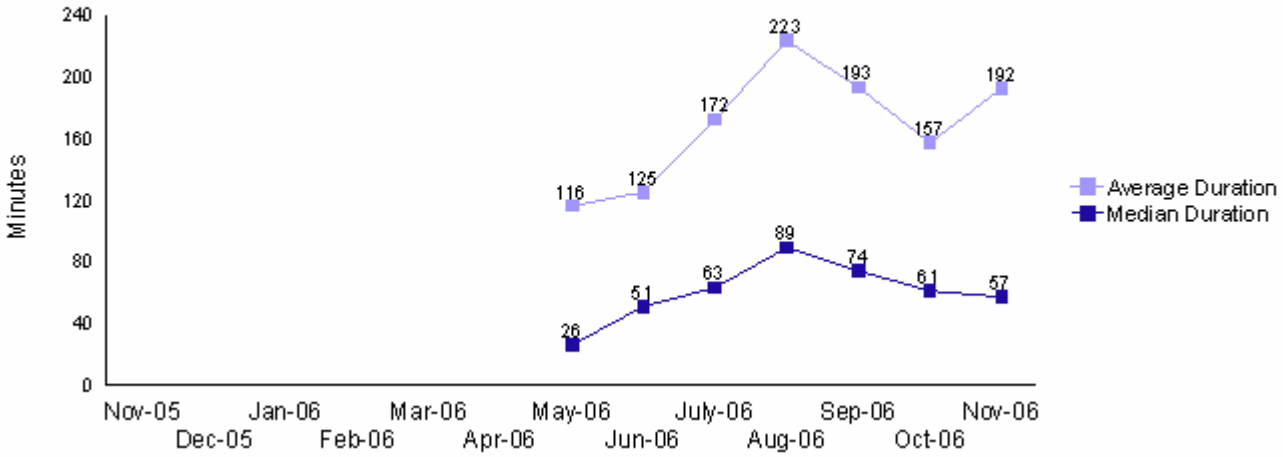
CMS Message Duration

Data Source: STC CMS Logs

Note 1: September through November CMSs reflect only Richmond and Staunton.
Note 2: No CMS data from HR STC available at the STL at this time.

November 2006 Statewide Average CMS Message Duration = 192 minutes
November 2006 Statewide Median CMS Message Duration = 57 minutes

Statewide Average and Median CMS Message Duration



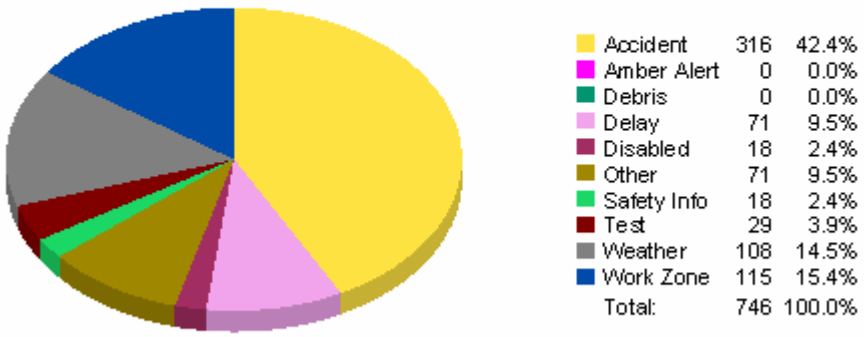
CMS Message Type

Data Source: STC CMS Logs

Note 1: Data reflects only Richmond and Staunton.
Note 2: No CMS data from HR STC available at the STL at this time.

Statewide CMS Messages by Type

November 2006



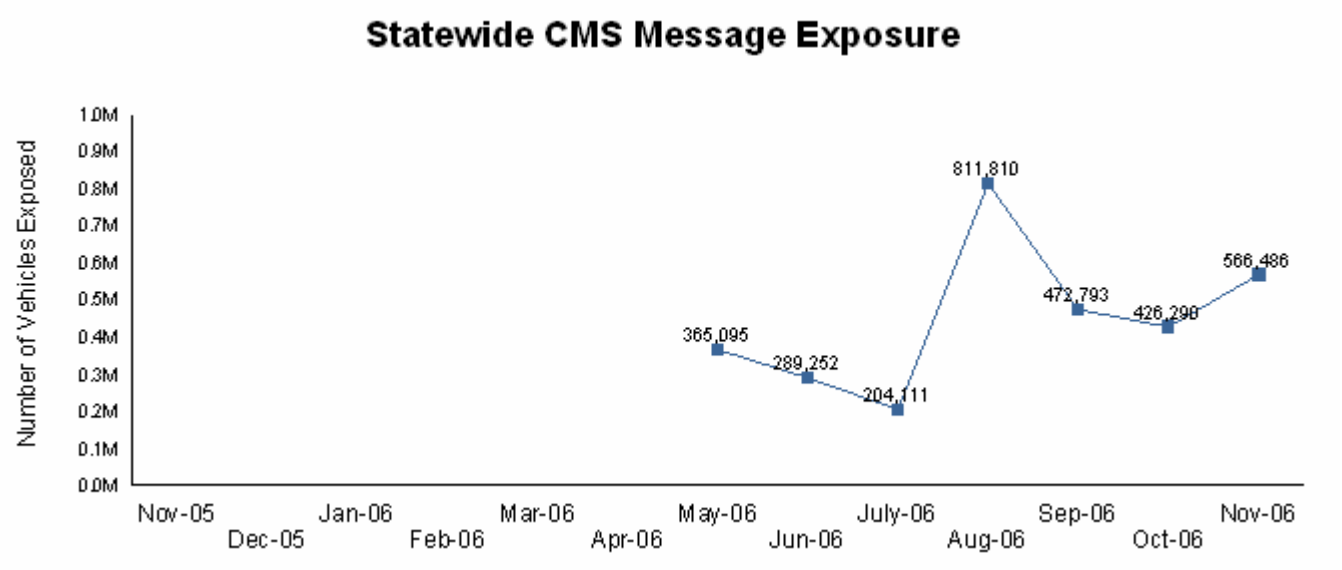
Accident	316	42.4%
Amber Alert	0	0.0%
Debris	0	0.0%
Delay	71	9.5%
Disabled	18	2.4%
Other	71	9.5%
Safety Info	18	2.4%
Test	29	3.9%
Weather	108	14.5%
Work Zone	115	15.4%
Total:	746	100.0%

CMS Message Exposure

Data Sources: STC CMS and Traffic Logs

Note: Data reflects only Richmond.

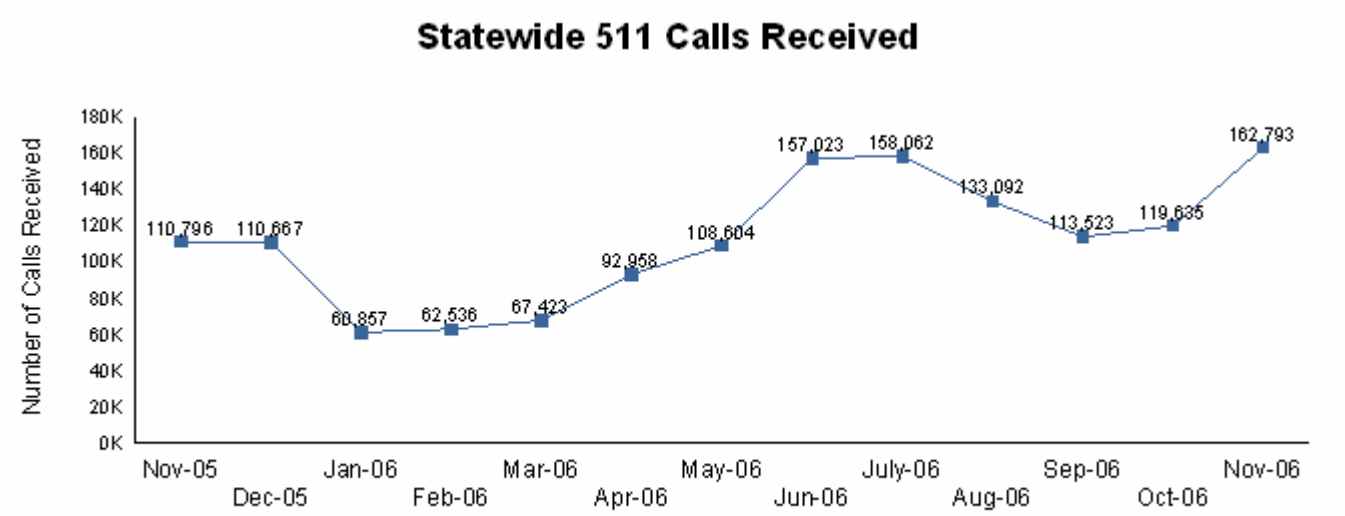
November 2006 Statewide Number of Vehicles Exposed to CMS Messages = 566,486



511 Phone

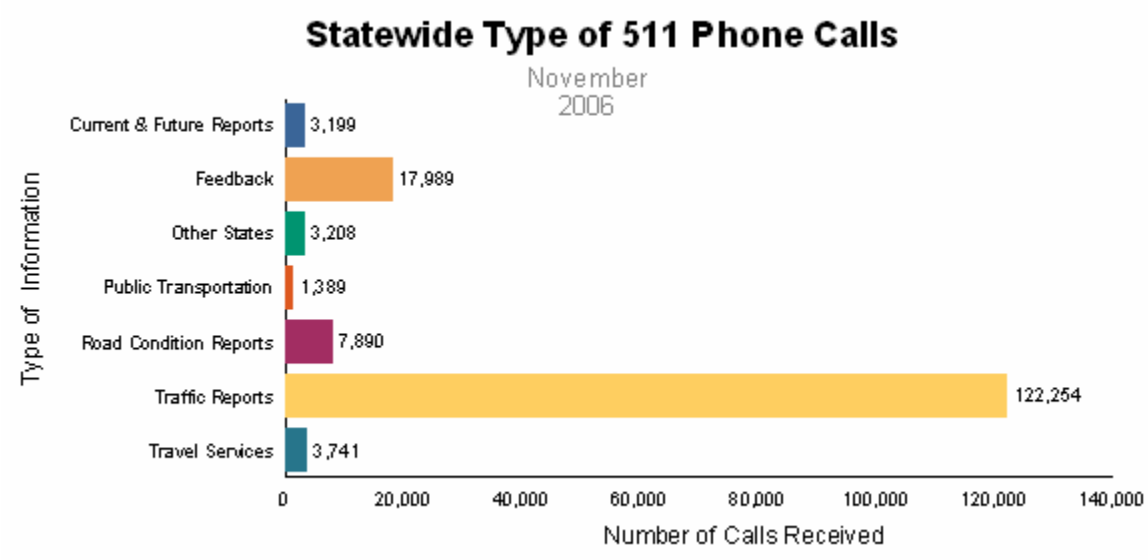
Data Source: 511 Monthly Report
From VDOT OSD

November 2006 Statewide Number of 511 Calls Received = 162,793



511 Phone

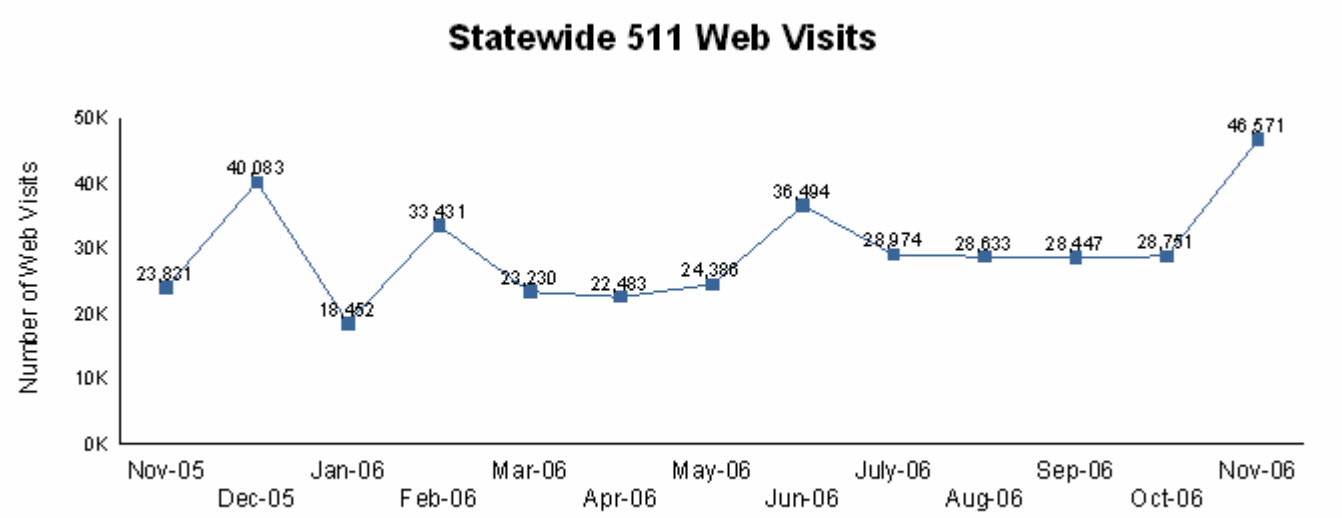
Data Source: 511 Monthly Report
From VDOT OSD



511 Web Site

Data Source: 511 Monthly Report
From VDOT OSD

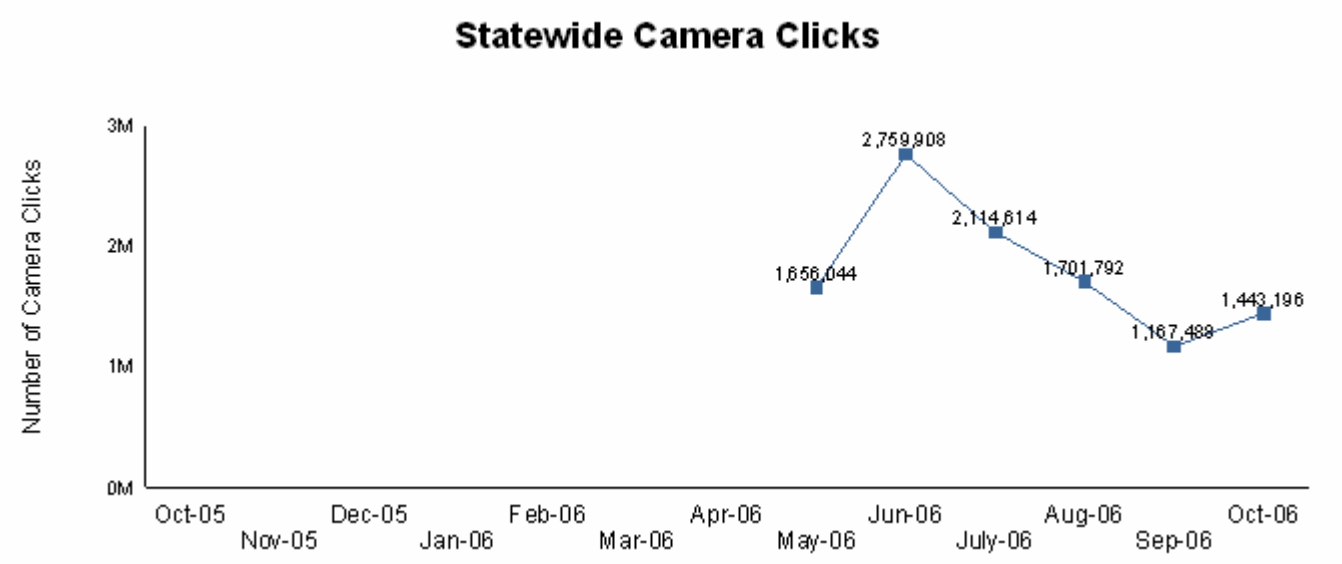
November 2006 Statewide Number of 511 Web Site Visits = 46,571



CCTV Usage

Data Source: TrafficLand Monthly Report
From VDOT OSD

Note 1: November camera data is not available in the STL as of the date of this report.
Note 2: The Northern Region includes two additional media portals.



ITS DEVICE RELIABILITY

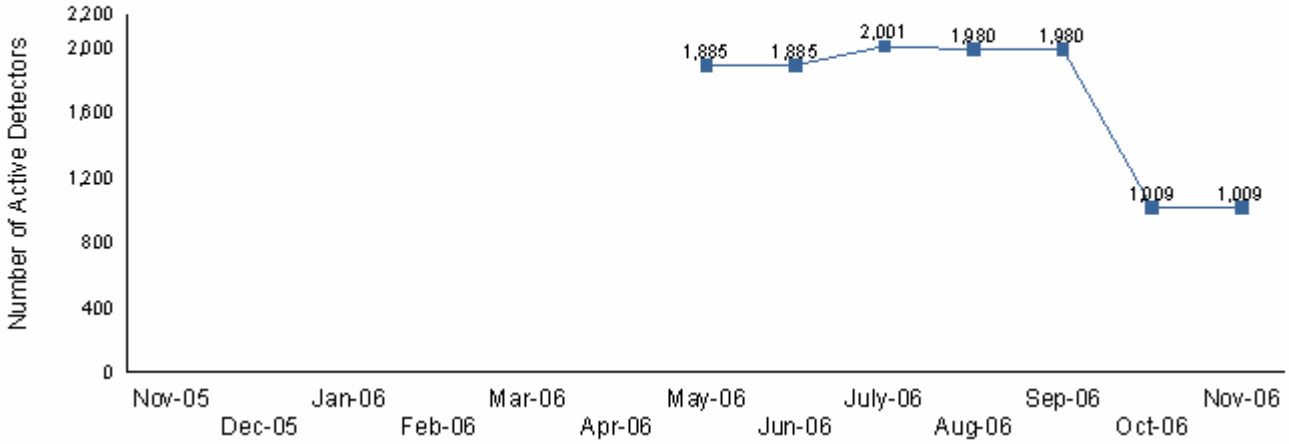
Detector Reliability

Data Source: STC Traffic Detector Information

Note 1: Only NOVA STC and HR STC detectors known to the Smart Travel Lab are used.
Note 2: For NOVA STC, no ramp metering detectors are included.
Note 3: No active detector information is available in the HR STC at this time; all HR detectors are assumed active.
Note 4: October and November data reflect only HR STC.

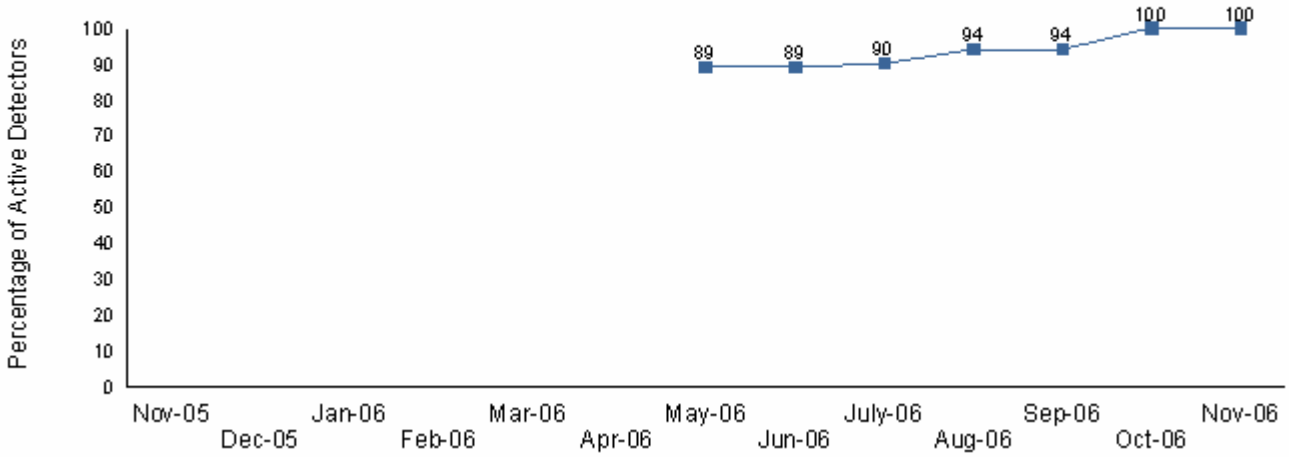
November 2006 Statewide Average Number of Active Detectors = 1009

Statewide Number of Active Detectors



November 2006 Statewide Average Percentage of Active Detectors = 100

Statewide Percentage of Active Detectors

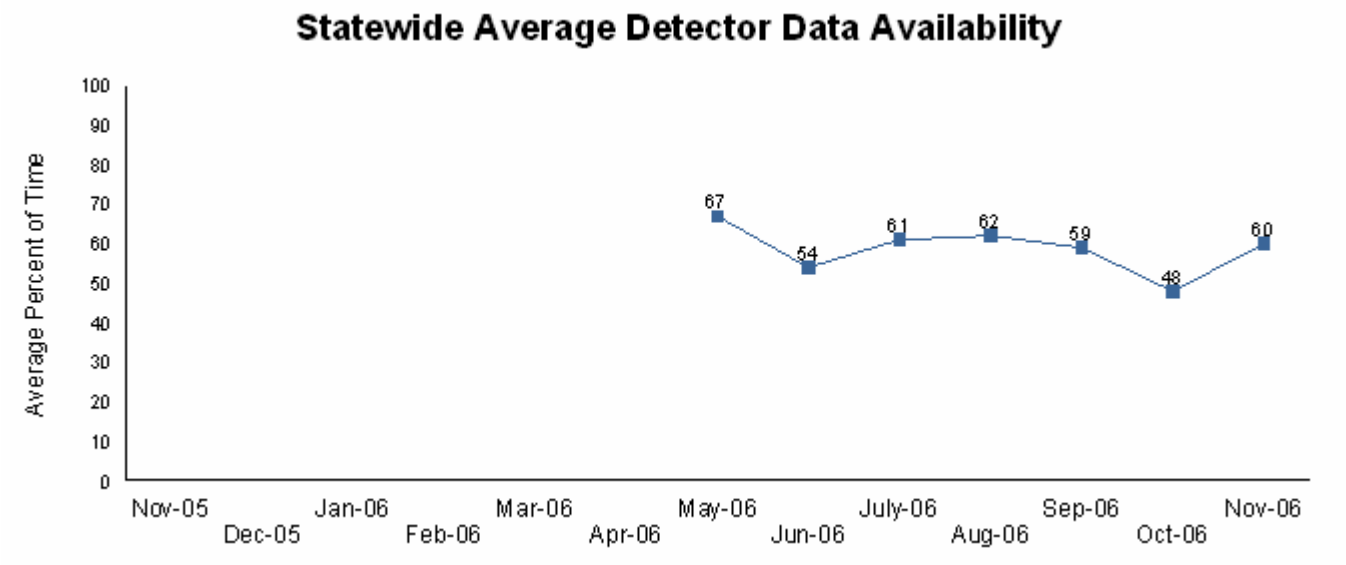


Detector Reliability

Data Sources: STC Traffic Logs, STC Active Detector Information and STL Traffic Data Reasonability Tests

Note 1: Only NOVA STC and HR STC detectors known to the Smart Travel Lab are used.
Note 2: For NOVA STC, no ramp metering detectors are included.
Note 3: HR STC Detector Reliability numbers are preliminary.
Note 4: October and November data reflect only HR STC.

November 2006 Statewide Average Percent of Time Detectors Gave Reasonable Data = 60 %

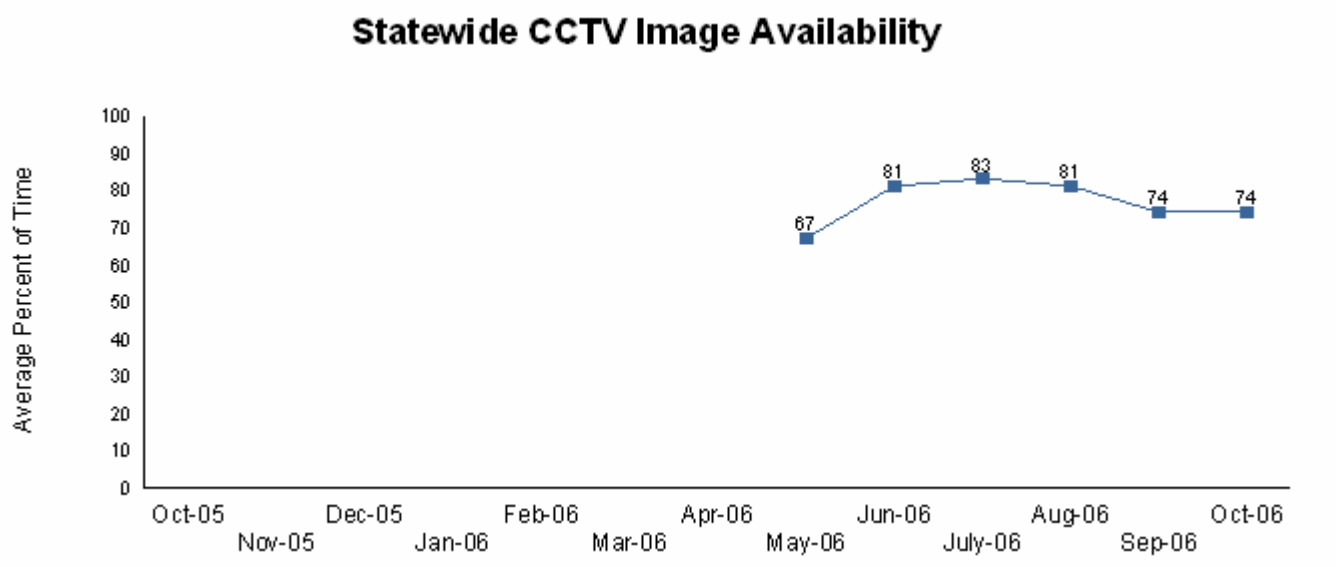


CCTV Reliability

Data Source: TrafficLand Monthly Report
From VDOT OSD

Note 1: November camera data is not available in the STL as of the date of this report.

October 2006 Statewide Average Percentage of Time Cameras Gave Good Images = 74

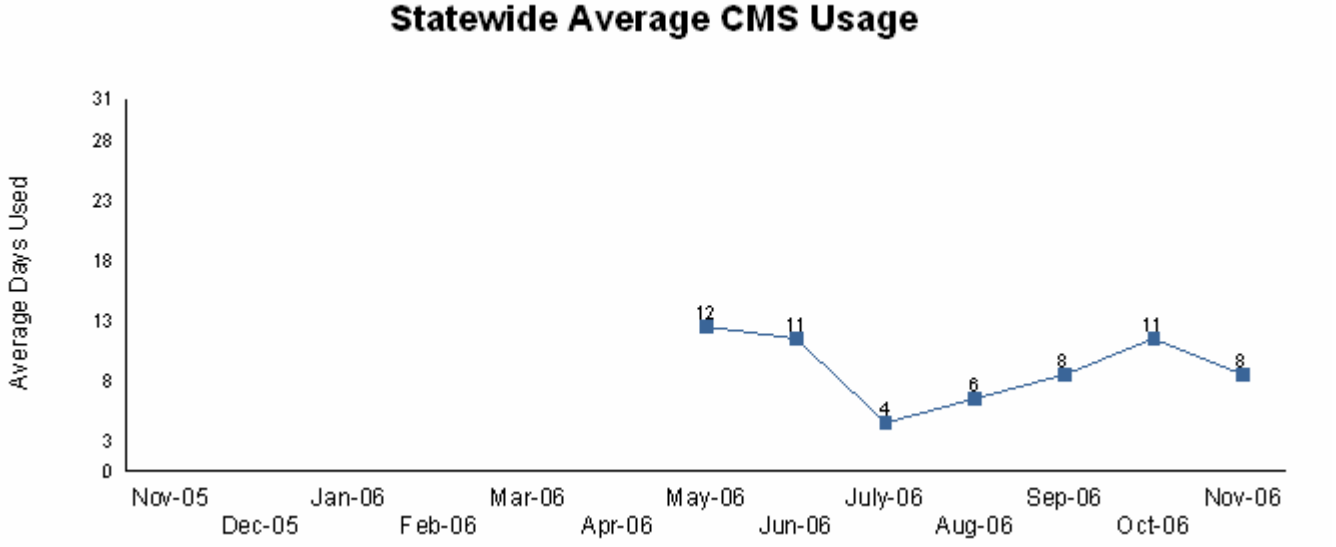


CMS Usage

Data Source: STC CMS Logs

Note 1: September through November CMSs reflect only Richmond and Staunton.
Note 2: No CMS data from HR STC available at the STL at this time.

November 2006 Statewide Average Number of Days CMSs Used = 8



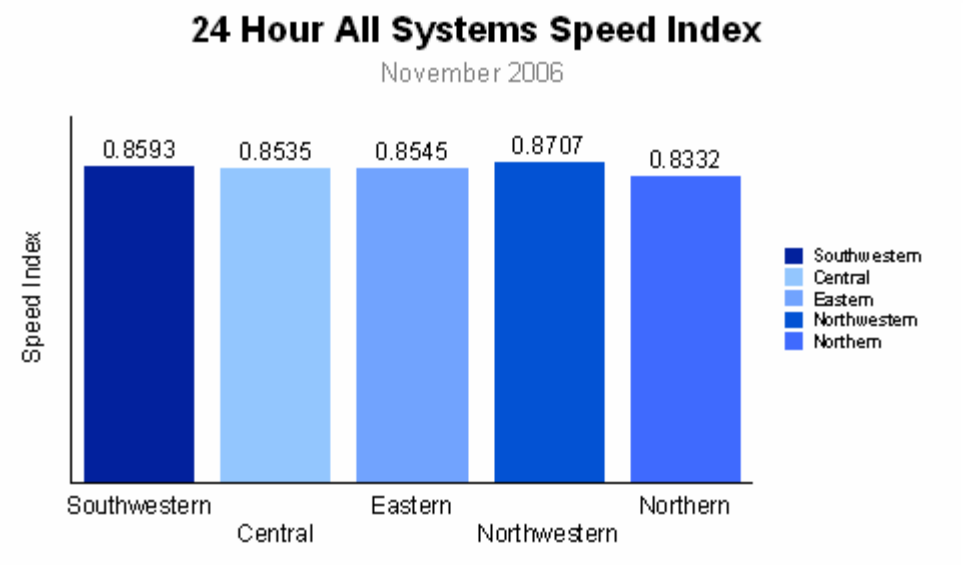
REGIONAL PERFORMANCE MEASURES

Performance Measure definitions and other metadata are available in Appendix A.

TRAFFIC

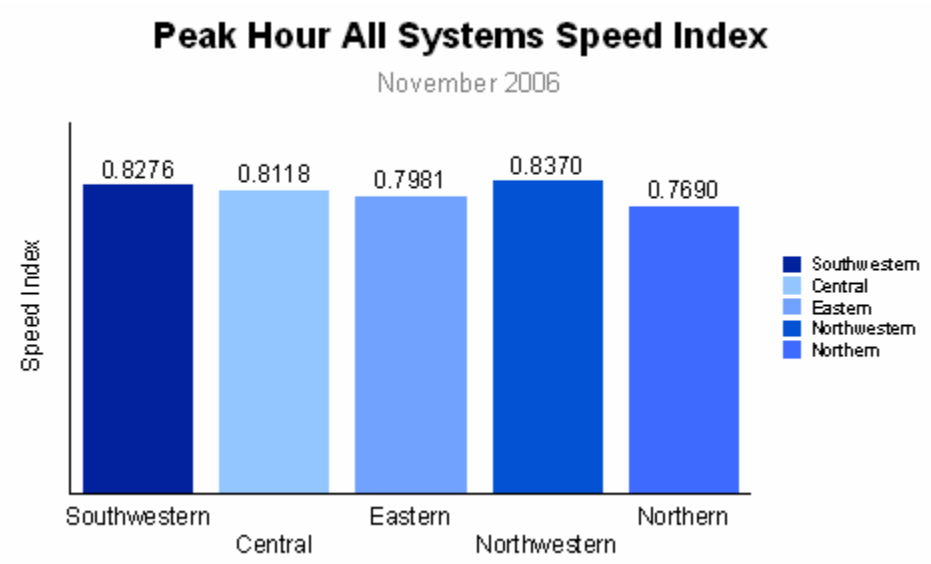
Speed Index

Data Source: TMS Continuous Count Stations
From VDOT TED



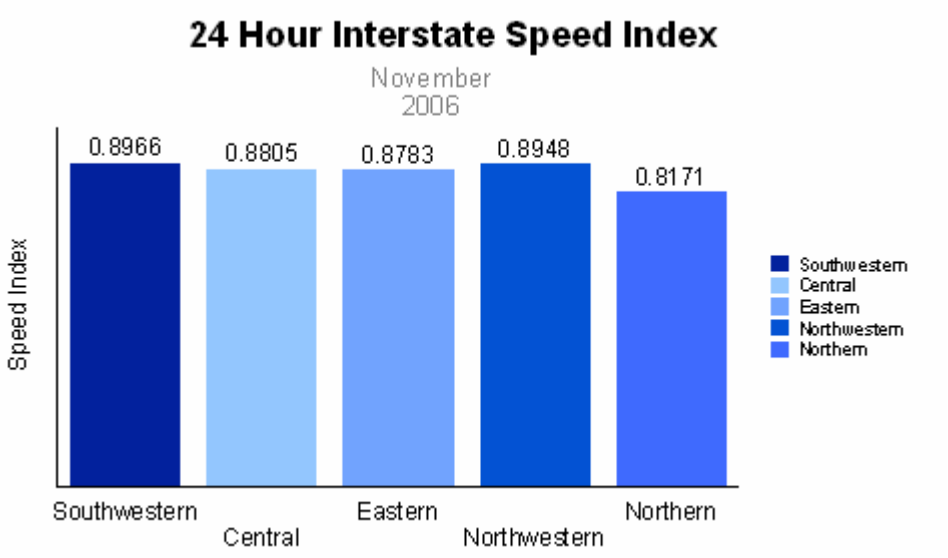
Speed Index

Data Source: TMS Continuous Count Stations
From VDOT TED



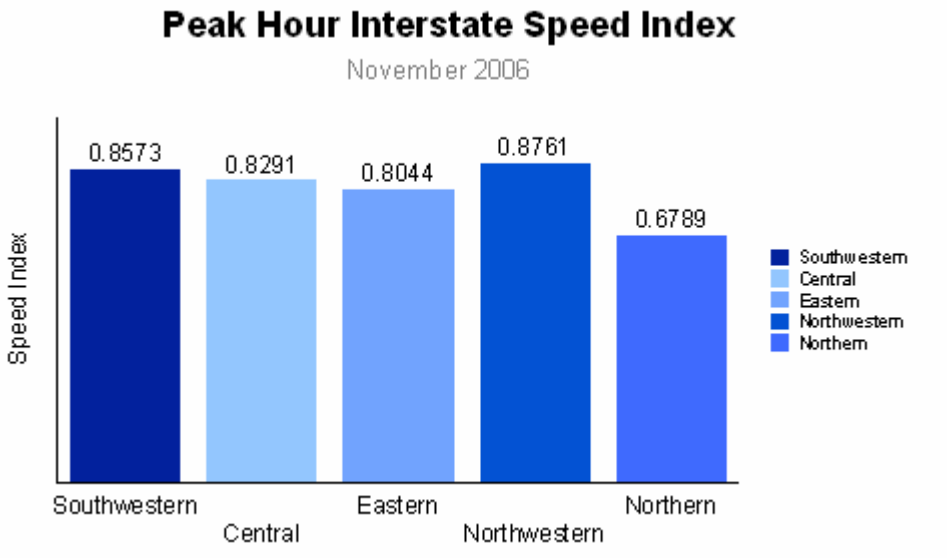
Speed Index

Data Source: TMS Continuous Count Stations
From VDOT TED



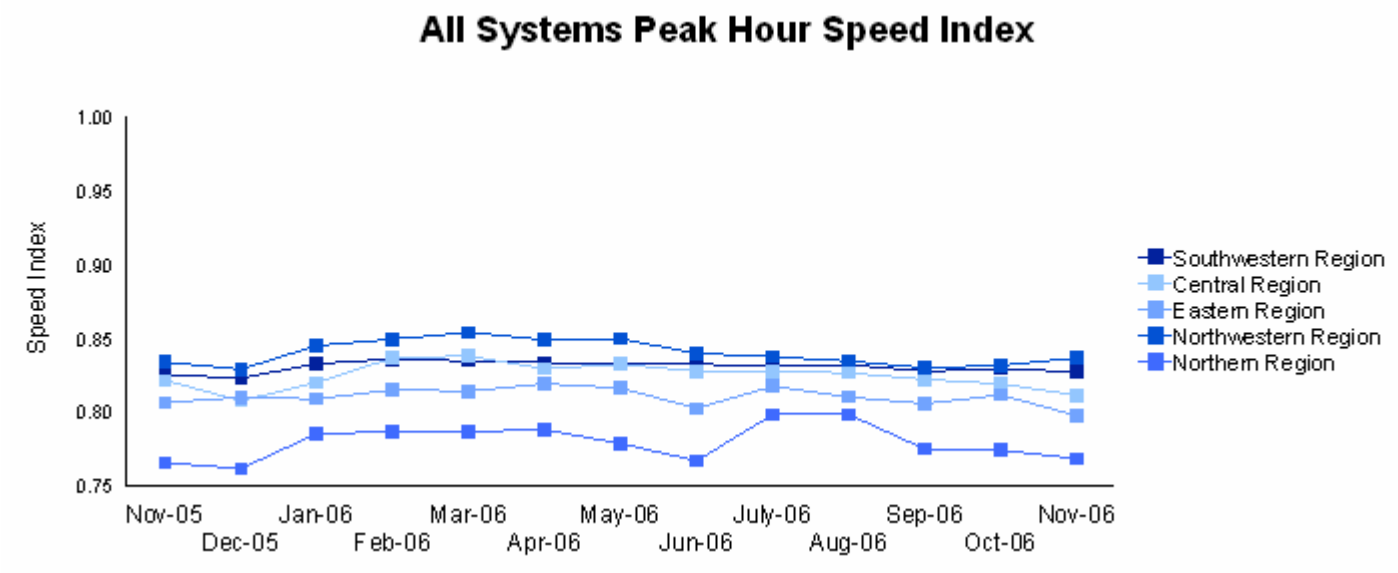
Speed Index

Data Source: TMS Continuous Count Stations
From VDOT TED



Speed Index

Data Source: TMS Continuous Count Stations
From VDOT TED



Speed Index

Data Source: TMS Continuous Count Stations
From VDOT TED

Tables

November 2006 24 Hour Speed Index

	System				
	Secondary	Primary	Interstate	Urban	All Systems
Southwestern	-	0.8768	0.8966	-	0.8593
Central	-	0.8824	0.8805	-	0.8535
Eastern	-	0.8721	0.8783	-	0.8545
Northwestern	-	0.8709	0.8948	-	0.8707
Northern	-	0.8183	0.8171	-	0.8332
Statewide	0.8353	0.8663	0.8757	0.8374	0.8538

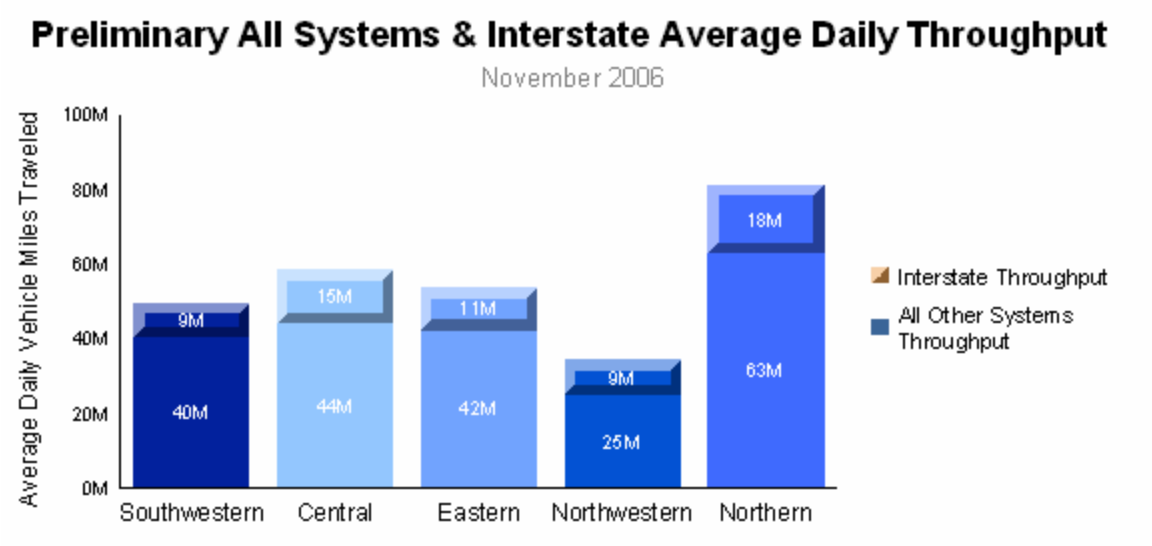
November 2006 Peak Hour Speed Index

	System				
	Secondary	Primary	Interstate	Urban	All Systems
Southwestern	-	0.8526	0.8573	-	0.8276
Central	-	0.8396	0.8291	-	0.8118
Eastern	-	0.8092	0.8044	-	0.7981
Northwestern	-	0.8432	0.8761	-	0.8370
Northern	-	0.7606	0.6789	-	0.7690
Statewide	0.8031	0.8208	0.8085	0.7963	0.8064

Throughput

Data Source: TMS Continuous Count Stations
From VDOT TED

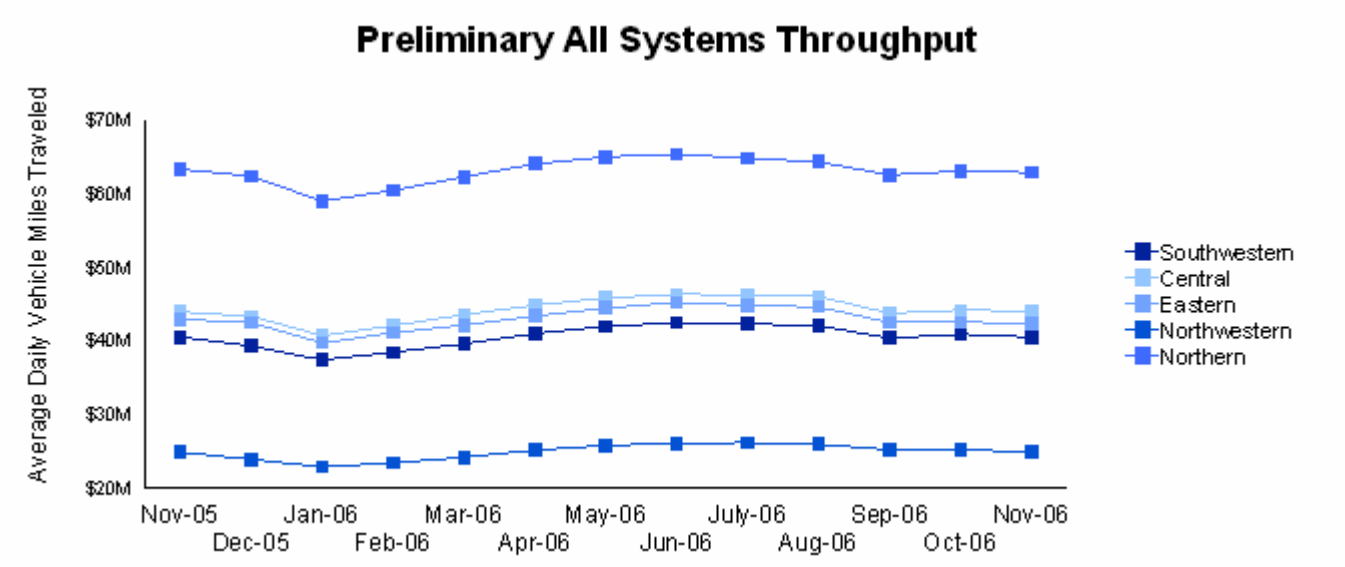
Note: All current year statewide throughput values are considered preliminary because they are based on monthly data and may differ from the final numbers that are obtained after an annual verification process. Previous year statewide values are not preliminary.



Throughput

Data Source: TMS Continuous Count Stations
From VDOT TED

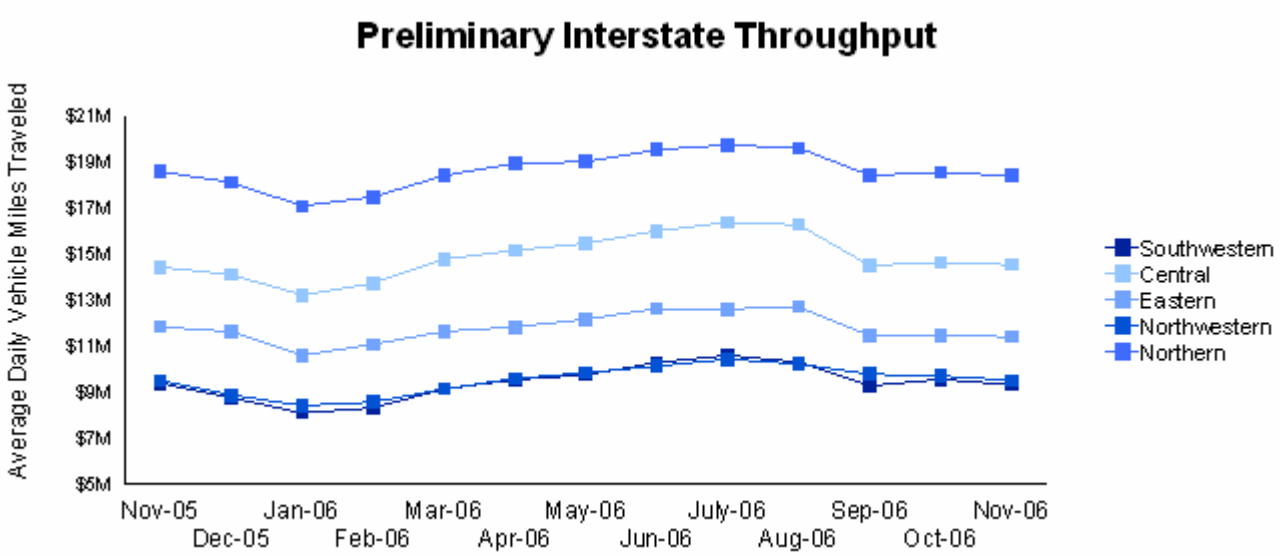
Note: June and July estimates have been revised.



Throughput

Data Source: TMS Continuous Count Stations
From VDOT TED

Note: June and July estimates have been revised.



Throughput

Data Source: TMS Continuous Count Stations
From VDOT TED

Tables

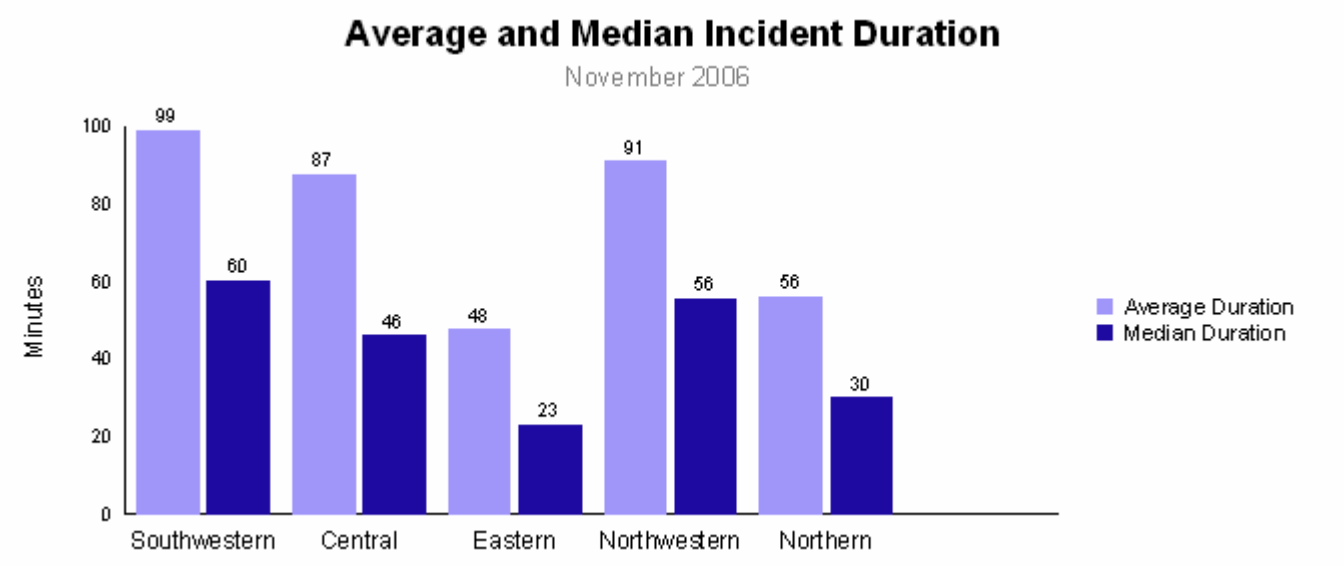
November 2006 Preliminary Average Daily Vehicle Miles Traveled

	System				
	Secondary	Primary	Interstate	Urban	All Systems
Southwestern	7,367,953	16,914,102	9,308,988	6,857,995	40,449,038
Central	9,357,086	15,813,911	14,501,053	4,308,472	43,980,522
Eastern	2,544,787	8,926,361	11,383,389	19,444,375	42,298,913
Northwestern	4,136,595	8,565,976	9,499,075	2,693,223	24,894,869
Northern	19,347,645	20,713,699	18,364,569	4,317,968	62,743,881
All Regions	42,754,066	70,934,050	63,057,074	37,622,033	214,367,223

INCIDENTS

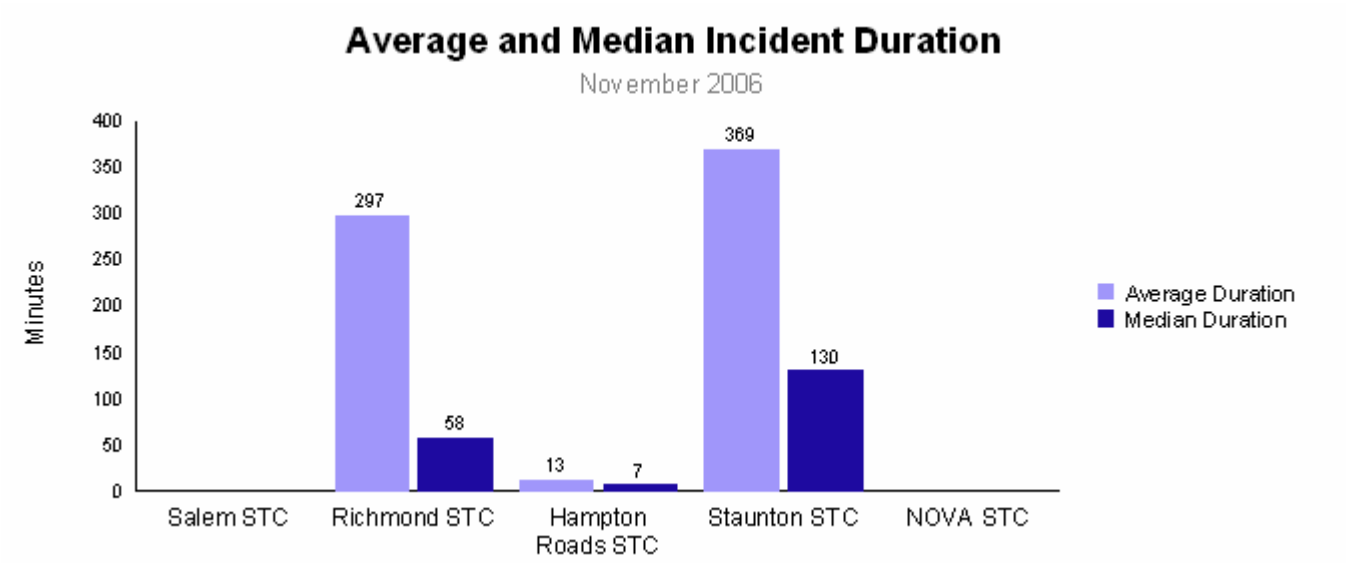
Incident Duration

Data Source: VOIS I Monthly Report
From VDOT OSD



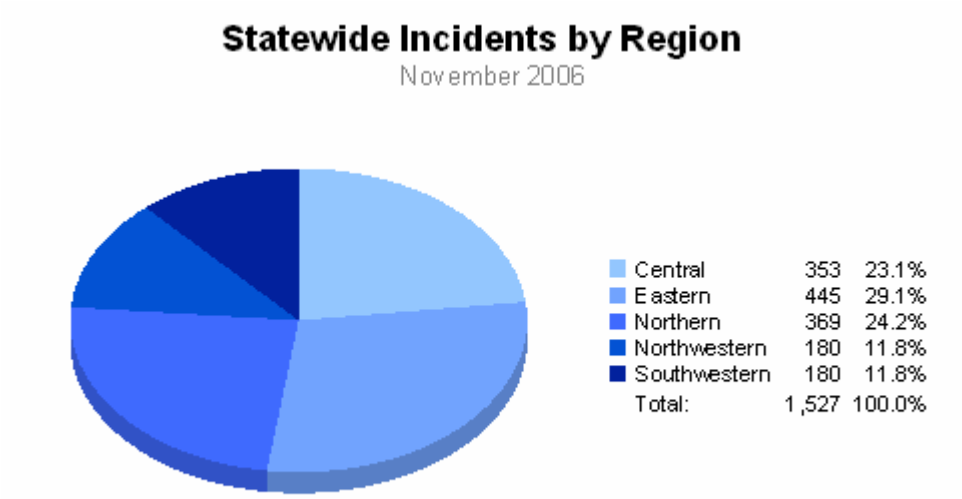
Incident Duration

Data Source: STC Incident Logs



Number of Incidents

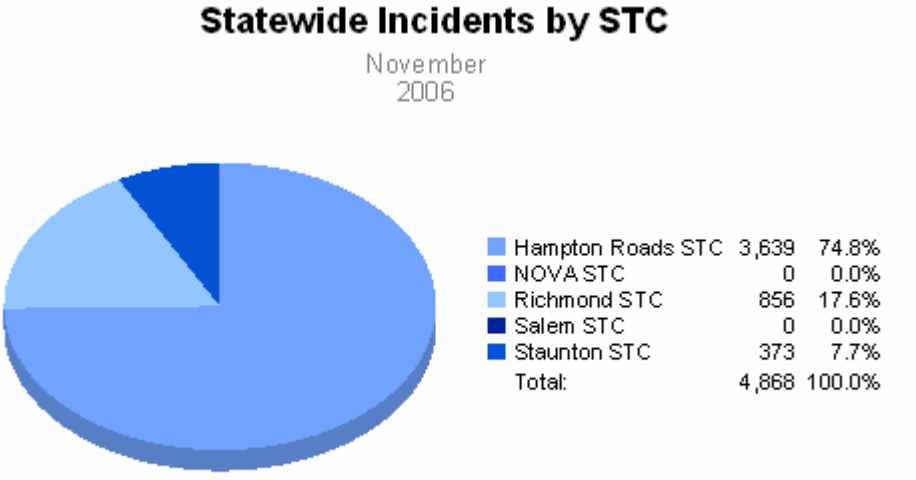
Data Source: VOIS I Monthly Report
From VDOT OSD



Number of Incidents

Data Source: STC Incident Logs

Note: The value of zero for Salem and NOVA indicates that there was no data for November in the STL.

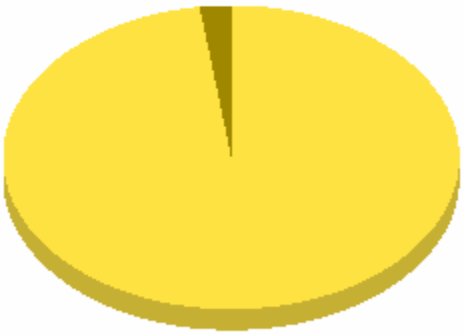


Regional Incidents

Data Source: VOIS I Monthly Report
From VDOT OSD

Southwestern Region Incidents by Type

November 2006



Accident	176	97.8%
Amber Alert	0	0.0%
Debris	0	0.0%
Disabled	0	0.0%
Other	4	2.2%
Road Hazard	0	0.0%
Weather	0	0.0%
Work Zone	0	0.0%
Total:	180	100.0%

Regional Incidents

Data Source: VOIS I Monthly Report
From VDOT OSD

Central Region Incidents by Type

November 2006

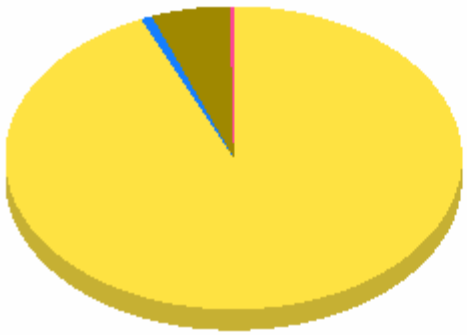
Accident	330	93.5%
Amber Alert	0	0.0%
Debris	0	0.0%
Disabled	0	0.0%
Other	23	6.5%
Road Hazard	0	0.0%
Weather	0	0.0%
Work Zone	0	0.0%
Total:	353	100.0%

Regional Incidents

Data Source: VOIS I Monthly Report
From VDOT OSD

Eastern Region Incidents by Type

November 2006



Accident	415	93.3%
Amber Alert	0	0.0%
Debris	0	0.0%
Disabled	4	0.9%
Other	25	5.6%
Road Hazard	1	0.2%
Weather	0	0.0%
Work Zone	0	0.0%
Total:	445	100.0%

Regional Incidents

Data Source: VOIS I Monthly Report
From VDOT OSD

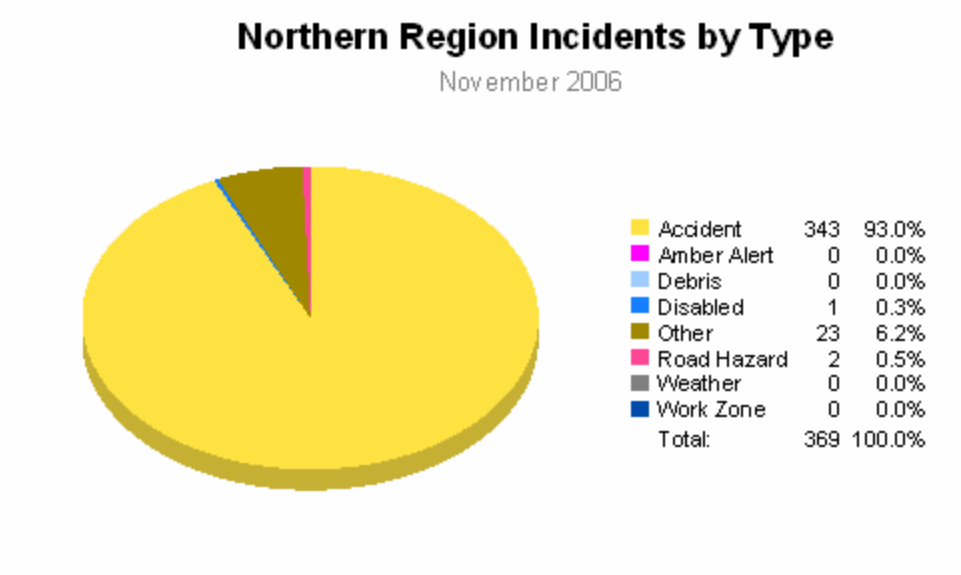
Northwestern Region Incidents by Type

November 2006

Accident	167	92.8%
Amber Alert	0	0.0%
Debris	0	0.0%
Disabled	0	0.0%
Other	12	6.7%
Road Hazard	1	0.6%
Weather	0	0.0%
Work Zone	0	0.0%
Total:	180	100.0%

Regional Incidents

Data Source: VOIS I Monthly Report
From VDOT OSD



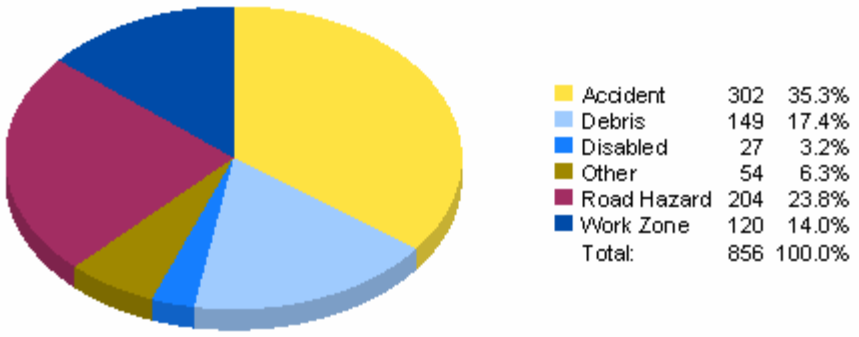
STC Incident Activity

Data Source: STC Incident Logs

Note: No incident data is available in the STC for Salem or NOVA as of the date of this report.

Richmond STC Incidents by Type

November 2006

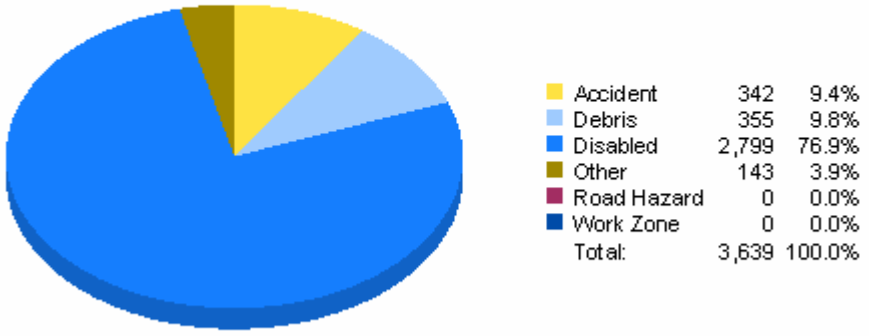


STC Incident Activity

Data Source: STC Incident Logs

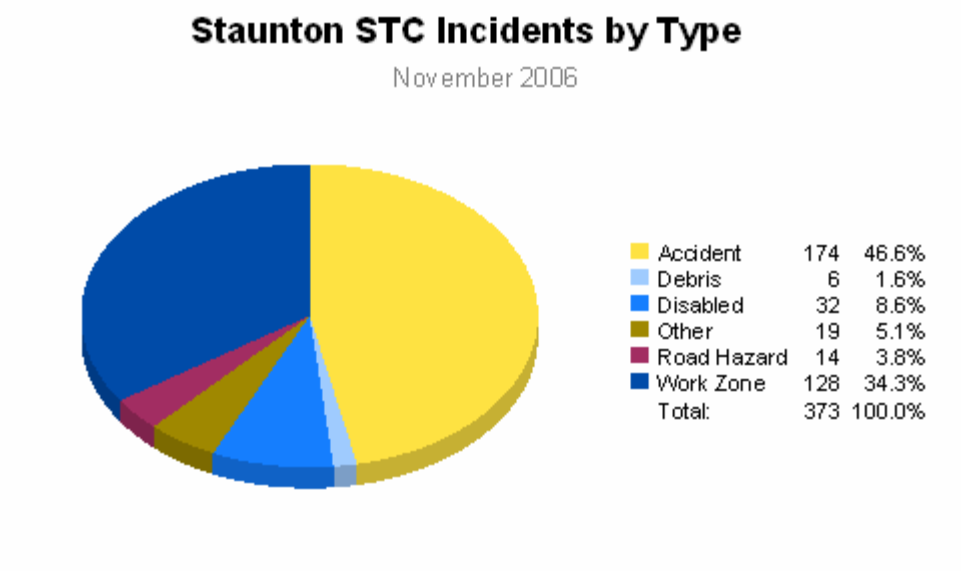
Hampton Roads STC Incidents by Type

November 2006



STC Incident Activity

Data Source: STC Incident Logs

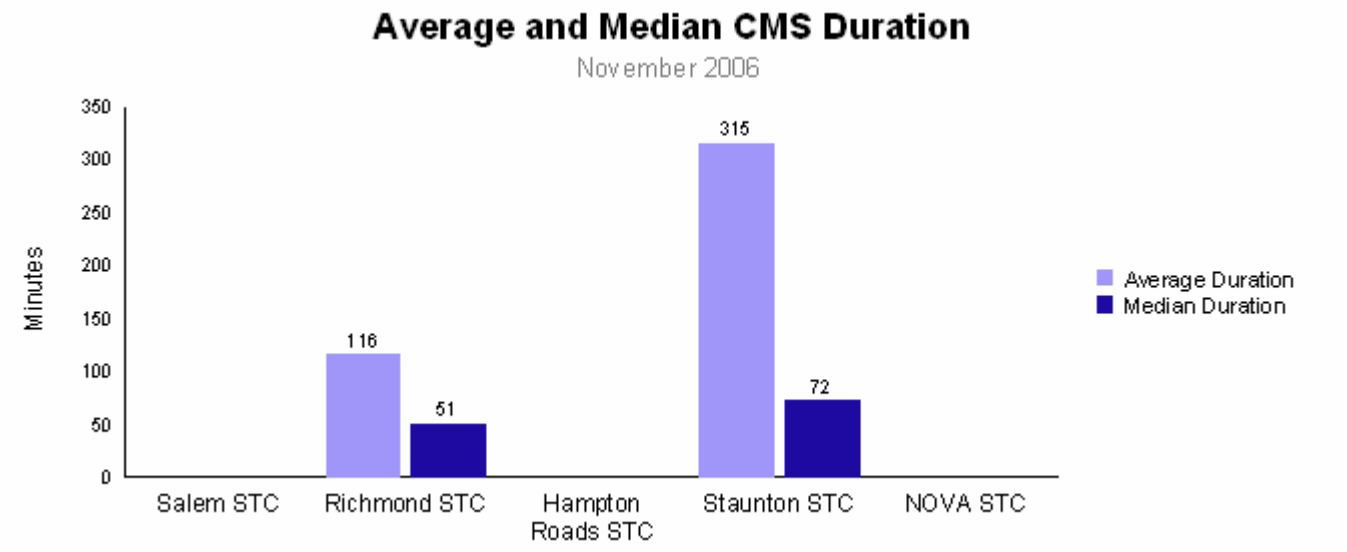


TRAVELER INFORMATION

CMS Message Duration

Data Source: STC CMS Logs

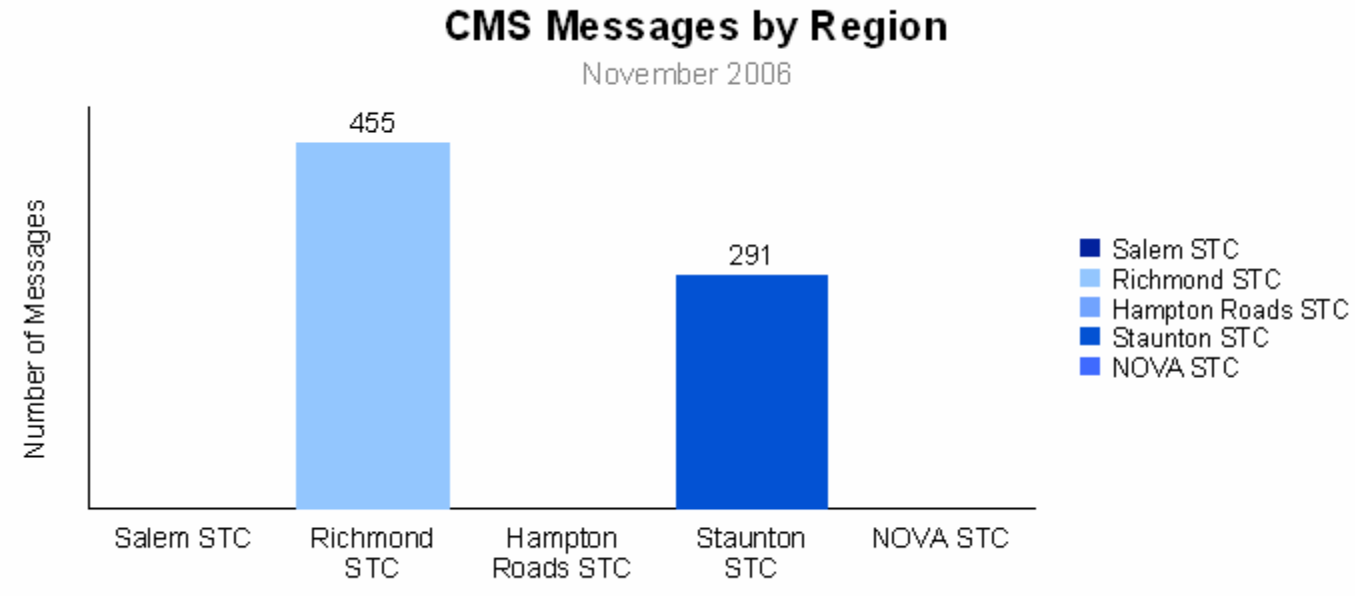
Note 1: No CMS data available for Hampton Roads, Salem or NOVA STC in the Smart Travel Lab as of the date of this report.



Number of CMS Messages

Data Source: STC CMS Logs

Note 1: No CMS data available for Hampton Roads, Salem or NOVA STC in the Smart Travel Lab as of the date of this report.



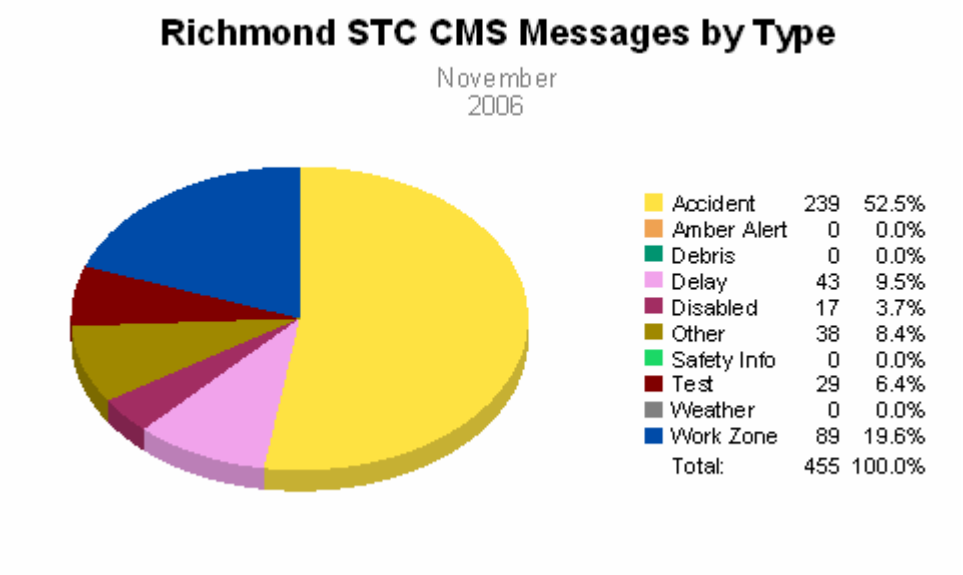
CMS Message Type

Data Source: STC CMS Logs

Note 1: No CMS data available for Salem or NOVA STC in the Smart Travel Lab as of the date of this report.

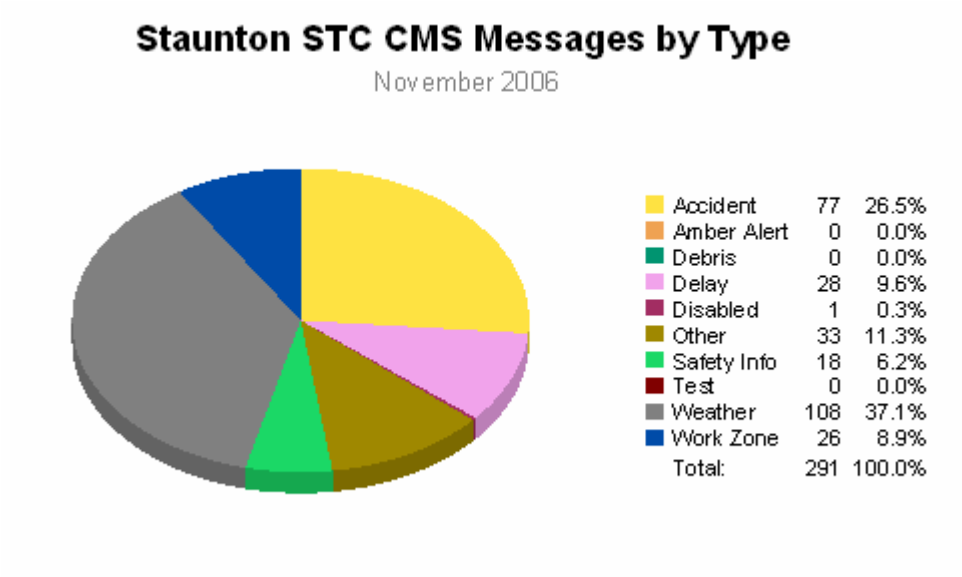
CMS Message Type

Data Source: STC CMS Logs



CMS Message Type

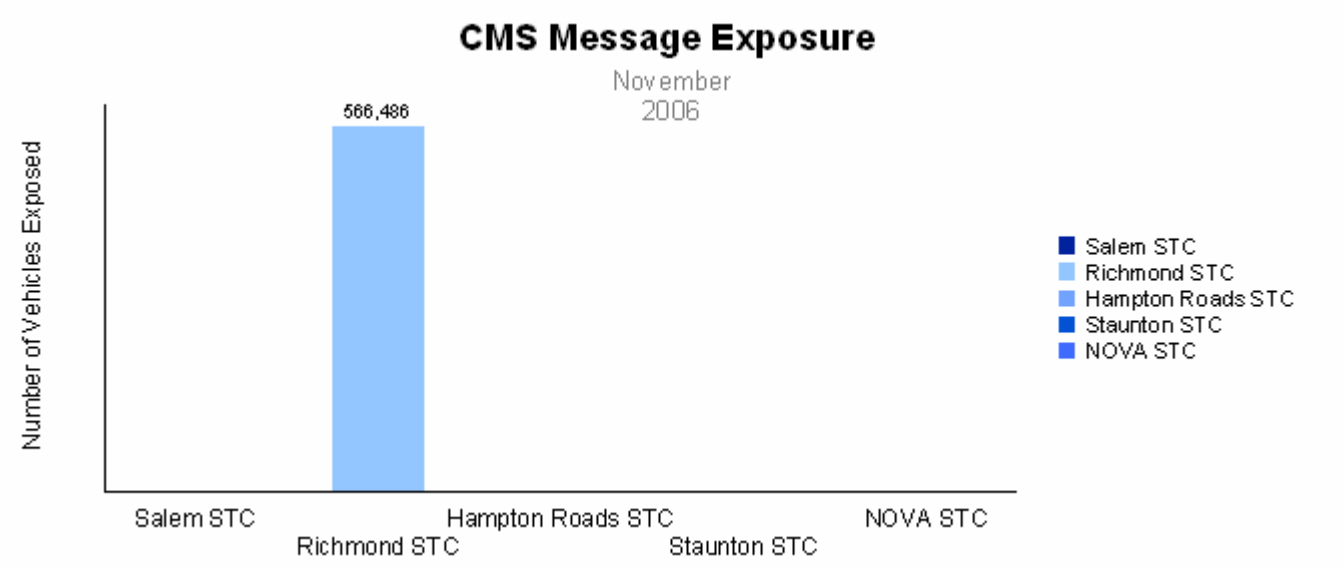
Data Source: STC CMS Logs



CMS Message Exposure

Data Sources: STC CMS and Traffic Logs

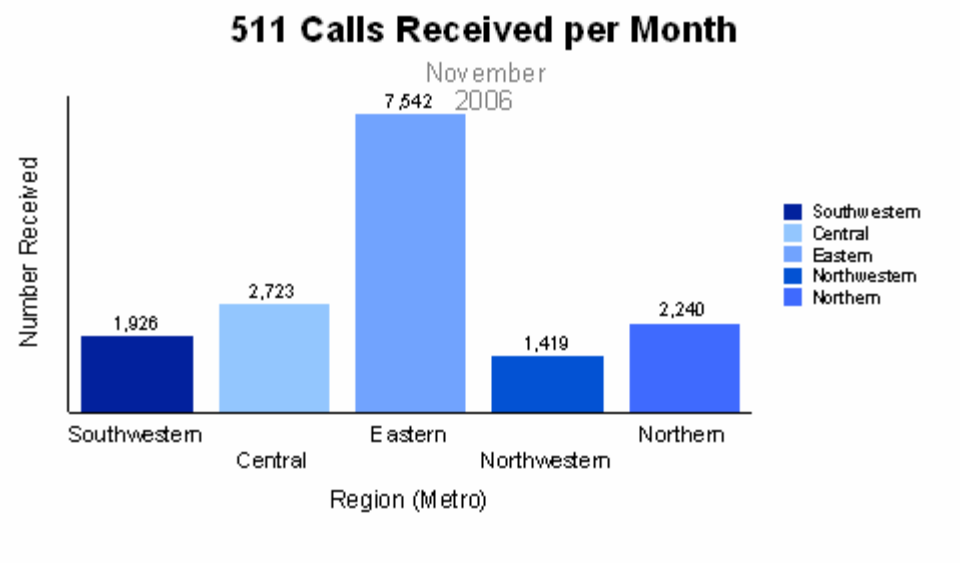
Note: Data reflects only Richmond.



511 Phone

Data Source: 511 Monthly Report
From VDOT OSD

Note: 511 phone data available for metro areas only.



511 Phone

Data Source: 511 Monthly Report
From VDOT OSD

Note: No 511 phone "call type" regional data available in the Smart Travel Lab at this time.

511 Web Site

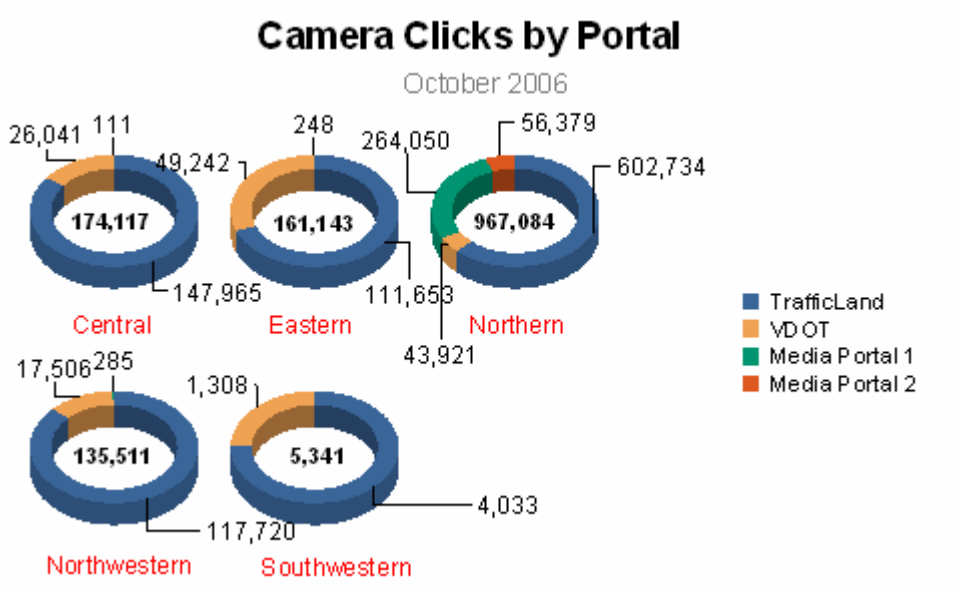
Data Source: 511 Monthly Report
From VDOT OSD

Note: No 511 web site visit regional data available in the Smart Travel Lab at this time.

CCTV Usage

Data Source: TrafficLand Monthly Report
From VDOT OSD

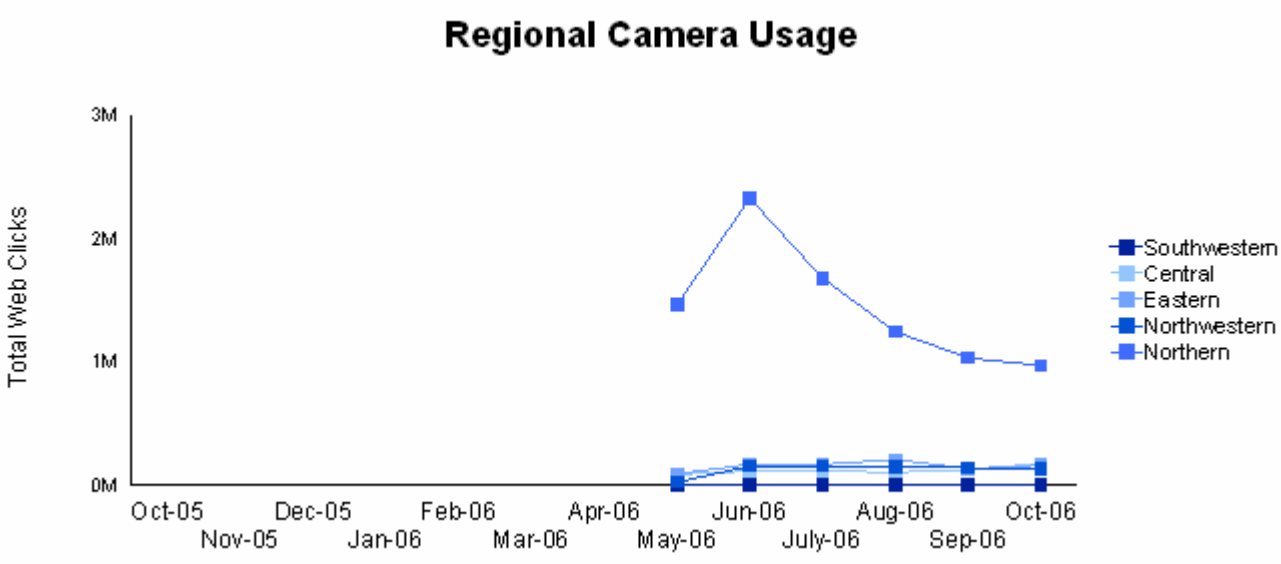
Note 1: November camera data is not available in the STL as of the date of this report.
Note 2: The Northern Region includes two additional media portals.



CCTV Usage

Data Source: TrafficLand Monthly Report
From VDOT OSD

Note 1: November camera data is not available in the STL as of the date of this report.

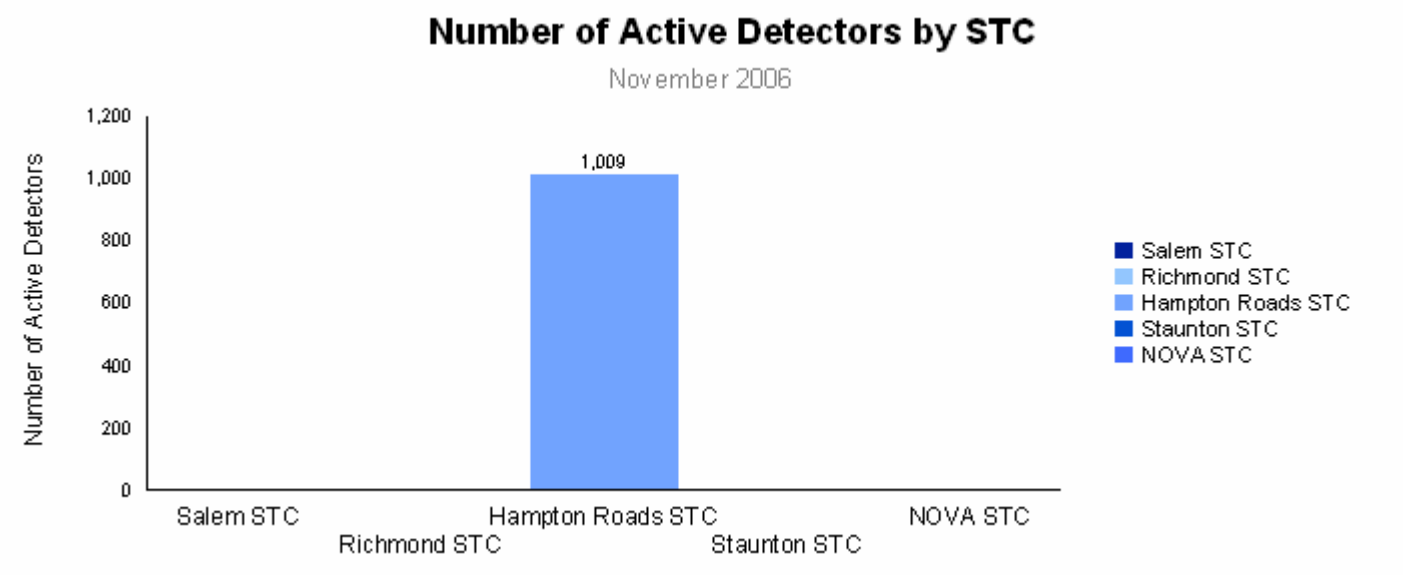


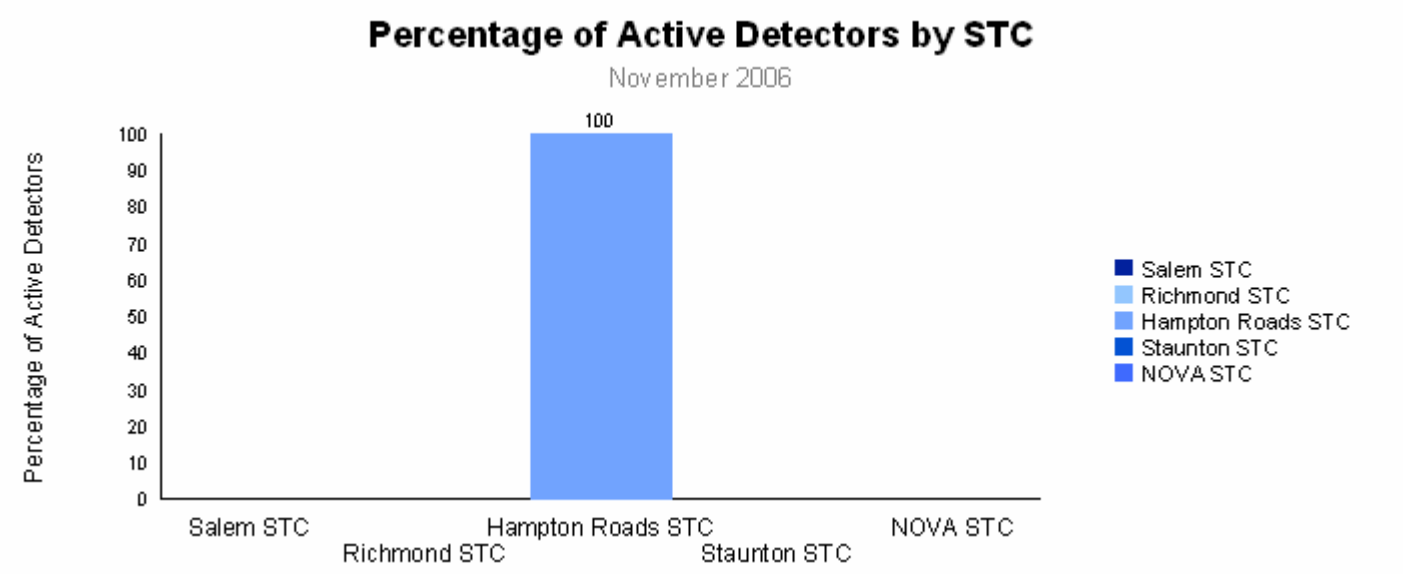
ITS DEVICE RELIABILITY

Detector Reliability

Data Source: STC Traffic Detector Information

Note 1: Only NOVA STC and HR STC detectors known to the Smart Travel Lab are used.
Note 2: For NOVA STC, no ramp metering detectors are included.
Note 3: No active detector information is available in the HR STC at this time; all HR detectors are assumed active.
Note 4: October and November data reflect only HR STC.

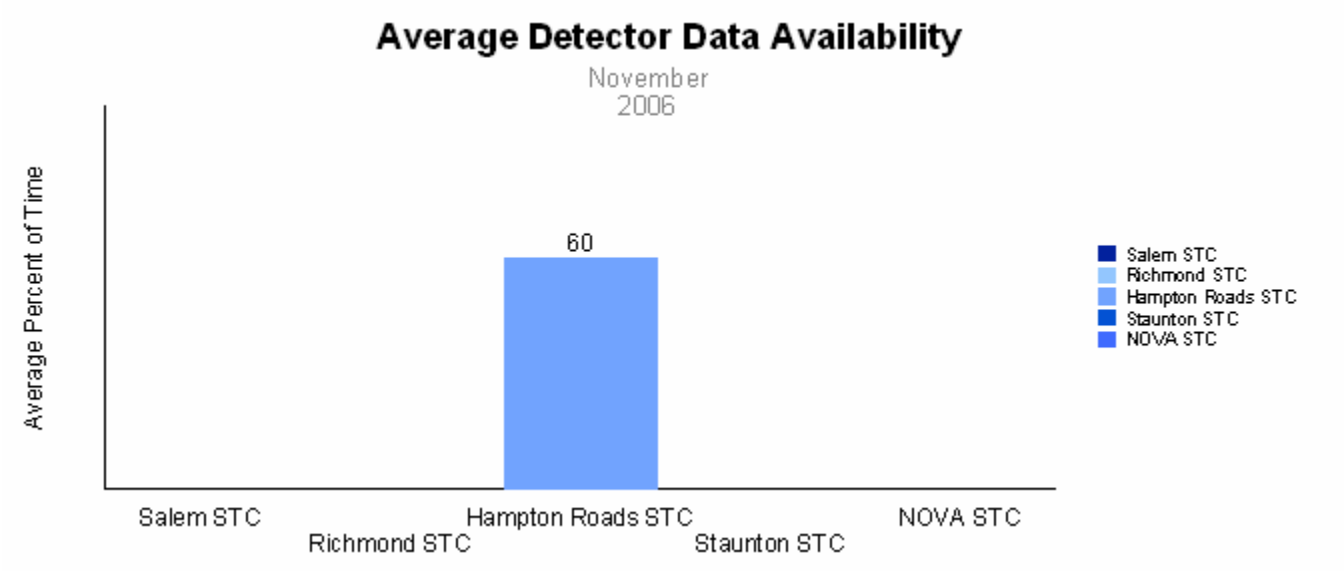




Detector Reliability

Data Sources: STC Traffic Logs, STC Active Detector Information and STL Traffic Data Reasonability Tests

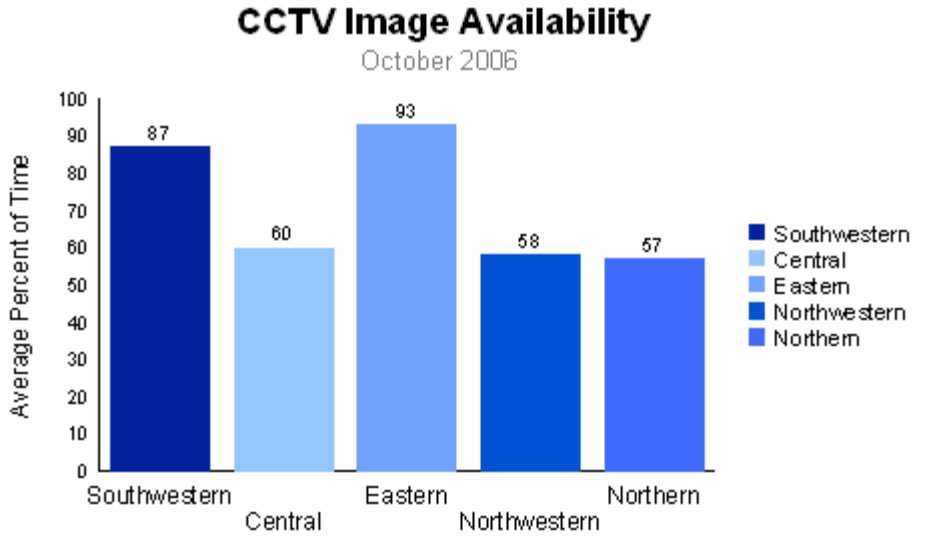
Note 1: Only NOVA STC and HR STC detectors known to the Smart Travel Lab are used.
Note 2: For NOVA STC, no ramp metering detectors are included.
Note 3: HR STC Detector Reliability numbers are preliminary.
Note 4: October and November data reflect only HR STC.



CCTV Reliability

Data Source: TrafficLand Monthly Report
From VDOT OSD

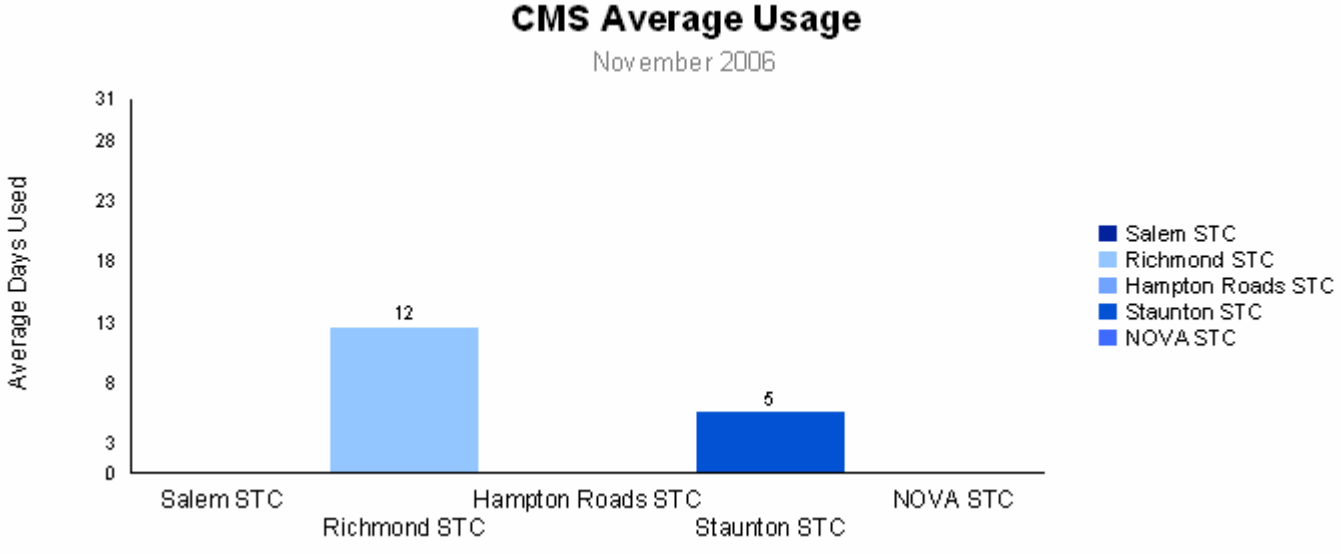
Note 1: November camera data is not available in the STL as of the date of this report.



CMS Usage

Data Source: STC CMS Logs

Note: No CMS data available for Hampton Roads STC or NOVA STC in the Smart Travel Lab at this time.



Appendix A – Performance Measures Definitions, Data Sources and Additional Considerations

TRAFFIC			
Measure Name	**Measure Definition**	**Data Source**	**Additional Considerations**
24 Hour All Systems Speed Index (SI) 24 Hour Interstate Speed Index	Average speed for whole day as a fraction of a baseline speed.	VDOT TED TMS CCS (continuous count stations)	From: TED, VDOT **Baseline speed** = Consider the 85th percentile speed for each 15-minute interval of the year and select the 85th percentile of those 85th percentile speeds. This value is the speed at which vehicles tend to travel when not impeded by weather, traffic or other conditions. Most of the time, 2003 was used as the year for calculating the baseline speed, with the exception of the cases when equipment or the facility was changed (ex: adding more lanes), when the earliest year with available data in current configuration was used. **Speed** = Average speed at a CCS during a 15-minute data collection interval. **Station SI** = Speed divided by baseline speed. Can be less than 1, equal to 1, or greater than 1. **Regional aggregation:** Average of the station SIs from all road systems within the region **Statewide aggregation:** Volume-weighing of regional values. Note 1: **The measure is presented in tabular format for the urban, secondary, primary, interstate and all systems. Only the interstate and all systems values are plotted.** Note 2: **The relatively high values for the SI observed throughout the state (especially in the Northern and Eastern regions) are explained by the strategic placement of the CCSs in areas with little or no congestion, which was needed for obtaining good vehicle classification data, the original purpose of the CCS system. As such, the speeds from CCSs do not represent a random sampling.**
Peak Hour All Systems Speed Index Peak Hour Interstate Speed Index	Average speed for the peak hour as a fraction of a baseline speed.	VDOT TED TMS CCS (continuous count stations)	From: TED, VDOT Same definitions, aggregation and notes as for the SI whole day. **Peak hour** = One-hour interval within a calendar day period starting at 00, 15, 30 or 45 minutes past the hour that experiences the highest traffic volume for the day at each TMS CCS location.

Throughput	Preliminary All Systems Average Daily Vehicle Miles Traveled (ADMVT) Preliminary Interstate Average Daily Vehicle Miles Traveled	VDOT TED TMS continuous count, coverage count, local, and uncounted stations	From: TED, VDOT **Link VMT =** Number of vehicles traversing a link (monitored by a traffic count station) multiplied by the length of the link. **Link MVMT (Monthly VMT)** = Sum of all link VMTs for the month **Link ADVMT (Average Daily VMT) =** MVMT divided by number of days in the month **Continuous data traffic count** = MADT (already calculated by TMS). **Coverage data traffic count** = MADT (calculated from previous years' AADT, adjusted by known seasonal and day of week factors). **Local data traffic count** = latest available traffic count. No seasonal or day of week adjustments. **Uncounted data traffic count** = Imputed from known traffic counts from similar locations. **Regional aggregation:** Sum of MADVMT for each road system. **Statewide aggregation:** Sum of MADVMT for each region. **Note 1:** The measure is presented in tabular format for the urban, secondary, primary, interstate and all systems. Only the interstate and all systems values are plotted. **Note 2:** All the throughput values for the current calendar year are preliminary because they are based on monthly data and may differ from the final numbers that are obtained after an annual verification process. It is possible that the yearly totals will not be the sum of the monthly totals. **Note 3:** None of the throughput values from previous calendar year include an adjustment to match official year end value except the adjusted statewide total values. The adjustment is not pro-rated into any of the other reported values at this time.

INCIDENTS			
Measure Name	**Measure Definition**	**Data Source**	**Additional Considerations**
Incident Duration	Average and median incident duration	VOIS I monthly report from VDOT OSD	**Duration** = Time from first notification until all lanes cleared **Current duration definition** = Time from when incident is entered in VOIS I until it is marked as finished (in minutes). **Aggregation:** Average/median of the durations of all incidents, irrespective of their types. **Note:** VOIS type "Congestion" and similar is not used.
Incident Duration	Average and median incident duration	STC incident logs	**Duration** = Time from first notification until all lanes cleared **Current duration definition** = Time from when incident is entered in the STC logs until it is marked as finished (in minutes). Same aggregation method as for VOIS incident data.
Incidents by Region	Number of incidents from each region	VOIS I monthly report from VDOT OSD	Available for regional report only.
Incidents by Region	Number of incidents from each STC	STC incident logs	Available for regional report only.

Incidents by Type	Number and percent of incidents broken down by type and total number of incidents	VOIS I monthly report from VDOT OSD	**Incident types:** To make the charts clearer, the categories from the VOIS reports were grouped together as follows: **A decision was made to exclude Congestion as a type from VOIS incident performance measure reporting. Consequently, terms such as congestion, delay, train derailment, school bus, train, bridgelift, etc., were not counted. Terms connoting commercial, transit, public, and private motor vehicles were included under the Accident type following the logic that incidents involving vehicles (that are not delay-only related) are usually accidents; terms such as accident, crash were also included. Terms such as debris, tree, tree down, dead animals, abandoned, etc. were included in the Debris incident type because these are items one usually associates with roadway debris. The Disabled incident type includes terms such as disabled or fire (presumed to be auto on fire unless otherwise qualified). Road Hazard incident type includes terms such as road condition, visibility, weather, pavement, static signs, guardrail, sinkhole, structure fire, brush fire, and hazmat. The Work Zone type includes terms such as work zone and blasting. The incident type category Other includes terms that are too ambiguous or otherwise inappropriate for the aforementioned type categories, such as HOV, other, police, ferry, bridge, medical emergency, rest area, over height, bridge, CBA, tunnel, unfounded, unknown, event, traffic signals, SSP, VDOT callout, and training.** Aggregation: **Data was aggregated directly from each individual incident.** Note 1: **VOIS type "Congestion" is not used.** Note 2: **Differences in percentages between incident types from different regions can be explained by differences in the way the STC's operate.**

STC Incident Activity	Number and percent of incidents broken down by type and total number of incidents	STC incident logs	**Incident types:** To make the charts clearer, the STC incident types were grouped together as follows: Accident: accident, crash Debris: debris, dead animals, abandoned Disabled: disabled, fire Road Hazard: road condition, visibility, weather, pavement, static signs, guardrail, TEOC Work Zone: work zone, blasting Other: bridge, CBA, tunnel, unfounded, unknown, event, traffic signals, SSP, VDOT callout, training, other **Aggregation:** Data was aggregated directly from each individual incident. **Note:** Differences in percentages between incident types from different regions can be explained by differences in the way the STC's operate.

TRAVELER INFORMATION			
Measure Name	**Measure Definition**	**Data Source**	**Additional Considerations**
CMS Message Duration	Average and median CMS message duration	CMS logs for Salem, Richmond, Staunton and NOVA STCs	**Duration:** Time from when message was posted on a CMS sign until message was taken off the sign (in minutes). **Aggregation:** Average/median of the durations of all messages, irrespective of their types. **Note 1:** Only messages with known end times were used. **Note 2:** No CMS data available from HR STC at this time in the STL.
CMS Messages By Region	Number of CMS messages from each STC	CMS logs for Salem, Richmond, Staunton and NOVA STCs	Available for regional report only. **Note:** No CMS data available from HR STC at this time in the STL.
CMS Messages by Type	Number of CMS messages posted on all signs broken down by type and total number of CMS messages	CMS logs for Salem, Richmond, Staunton and NOVA STCs	**CMS message types:** CMS message types were extracted from the message text. To make the charts clearer, the CMS messages were grouped together as follows: Accident: accident, acc cleanup Amber alert: child, abduction, amber Traffic delay: delay, congestion, slow, heavy Test: test Work Zone: work, road, bridge, tunnel, zone, blasting, paving, mowing, spraying Road Hazard: disabled, fire, debris Safety Info: buckle, drink, drive, safe Weather: fog, ice, tornado, wind Other: closed, football, holiday, 511, procession, festival, police, radio Aggregation: **Data was aggregated directly from each individual message.** Note: **No CMS data available from HR STC at this time in the STL.**

CMS Message Exposure	Number of vehicles exposed to CMS messages	CMS and traffic logs Richmond STC	**Aggregation:** Sum of all number of vehicles exposed to messages posted on all the CMS signs where traffic counts could be estimated from traffic counts at close traffic stations. A traffic station is considered close to a CMS sign if it is not separated by a major interchange or more than one exit. Both upstream and downstream traffic stations are considered and when both fit the above criteria, the closest one in distance is selected. **Note 1:** No CMS data available from HR STC at this time in the STL. **Note 2:** No traffic data available from Salem and Staunton STC's at this time in the STL. **Note 3**: No CMS-STC traffic station matching available for NOVA at this time in the STL. **Note 4:** For Richmond STC: Traffic at only 7 out of 14 CMSs could be estimated in the way described in the aggregation method. **Note 5:** For Richmond STC: Traffic data is recorded with a 5-minute resolution. Timestamps for message start and end times are recorded with a 1-second resolution. There is no pro-rating on the number of vehicles in the 5-minute interval when the message starts or in the 5-minute interval when the message ends.
511 Calls Received	Number of phone calls received by the Virginia 511 system	511 monthly report from VDOT OSD	**Aggregation:** Total number of phone calls. **Note 1:** Only metro area data available. The metro areas included in each region are as follows: Central: Petersburg/Colonial Heights/Hopewell, Fredericksburg, Richmond Eastern: Williamsburg, Hampton Roads/Tidewater Northern: Northern Virginia Northwestern: Winchester, Lexington, Charlottesville, Staunton, Harrisonburg Southwestern: Danville, Lynchburg/Madison Heights, Blacksburg/ Christiansburg, Bristol, Roanoke/Salem
Type of 511 Phone Calls	Number of phone calls received by the Virginia 511 system broken down by type of information requested	511 monthly report from VDOT OSD	**Aggregation:** Numbers extracted directly from the 511 monthly report. **Note:** Available for the statewide report only. (No regional type of 511 phone call data included in the 511 monthly report from VDOT OSD at this time.)

511 Website Visits	Number of Virginia 511 website visits	511 monthly report from VDOT OSD	**Aggregation:** Numbers extracted directly from the 511 monthly report. **Note:** Available for the statewide report only. (No regional 511 web site visit data included in the 511 monthly report from VDOT OSD at this time.)
CCTV Usage	**Number of web camera clicks. A click is logged by the system anytime a user clicks on a camera icon from a map.**	TrafficLand monthly report from VDOT OSD	Aggregation: **Sum of the number of clicks for each camera.** Note 1: **The information from the cameras in the Central, Eastern, Southwestern and Northwestern regions is disseminated to the public through two web portals (TrafficLand and VDOT Dashboard)** **Note 2:** The information from the cameras in the Northern, region is disseminated to the public through four portals (TrafficLand, VDOT Dashboard plus two additional media portals)
Camera Clicks by Portal	Number of web clicks for all CCTV cameras broken down by portal.	TrafficLand monthly report from VDOT OSD	Aggregation: **Sum of the number of clicks for all the cameras from each portal.** Note 1: **The information from the cameras in the Central, Eastern, Southwestern and Northwestern regions is disseminated to the public through two web portals (TrafficLand and VDOT Dashboard)** Note 2: **The information from the cameras in the Northern, region is disseminated to the public through four portals (TrafficLand, VDOT Dashboard plus two additional media portals)**

ITS DEVICE RELIABILITY			
Measure Name	**Measure Definition**	**Data Source**	**Additional Considerations**
Number and Percentage of Active Detectors	Number of active detectors. Percentage of active detectors out of the total number of STC detectors	STC active detector data	Active detector = **Detector that is known by the STC staff not to be milled or under construction.** Aggregation = **Data was aggregated directly from each individual message.** Note 1**: No active detector information available from Staunton and Salem STC's at this time in the STL.** Note 2**: No active detector information available from HR STC at this time in the STL, all HR detectors are assumed active** Note 3: **Only distinct detectors for which STL is archiving data are included.** Note 4: **For NOVA STC, no ramp metering detectors and included.**

Average Detector Data Availability	Average percentage of time active detectors reported reasonable data	STC Traffic logs, STC active detector data and STL data reasonability tests for NOVA and HR STC's	**Reasonable records/data =** Records/Data that pass all the STL data reasonability screening tests. **Total number of expected records** = 1440 * (number of days in month) for 1-minute records and (288 * number of days in month) for 5-minute records. **Since detector polling and aggregation intervals are very low (few minutes of less), the total number of expected records approximates the time a detector is expected to give good data.** Active detector **= detector that is known by the STC staff not to be milled or under construction.** Regional aggregation: **Traffic data from NOVA STC is collected at 1-minute intervals. Traffic data from HR is aggregated at 1-minute intervals in the STL. Compute the percentage of good records out of the total number of expected records for each active detector and take the average of all these.** **Statewide aggregation:** Data was aggregated directly from data for each individual active detector. Same notes as above plus **Note 5:** No traffic data available from the Staunton and Salem STC's at this time in the STL. **Note 6:** No data reasonability tests implemented for the Richmond STC at this time. **Note 7:** HR detector reliability numbers are preliminary because they have not been validated by HR STC.

CCTV Image Availability	Average percentage of time CCTV cameras gave good images	TrafficLand monthly report from VDOT OSD	TrafficLand polls the cameras every 30 minutes. **Good image =** (as defined by Traffic Land). It is not warning, error or critical. **Warning:** TrafficLand retrieved an image that is either too light or too dark, more than likely an iris issue. **Error:** TrafficLand retrieved an image that is outside of tolerances. Examples are: black screen, whiteout screen, blue screen, grey screen. **Critical:** TrafficLand could not reach the encoder. 'Temporarily not available' image served to the customer. Could be caused by network interrupt to the STC or hardware problem with the encoder. **Aggregation:** calculate average of the percent of time each camera gave good images for all the cameras. TrafficLand supplies the percent of time each camera gives good images. **Note:** This measure is contingent on TrafficLand infrastructure and way of operation.
CMS Average Usage	Average number of days CMS's used	CMS logs from Salem, Richmond, Staunton and NOVA STC's	**Aggregation:** Sum of the number of days a CMS sign was used al least once (there was at least one message posted on it). **Note 1:** No CMS data available from HR STC at this time in the STL. **Note 2:** This measure is used instead of a "true" CMS reliability measure, since no CMS reliability data is available at this time in the STL.

Appendix A general notes:

1. For all measures, final spatial aggregation levels are operations regions (regional) and statewide.
2. For all measures, final temporal aggregation level is the reported month.
3. Unless otherwise specified, data from the whole day was used in calculating all the measures.
4. For the statewide aggregation for measures that output a number and a percent for records having a particular property:
    a. The total number of records was obtained by summing up the number of individual records having that property
    b. The percent of records was obtained by dividing the above number by the total number of records statewide.
5. For all INCIDENT and CMS measures (for which data is collected at the STC level), regional differences can be explained by the differences in operations procedures between the STC's.