DEVELOPMENT OF ACCESS MANAGEMENT PERFORMANCE MEASURES

Prepared by

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DEVELOPMENT OF ACCESS MANAGEMENT PERFORMANCE MEASURES

FINAL REPORT

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16. Abstract In 2007, the Virginia General Assembly passed legislation calling for Access Management, the regulation of entrances and intersections along highway corridors in Virginia. Some property owners may oppose access management. Therefore, performance measures are needed to assess whether the access management program is achieving its intended results. An important step of developing performance measures is to reach out to stakeholders. This can be both time consuming and expensive. This study (1) shows the effect of stakeholder involvement on the development of performance measures, (2) evaluates the challenges associated with involving stakeholders, and (3) makes recommendations for stakeholder involvement in the future.

Two groups of stakeholders were involved: (1) the people who will be using the measures and (2) the people who will be implementing the measures. A survey was conducted of transportation professionals in Virginia to represent people who will be using the measures. A steering committee of VDOT officials was appointed to represent people who will be implementing the measures.

Involving these stakeholders affected the recommended performance measures in the following ways: (1) Measures must be easy to apply. (2) The final forms of the measures were tailored to VDOT. (3) Multiple measures were used rather than a single aggregate measure. (4) A target of improvement over time was set for all measures. (5) Safety was found to be important to measure. (6) Measures should involve a tangible result. (7) The uniform application of access management standards is important to measure.

There are numerous challenges associated with involving stakeholders. If not properly handled, this task can become very time consuming. Some challenges are: (1) Thorough work must be conducted before, during, and after conducting a survey. (2) Selection of criteria to evaluate performance measures requires input from stakeholders. (3) Interaction with stakeholders requires preparation and follow-up. (4) When tailoring measures to a specific user, ability to compare to national standards should be retained.

The following recommendations are made: (1) When performance measures are developed, involve the people who will be using and implementing them. (2) Adequately prepare for all interaction with stakeholders.

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ABSTRACT

In 2007, the Virginia General Assembly passed legislation calling for Access Management, the regulation of entrances and intersections along highway corridors in Virginia. Some property owners may oppose access management. Therefore, performance measures are needed to assess whether the access management program is achieving its intended results. An important step of developing performance measures is to reach out to stakeholders. This can be both time consuming and expensive. This study (1) shows the effect of stakeholder involvement on the development of performance measures, (2) evaluates the challenges associated with involving stakeholders, and (3) makes recommendations for stakeholder involvement in the future.

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1.1 Background

Introduction

In 2007, the Virginia General Assembly passed legislation calling for the creation of access management regulations for Virginia's network of state highways (Virginia Department of Transportation, 2008a). Access management involves the coordination and regulation of entrances and intersections along a highway corridor. It limits the number of locations where vehicles can enter, exit, or cross the highway and includes techniques such as spacing intersections at adequate distances, consolidating multiple driveways, opening existing medians only where necessary, controlling the number of traffic signals, providing auxiliary lanes for turning vehicles, and assuring an integrated street network that supports the corridor. The appropriate use of access management can improve the safety and traffic operations of a highway corridor (Gluck, Levinson, and Stover, 1999).

Reason for Access Management Performance Measures

Some property owners may oppose access management out of concern that restricting access may adversely impact business activities and property values (Luedtke and Plazak, 2004). Research has shown that access management can have both positive and negative

effects on the businesses along a highway (Gluck, Levinson, and Stover, 1999; Plazak and Preston, 2005). Since access management may be controversial, the Virginia Department of Transportation must have clear measures of the effect of the program. Performance measures provide a method of "monitoring progress toward a result or goal" (Cambridge Systematice, 2006, p. iii). A research project was conducted by the Virginia Transportation Research Council, and performance measures were recommended for Virginia's access management program. The results of that project can be found in *Access Management Performance Measures for Virginia: A Practical Approach for Public Accountability* (Connelly, Hoel, and Miller, 2009).

Challenges of Developing Performance Measures

The development of performance measures involves four general steps: (1) reach out to stakeholders, (2) identify potential measures, (3) evaluate and refine measures, and (4) successfully use measures. The first step, *reach out to stakeholders* can be both time consuming and expensive. However, it is important to tailor performance measures to the people who will be using and implementing them (Wye, 2002). Using the development of performance measures for Virginia's access management program as an example, this study (1) shows the effect of stakeholder involvement on the development of performance measures, (2) evaluates the challenges associated with involving stakeholders, and (3) makes recommendations for stakeholder involvement in the future.

1.2 Access Management Principles

According to the *Access Management Manual* (Transportation Research Board, 2003), an access management program involves "the systematic control of the location, spacing, design, and operation of driveways, median openings, interchanges, and street connections to a roadway" (p. 3). Access management begins with administrative actions by a regulatory agency which results in entrances to a roadway being built according to a set of established standards. VDOT was permitted to do this in 2007 when the Virginia General assembly passed legislation allowing VDOT to develop and implement access management regulations for its network of highways (Virginia Department of Transportation, 2008a). By using these design standards, highway safety and mobility should improve.

How Access Management Affects Roadway Design

Access management requires highways to be designed using seven objectives: (1) reduce conflict points, (2) provide adequate distance between traffic signals, (3) provide adequate distance between unsignalized access points, (4) use medians and two-way-left-turn lanes, (5) use dedicated turn lanes, (6) restrict median openings to appropriate locations, and (7) use frontage roads and supporting streets (Gluck, Levinson, and Stover, 1999; Transportation Research Board, 2003).

Conflict points occur when the paths of two vehicles merge, diverge, cross, or weave. These locations have the potential for a collision (Transportation Research Board, 2003). Figure 1.2.1 shows an intersection with an island restricting left turns. Since left turn movements involve considerably more conflict points than right turns, this design feature greatly reduces the number of conflict points.

Figure 1.2.1: Intersection with turning movements restricted. The island at this driveway restricts left turns, thus reducing the number of conflict points. Intersection with westbound Route 3, across from intersection with Route 1101 (Sheraton Hills Drive), Spotsylvania County. Photograph by author.

The spacing of signalized and unsignalized intersections and driveways affects both the safety and traffic operations of a roadway. If signals are not spaced at an adequate distance along a corridor, it becomes difficult for traffic to progress through multiple signals at an acceptable speed (see Figure 1.2.2). If driveways are spaces too closely,

vehicle conflict and friction will increase, making it difficult for the motorist to anticipate and recover from turning maneuvers (see Figure 1.2.3). Without adequate spacing between intersections, it becomes difficult to provide turning lanes. Increasing the density of signals or access points along a corridor has been shown to increase the crash rate. (Gluck, Levinson, and Stover, 1999).

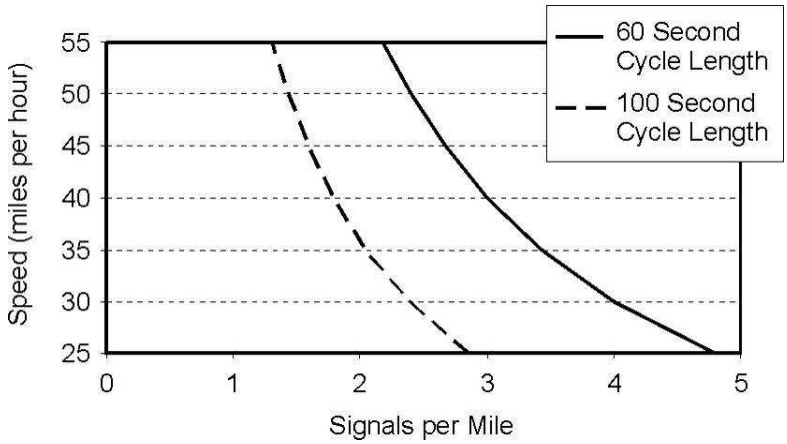

Figure 1.2.2: Relationship between signal spacing and peak hour speed. Drawn from data in *NCHRP Report 420* (Gluck, Levinson, and Stover, 1999, p. 24)

Figure 1.2.3: Numerous closely spaced driveways create a confusing situation for drivers. Eastbound Route 3, looking at intersection with Routes 707 and 1112 (Chewing Lane and Rutherford Drive), Spotsylvania County. Photograph by author.

Since a large number of crashes involve left turning movements, it is important to regulate and assist these maneuvers (Transportation Research Board, 2003). Medians and two-way-left-turn lanes (TWLTLs) separate opposing flows of traffic, and medians can be used to restrict left turns to only safe locations (Gluck, Levinson, and Stover, 1999). Dedicated left turn lanes make highway operations safer by (1) removing left turning vehicles from the through traffic and (2) allowing drivers to see oncoming traffic because their vehicle is offset from opposing left turning vehicles (Gluck, Levinson, and Stover, 1999). Median openings should be constructed only at appropriate locations, and constructed to appropriate design standards. One option is to channelize traffic in median openings and restrict certain movements (Levinson, et al., 2005).

A supporting street network is essential for an access management program to work (Transportation Research Board, 2003). Trips of moderate length and circulation between neighboring properties should be made on minor arterial and collector roadways, while the principal arterial roadways are reserved for longer distance travel (AASHTO, 2004). Figure 1.2.4 shows a location where access between two adjacent parking lots is restricted. Similar to constructing a supporting street network, access between adjacent parking lots helps keep local traffic off arterial roadways.

Figure 1.2.4: Restricted access between two parking lots. The concrete barrier in this photograph blocks access between the parking lots. This forces vehicles back onto the main roadway to travel between the properties. Southern side of Route 3, looking towards signal at intersection with Route 694 (Heatherstone Drive), Spotsylvania County. Photograph by author.

Administrative Procedures Needed for Successful Access Management

Two general administrative procedures are necessary for a successful access management program. These administrative objectives are: (1) cooperation between government agencies at different levels and (2) planning for future growth.

Cooperation allows various agencies to use their individual powers to a mutual benefit (Williams, 2004), and it increases the chance that conclusions will be accepted by all parties (Urban Land Institute, 1994). Proper planning is needed because poorly managed access develops slowly as a highway corridor is built up. Planning can include using functional classification for roadways, taking an inventory of current driveways, identifying where future access should be granted, and encouraging local governments to support access management (Plazak, et al., 2004).

Results of a Successful Access Management Program

If an access management program is successful, two major outcomes are: (1) improved mobility and (2) improved highway safety (Transportation Research Board, 2003). By improving mobility, the need for new highways may be reduced, since poor access management can cause the capacity of an existing highway to diminish to the level that a new highway must be built (Plazak, et al., 2004). Also, by improving mobility, access management allows a highway to operate more efficiently than otherwise. For example, a four lane highway with well managed access can accommodate as much traffic as a six

lane highway with poorly managed access (Transportation Research Board, 2003). Secondary outcomes of improved mobility may include an improved economy, reduced fuel consumption, and decreased emissions (Transportation Research Board, 2003).

1.3 Reasons for Access Management Performance Measures in Virginia

By definition, access management regulates the ability of commercial property owners to develop their land. Often, property owners believe that any limitation of access will result in a decrease in the viability of the property as a commercial parcel (Luedtke and Plazak, 2004). While research has shown that access management can have a positive effect on businesses along a corridor (Plazak and Preston, 2005), businesses which rely on pass by traffic may be harmed by access management techniques (Gluck, Levinson, and Stover, 1999). Since the Virginia General Assembly retains the authority to continue, alter, or stop the access management program, it is important to be able to clearly evaluate whether the perceived and actual reduction of property rights is justified. Thus, the Virginia Department of Transportation (VDOT) Transportation Planning Research Advisory Committee (TPRAC) indicated that access management performance measures should be identified (TPRAC, 2007). Since no access management performance measures were readily available, a steering committee was established to oversee the development of access management performance measures for Virginia's access management program.

According to Sinha and Labi (2007, p. 21), “Performance measures represent, in quantitative or qualitative terms, the extent to which a specific function is executed.” Ideally, performance measures should directly measure the extent to which the access management program goals are achieved. When goals are difficult to measure, surrogate measures of intermediate actions can be used if these actions have been shown to achieve the goals (Wye, 2002). Performance measures for Virginia’s access management program will allow VDOT leadership to evaluate and improve the program, make the program transparent, and effectively communicate the results of the program.

1.4 Background of Performance Measure Development

The literature regarding performance measures was reviewed to establish a methodology for their development. Four general areas are included in performance measure development. The actions in these areas should be repeated, and performance measures should be reevaluated to ensure they are still functioning as intended (Keel, O’Brien, and Morrissey, 2006). The four general areas are:

- Outreach and communication.
- Measure identification.
- Evaluation and refinement.
- Successful use of performance measures.

Outreach and Communication

Proper communication of a performance measure begins with the identification of stakeholders who will be implementing and using the measure. The audience of a performance measure should be identified, and the performance measure should be tailored to that specific audience (Wye, 2002). Stakeholder involvement includes two key groups. First, stakeholders who will be using the measure should be consulted to ensure that the measures selected have both "validity and relevance" (Keel, O'Brien and Morrissey, 2006, p. 13). Second, the people who will be tabulating the measures should be consulted to ensure the feasibility of their implementation (Cambridge Systematics, Inc., 2006). Based on communication with the stakeholders, there should be a clear understanding of the criteria for a successful performance measure.

There are many criteria which can be used to assess a potential performance measure. Cambridge Systematics Inc. (2006) notes, "Selection criteria should reflect the intended purpose, use, and audience for the performance measure" (p. 14). Not all criteria are applicable to all measures. As an example, two lists of criteria are given in Table 1.4.1.

Table 1.4.1: Criteria to evaluate performance measures from two sources.

NCHRP Report 551: Performance Measures and Targets for Transportation Asset Management **(Cambridge Systematics, Inc., 2006, pp. 15-16)**	***Urban Transportation Planning: Second Edition*** **(Meyer and Miller 2001, pp. 226-227)**
Feasible	Measurability
Policy Sensitive	Pertinence
Supports Long-Term Strategic View	Clarity
Useful for Decision Support	Sensitivity
Useful Across the Organization and Beyond	Appropriate Level of Detail
	Insensitivity to Exogenous Factors
	Comprehensiveness
	Discrimination Between Influences

The third component of outreach and communication regarding performance measures is that once measures are identified and defined a communication strategy should be developed for the intended audience. Graphics should be used to make the measures easily understood by their users. When measures are disseminated, it should be done in a timely fashion, and the information must be accurate (Cambridge Systematics, Inc., 2006).

Measure Identification

New performance measures may be needed for three reasons: (1) a lack of "coverage," (2) a lack of "use," or (3) improper "alignment" (Cambridge Systematics, Inc., 2006, p. 13). If there is a lack of coverage, there is an important goal or objective not assessed by the existing measures. A lack of use indicates an existing measure is not being used to allocate resources. Improper alignment occurs when measures cannot be used across various subdivisions of the same general program. For example, to evaluate students in two different classes, class rank may be a better performance measure than average grades since different exams and assignments may be used in each class.

Once areas where new measures are needed have been identified, candidate performance measures should be identified. Keel, O'Brien, and Morrissey (2006) give four questions which help identify performance measures (p. 14):

- What are the most direct effects of each strategy on the agency's "customers"?
- What information does management need to track movement toward key goals and objectives?

- What performance measures best reflect the expenditures of the agency's budget?
- Do these performance measures clearly relate to the agency's mission, goals, objectives, and strategies?

Early in the process of developing performance measures, it is not necessary to determine a specific definition and data collection plan for each measure, but rather to recognize potential measures and begin to evaluate their strengths and weaknesses (Cambridge Systematics, Inc., 2006).

Evaluation and Refinement

When new performance measures are proposed, they must be evaluated and refined to ensure that they (1) meet the established criteria, (2) are tailored to the people using them, and (3) are have a feasible implementation strategy. As shown in Figure 1.4.1, a table can be made to evaluate whether each candidate measure meets, partially meets, or does not meet each criterion (Cambridge Systematics, Inc., 2006).

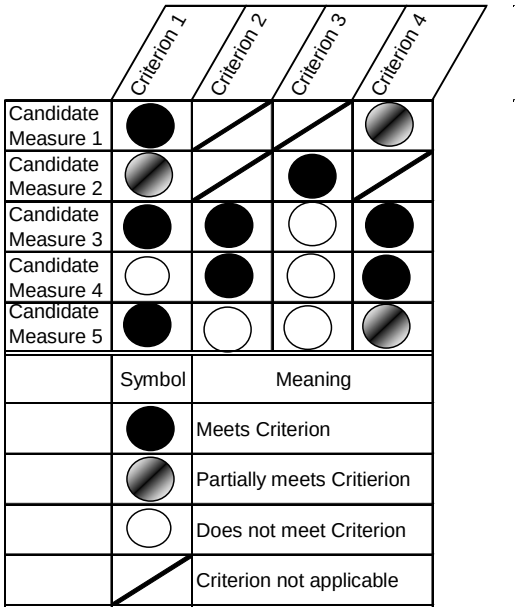

Figure 1.4.1: Method of organizing and evaluating candidate measures.

Once measures have been screened against the established criteria, the measures selected for use must be precisely defined and tailored to the people using them. The definition of a performance measure should include the following: (1) a short definition and explanation of the measure, (2) an explanation of the importance of the measure, (3) a specific definition of the calculation procedure, and (4) an explanation of any limitations of the measure (Keel O'Brian and Morrissey, 2006). Cambridge Systematics Inc. (2006) makes the following suggestions about how to appropriately measure a specific function:

- Project level measures require more detail than corridor and network level measures.
- Rates and ratios make measures easier to compare and put into perspective.
- When a performance measure is difficult to communicate, a threshold value can be established and the measure can become the percentage of the system meeting that threshold.
- Measures should reflect the scope of the program.
- Measures of "agency activity or 'output'" can provide values quickly whereas measures of end goals require more time to assess progress (p. 24).

Finally, each measure needs a clear description of where the data comes from and how to collect it (Keel, O'Brien and Morrissey, 2006). If there are any issues with data quality or the data collection process, then they should be addressed at this time. The following issues should be noted (Cambridge Sysetmatics, Inc., 2006):

- One “official” data source should be identified if multiple sources are available (p. 27).
- Values of constants (such as the optimal free flow speed).
- Changes which may make tracking of the measure over time difficult.
- Recommended improvements to the data collection procedure.

Successful Use of Performance Measures

Once a performance measure has been implemented, steps must be taken to ensure it is used by the stakeholders. The data accuracy and calculation methodology must give the measure credibility (Cambridge Systematics, Inc., 2006). Engineers like to be able to “drill down into the lowest levels of the data” (Hranac and Petty, 2007, p. 40). If users cannot understand where the data were obtained and how the measures were tabulated, they are less likely to use the measures to make decisions. Any factors which affect the value of a performance measure should be noted and recorded, and a system should be established for recording historical values of a performance measure to use for identification of trends (Cambridge Systematics, Inc., 2006).

A final component of the successful use of a performance measure is the development of forecasts and targets. Targets make it possible to predict what resources will be needed to achieve that target and can be used for requesting or allocating funding (Cambridge Systematics, Inc., 2006). Targets for a performance should realistically reflect the

constraints the program is under. Some points to consider when setting performance measure targets are (Cambridge Systematics, Inc., 2006):

- The level achieved by other agencies or a national standard can be used as a target.
- Surveys and customer input can be used to establish acceptable thresholds.
- The costs and benefits of achieving a target should be estimated, and the target should be set with these in mind. (For example, costs may increase substantially to meet a target value of 100% rather than 95%, thus 95% may be a better target).
- If the target is 100% achievement of a minimum standard, the standard should be defined such that this is feasible.

While targets can be helpful tradeoffs do exist and with limited resources available all targets cannot be met. Sometimes achievement of one target may take resources away from another area. Thus, forecasts should be developed to understand how alternative allocations of resources will affect the achievement of various performance measures (Cambridge Systematics, Inc., 2006).

1.5 PURPOSE AND SCOPE

One of the four major areas of performance measure development is outreach and communication. This task can be time consuming and expensive, and therefore it is important to properly decide upon how to involve stakeholders. The purpose of this study is to: (1) show the effect of stakeholder involvement on the development of performance measures for Virginia's access management program, (2) evaluate the

challenges associated with involving stakeholders, and (3) make recommendations for stakeholder involvement in the future.

The scope of this study is limited to an evaluation of the stakeholder involvement when performance measures were developed for Virginia's access management program.

1.6 METHODOLOGY OF RESEARCH STUDY

The project to identify performance measures for Virginia's access management program was used as a case study for this research effort. The results of that project are detailed in the Virginia Transportation Research Council report *Access Management Performance Measures for Virginia: A Practical Approach for Public Accountability* (Connelly, Hoel, and Miller, 2009). That project involved five tasks: (1) review appropriate literature, (2) develop a catalog of potential access management performance measures, (3) survey expected users of these measures, (4) select promising performance measures as candidates for testing in a typical corridor within VDOT's highway network, and (5) recommend measures based on the results of steps 1-4. This study examines process used to conduct each of these tasks and the results of each task. It is organized as follows:

1. Literature review (Section 2.2).
2. Survey of transportation professionals (Section 2.3).
3. Establishment of candidate performance measures (Section 2.4).
4. Test application of candidate measures (Section 2.5).

5. Establish criteria and evaluate measures using those criteria (Section 2.7)
6. Present measures to VDOT steering committee and refine measures (Section 2.7).

Stakeholder involvement resulted in a different set of performance measures being recommended than if they had been developed without involving stakeholders. The effects of stakeholder involvement are discussed in Section 3.2. While involving stakeholders has produced a more useful set of recommended performance measures, it does present some challenges. These are discussed in Section 3.3.

CHAPTER 2: OVERVIEW OF METHODOLOGY USED TO IDENTIFY PERFORMANCE MEASURES FOR VDOT

2.1 INTRODUCTION

The process of finding performance measures for Virginia's access management program can be broken into six steps: (1) conduct a literature review, (2) survey transportation professionals, (3) select candidate performance measures, (4) perform a test application, (5) evaluate measures, and (6) recommend measures to VDOT. The following six sections (2.2 to 2.7) provide an overview of how each of these steps was undertaken and the results of each step. Section 2.8 provides a list of the measures recommended for use by VDOT.

2.2 LITERATURE REVIEW

A literature review was conducted using the library resources of The Virginia Department of Transportation and the University of Virginia. The literature review emphasized two areas: performance measurement and access management. All of the performance measures investigated for Virginia's access management program are supported by the literature. For each of the of potential performance measures given in Tables 2.4.1 and 2.4.2 corresponding literature sources are given for further information.

Summary of Literature Review

The literature review identified three areas where performance measures can be developed for an access management program. First, the progress towards the goals of the program can be measured. These are called outcome measures. The *Code of Virginia* (§ 33.1-198.1) establishes five goals for the access management program, summarized as follows: (1) reduce congestion leading to reduced fuel consumption and pollution, (2) improve highway safety, (3) support economic development, (4) limit the need for new highways, and (5) preserve the existing network of highways.

Seven design elements and two administrative procedures were identified in the literature review. A performance measure can be developed to quantify progress towards any of these objectives. They are summarized in Section 1.2 of this thesis. Two major literature sources associated with access management are:

- *NCHRP Report 420: Impacts of Access Management Techniques* (Gluck, Levinson, and Stover, 1999).
- *Access Management Manual* (Transportation Research Board, 2003).

2.3 SURVEY OF TRANSPORTATION PROFESSIONALS

Survey Development and Methods

A survey was conducted of a sample of transportation officials and professionals in Virginia who are familiar with access management. This group provided their views regarding effective performance measures for an access management program. The initial version of the survey was developed using the online survey program Zoomerang. Prior to implementation the survey was modified and reviewed by VDOT staff. The following issues were noted: (1) jargon should be eliminated, (2) the survey instrument should allow users to review their answers prior to submission, and (3) the survey instrument should provide an option to print the response.

The survey was tested by members and friends of VDOT's Transportation Planning Research Advisory Committee (TPRAC) shortly after the fall meeting held on November 29, 2007. Comments received in response to this pilot survey were used to modify the final survey instrument.

The final survey can be found in Appendix A and is summarized as follows:

- Four questions about the background of the respondent.
- Four questions asking respondents to rank various performance measures or groups of performance measures.

- Three questions asking respondents to rate various aspects of an access management program.
- Two open ended questions.

Potential survey respondents fell into two categories: those for whom e-mail addresses were available, and those for whom e-mail contact was not practical. For those without e-mail addresses, the version of the survey created with the Zoomerang program was used. A link to this survey was posted at the web site http://vtrc.net/am, and respondents were sent a letter instructing them to go to that site. For those with an e-mail address, a survey macro developed by the McIntire School of Commerce was used to ask the same questions as contained in the Zoomerang survey. Some of those respondents received a mailed letter asking them to participate in the survey and subsequently all those in this category received an e-mail with a link to the survey. Table 2.3.1 summarizes the survey population and the contact method.

Table 2.3.1: Potential survey respondents and method used to contact.

Employer of Respondent	Number Contacted	Contact Method		Survey Version Used	Notes
		Mailed Letter	E-Mail		
Virginia County	95	X		Zoomerang	Mailed letter instructed appropriate planning staff to go to http://vtrc.net/am, where survey was posted.
Virginia City	39	X		Zoomerang	
Virginia Town	42	X		Zoomerang	
VDOT	25	X	X	McIntire	Link to survey was in e-mail, mailed letter notified respondent to expect an e-mail in near future.
MPO/PDC [a]	26	X	X	McIntire	
Private/Other	216		X	McIntire	Link to survey was in e-mail.

[a] An MPO is a Metropolitan Planning Organization. A PDC is a Planning District Commission.

More information about the survey and the methods used to analyze the results can be found in Appendix A.

Survey Results

A summary of the responses to the 13 survey questions is described in the following sections.

Question 1: What is your job title?

A variety of job titles were reported and these were classified as either engineer (33) or planner (56) if these terms were used. The remaining titles (54) varied widely and included diverse activities such as: city manager, county administrator, director of community development, director of public works, and traffic signal systems manager.

Question 2: Who do you work for?

Respondents represented the following employers:

- Cities—23 of 39 distributed
- Counties—50 of 95 distributed
- Towns—17 of 42 distributed
- MPO/PDC—14 of 26 distributed
- VDOT—19 of 25 distributed

- Private/Other—20 of 216 distributed

Question 3: Rank Outcomes

There were 124 responses in which all four outcomes were ranked. (Responses that ranked less than four outcomes were excluded.) Crashes was ranked highest most frequently with 55.6 percent, and highway performance was second with 38.7 percent. The results for each outcome are shown in Table 2.3.2.

Table 2.3.2 also shows the 95 percent confidence of the mean value for the percent of respondents ranking each outcome 4 (most useful). These values indicate the range for the mean with a confidence of 95 percent. Crashes, for example was selected by 55.6 percent of respondents, and with 95 percent confidence, between 46.9 and 64.4 percent of the population represented by the sample of survey respondents would rank crashes as the most useful of the four outcome measures. These results are also depicted in Figure 2.3.1.

Table 2.3.2: Summary of responses to question 3

Performance Measure Outcome	Percentage of Respondents Selecting PM Outcome as First Choice (%)	Range of Mean at 95% Confidence (%)
Air pollution	0.8	-0.8 - 2.4
Crashes	55.6	46.9 – 64.4
Property Values	4.8	1.1 - 8.6
Highway Performance	38.7	30.1 – 47.3

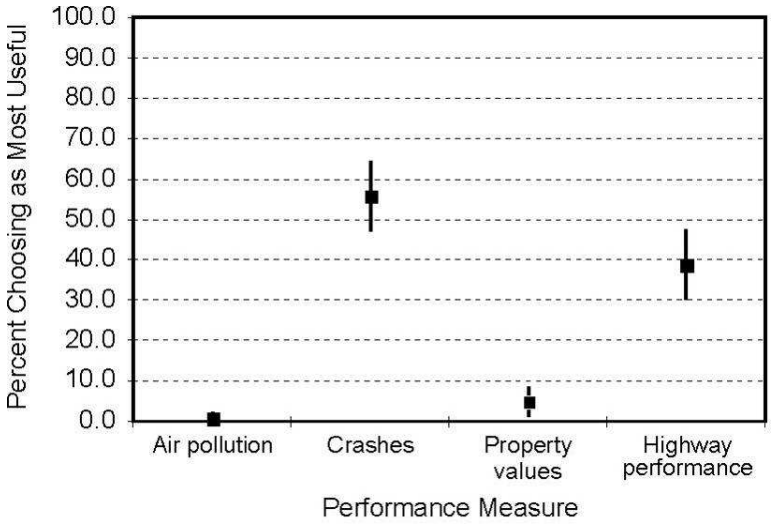

Figure 2.3.1: Graph of question 3 responses with confidence interval.

It was also determined whether the percentage of respondents that rank an access management outcome as either 4 (most useful) or 3 (next most useful) is statistically higher than 50%. The results are shown in Table 2.3.3. Crashes (87.9% or respondents ranking as most useful or next most useful) and highway performance (79.8%) are significantly greater than the 50% benchmark, whereas property values (26.6%) and air pollution (5.6%) are significantly below this 50% benchmark. Clearly crashes and highway performance are more preferred by survey respondents.

Table 2.3.3: Percentage of respondents ranking each measure 4 or 3.

Measure	% of Respondents Ranking 4 or 3	z value when compared to 50 %	Corresponding p value	Is difference from 50% statistically significant?
Air Pollution	5.6%	9.88	<0.001	Yes—Do not Favor Measure
Crashes	87.9%	8.44	<0.001	Yes—Favor Measure
Property Values	26.6%	5.21	<0.001	Yes—Do not Favor Measure
Highway Performance	79.8%	6.65	<0.001	Yes—Favor Measure

Question 4: Rank Design Elements

There were 126 responses to this question. Conflict points and driveways received the most favorable rankings with 43 percent of the respondents choosing conflict points and 26 percent choosing driveways as the most useful performance measure. These results are summarized in Table 2.3.4 and Figure 2.3.2.

Table 2.3.4: Summary of responses to question 4

Performance Measure Design Element	Percentage of Respondents Selecting PM as First Choice (%)	Range of Mean at 95% Confidence (%)
Conflict points	42.9	34.2 – 51.5
Traffic signals	19.8	12.9 – 26.8
Driveways	26.2	18.5 – 33.9
Supporting streets	11.1	5.6 – 16.6

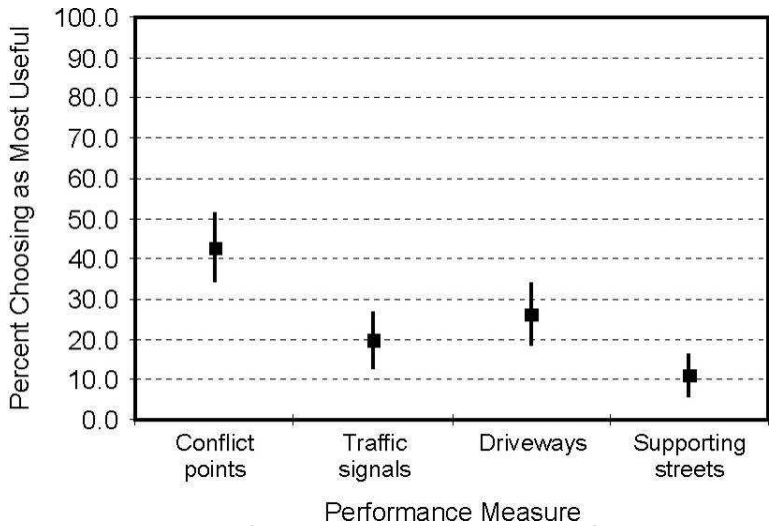

Figure 2.3.2: Graph of question 4 responses with confidence intervals

Table 2.3.5 summarizes the percentage of respondents ranking each measure 4 or 3 for question 4 responses. Again conflict points and driveways are the more favored design measures.

Table 2.3.5: Percentage of respondents ranking each measure 4 or 3.

Measure	% of Respondents Ranking 4 or 3	z value when compared to 50 %	Corresponding p value	Is difference from 50% statistically significant?
Conflict Points	63.5%	3.03	0.002	Yes—Favor Measure
Traffic Signals	51.6%	0.36	0.722	No—Indifferent about Measure
Driveways	62.7%	2.85	0.004	Yes—Favor Measure
Supporting streets	22.2%	6.24	<0.001	Yes—Do not Favor Measure

Question 5: Rank Administrative Procedures

There were 125 responses to this question. The administrative procedures in question 5 were defined in the survey as follows:

- Cooperation: percentage of localities which promote access management.
- Observation of development: number of local planning meetings attended by VDOT employees.
- Planning by VDOT: percentage of highways in developing area with an access management plan.
- Providing assistance: number of development plans reviewed by VDOT.

Observation of development received the least favorable response whereas planning by VDOT received the highest. These results are summarized in Table 2.3.6 and Figure 2.3.3.

Table 2.3.6: Summary of results for question 5

Administrative Procedure Measured	Percentage of Respondents Selecting PM as First Choice (%)	Range of Mean at 95% Confidence (%)
Cooperation	26.4	18.7 - 34.1
Observation of development	5.6	1.6 - 9.6
Planning by VDOT	42.4	33.7 – 51.1
Providing assistance	25.6	17.9 – 33.3

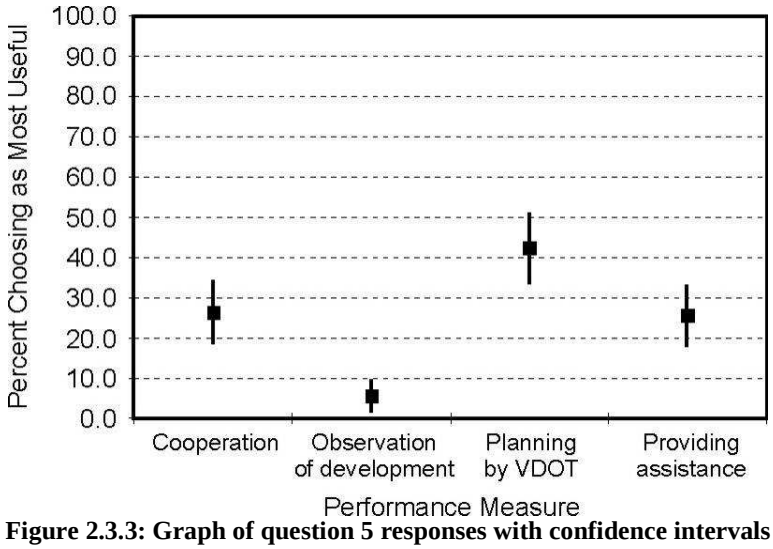

Figure 2.3.3: Graph of question 5 responses with confidence intervals

Table 2.3.7 summarizes the percentage of respondents ranking each measure 4 or 3 for question 5 responses. Again cooperation and planning by VDOT are the most favored administrative measure.

Table 2.3.7: Percentage of respondents ranking each measure 4 or 3.

Measure	% of Respondents Ranking 4 or 3	z value when compared to 50 %	Corresponding p value	Is difference from 50% statistically significant?
Cooperation	64.0%	3.13	0.002	Yes—Favor Measure
Observation of Development	16.0%	7.60	<0.001	Yes—Do not Favor Measure
Planning by VDOT	69.6%	4.38	<0.001	Yes—Favor Measure
Providing Assistance	50.4%	0.09	0.929	No—Indifferent about Measure

Question 6: Which set of measures that were ranked in the previous three questions: (Outcomes, Design Elements or Administrative Procedures) are most useful as access management performance measures.

There were 141 responses to this question. Outcome measures were chosen by of 50.4% of respondents. Design measures were chosen by 39 percent and administration by only 10.6%. These results are summarized in Table 2.3.8 and Figure 2.3.4.

Table 2.3.8: Results for question 6.

Set of Performance Measures	Percent of Respondents Selecting as First Choice (%)	Range of Mean at 95% Confidence (%)
Outcome	50.4	42.1 – 58.6
Design	39.0	31.0 – 47.1
Administrative	10.6	5.5 – 15.7

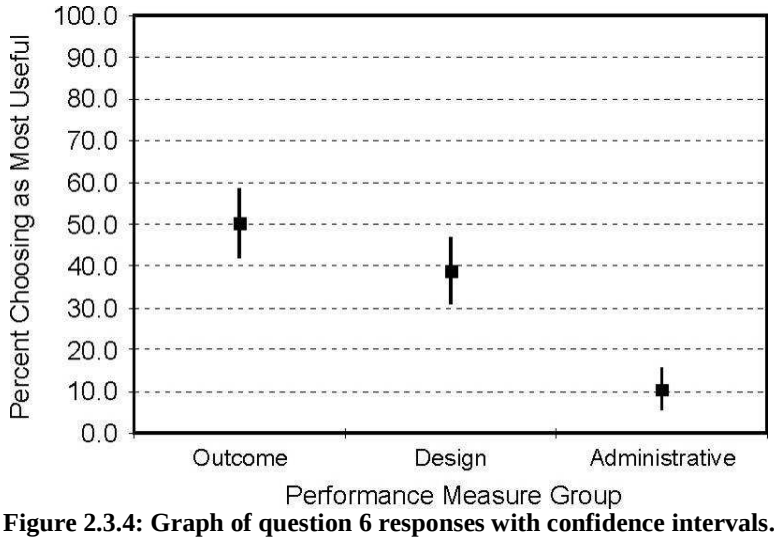

Figure 2.3.4: Graph of question 6 responses with confidence intervals.

Table 2.3.9 compares the percentage of respondents choosing each category to 33% for question 6 responses. Again outcome and design are more favored than administrative measures.

Table 2.3.9: Percentage of respondents choosing each category as most useful with statistical test for difference from 33%.

Measure Category	% Choosing as Most Useful	z value when compared to 33 %	Corresponding p value	Is difference from 33% statistically significant?
Outcome	50.4%	4.38	<0.001	Yes—Favor Category
Design	39.0%	1.52	0.129	No
Administrative	10.6%	5.65	<0.001	Yes—Do not Favor Category

Question 7: What other measures would also help to describe the performance of Virginia's access management program?

The responses may be placed into six categories, each of which reflects a particular viewpoint regarding access management. These views suggest that the perception of access management, and how to evaluate its efficacy, will vary by individual. Further, three of the six viewpoints expressed by survey respondents have also been raised, over time, in meetings with the project steering committee. Thus the preferred way to evaluate access management will vary not only by respondent, but by familiarity with this topic. A summary of responses is as follows.

1. Successful access management requires agency outreach to other entities, such as private businesses, the development community, localities, and planning boards.

2. Access management performance measures should reflect the use of other modes: pedestrian, bicycle, and transit. Context sensitive solutions are related to access management to the extent that they are used to influence pedestrian/bicycle use.
3. Successful access management requires consistent application of access standards, as reflected in landowner appeals, exceptions granted, and the use of a roadway classification system that balances good access control with property rights.
4. Access management's benefits, such as cost savings from capacity preservation, should be compared to its costs, such as agency expenditures for retrofitting a given arterial.
5. Since access management has been shown to be effective, the evaluation of access management should be based on a corridor's access geometry, such as shared access points, connectivity between parcels, and intersection design.
6. Evaluation of access management should be based on how it affects transportation outcomes, thus suitable performance measures include operating speed, delay, travel time, queue lengths, level of service, and certain traffic movements such as a change in U-turn frequency.

Question 8: Rate the importance of following six goals of Virginia's access management program.

As shown in Table 2.3.10, improved highway safety received the highest rating. This was consistent among cities, counties, MPO/PDCs, private organizations, towns, and VDOT employees. Reduced air pollution generally received low ratings.

Table 2.3.10: Average rating for each goal[a]

Goal	Average Rating
Reduced congestion	3.5
Reduced air pollution	2.6
Improved highway safety	3.8
Improved economy	2.9
Lowered need for new construction	3.1
Preservation of investment	3.3

[a]1-4 (Not important to Very important)

Question 9: Rate the importance of various design elements associated with access management.

As shown in Table 2.3.11, designing highways with a minimum number of conflict points received the highest overall rating, and was rated the highest by all groups (cities, counties, MPO/PDCs, private organizations, towns, and VDOT employees). Low ratings were less consistent with MPO/PDCs and towns rating restricting movements at median openings the lowest. Cities, counties and VDOT employees rated medians and TWLTLs lowest.

Table 2.3.11: Average rating for each design element[a]

Design Element	Average Rating
Designing highways with a minimum of conflict points	3.6
Spacing signals at long uniform distances	3.0
Spacing unsignalized access points at long distances	2.9
Using medians and TWLTLs	2.9
Using dedicated turning lanes	3.2
Restricting movements at median openings	2.9
Constructing a supporting roadway network	3.1

[a]1-4 (Not important to Very important)

Question 10: Rate various administrative procedures associated with access management.

The administrative elements in question 10 received high ratings. Overall, promoting cooperation between the state DOT and local governments was highly rated by counties, towns, and private organizations. Cities, MPO/PDCs, and VDOT employees rated creating a plan for the development of a corridor in a rapidly developing area highest. Reviewing development plans to determine the current access management situation in the state was generally given low ratings as an administrative procedure. Table 2.3.12 summarizes these results.

Table 2.3.12: Average rating for each administrative element [a]

Administrative Element	Average Rating
Developing agreements	3.3
Promoting cooperation	3.5
Developing an up-to-date land use plan	3.2
Creating a plan for development of a corridor	3.5
Providing up-to-date access management standards	3.4
Assisting to localities	3.2
Reviewing development plans to determine the current access management situation	2.9

[a] 1-4 (Not important to Very important)

Question 11: In general, what percentage of your time is devoted to access management issues?

Responses to question 11 varied greatly, ranging from almost zero to 70%. About half of the respondents spend 10% or more of their time on access management issues.

Question 12: Please describe your activities in the area of access management?

There are a large variety of activities represented by the respondents to this survey. The majority are involved in land development review. Responses ranged from developing access standards, conducting research, developing corridor plans, and advising others.

Question 13: What other comments do you have?

The responses to question 13 varied and express a range of views regarding access management. Seven general categories group the responses.

1. Uniform standards which are applied statewide are necessary for the successful implementation of access management. These standards should be related to the functional classification of the roadway and be supported by necessary research.
2. Outreach is necessary to communicate the reasoning behind managing access. This should include communication with local leaders and business owners and the incorporation of access management into comprehensive plans
3. The survey itself was of interest, with both a positive and negative opinion expressed.
4. More funding is necessary to implement access management.
5. Methods of implementing access management, such as interparcel connections are supported.

6. Access management is not necessary in all parts of Virginia, and it should only be applied in specific locations.
7. Access management is needed.

2.4 Establishment of Candidate Measures

The candidate measures tested in this study were developed from two main sources. The first and larger of the two sources was the literature which is summarized in Section 1.1 of this report. From this literature review, performance measure concepts were identified, and from these concepts, lists were made of potential performance measures, yielding a catalog of 42 potential measures. A preliminary assessment of these potential measures yielded 23 candidate performance measures. The second source of candidate performance measures was a meeting with VDOT officials from the Fredericksburg District. This meeting was held with the Fredericksburg District Planner, Eric Vogel, and the Fredericksburg District Preliminary Engineering Manager, Harry Lee. At this meeting, the administrative aspects of access management were discussed, and candidate administrative measures were developed.

The candidate measures have specifically defined units, which were not developed for all 42 potential measures. Some of the 42 potential measures are represented by more than one candidate measure. Tables 2.4.1 and 2.4.2 summarize the complete catalog of the 42 performance measures and the units of the 23 candidate measures which were evaluated with a test application.

Table 2.4.1: Catalog of performance measures based on goals

Performance Measure Goal	Potential Performance Measure	Units Used in Test Application	Supporting Literature
Reduce Congestion	Travel time	Minutes to travel highway segment	*Code of Virginia* (§ 33.1-198.1); Transportation Research Board, 2000; Rose et al., 2000
		Minutes to travel highway segment, less optimal travel time	
		Minutes to travel highway segment at an interchange	
	Density of vehicles	*Not a Candidate Measure*	*Code of Virginia* (§ 33.1-198.1); Transportation Research Board, 2000
	Speed Variation	Stop time in minutes; and number of stops	*Code of Virginia* (§ 33.1-198.1); Transportation Research Board, 2000
		Number of times vehicle's speed fell below 35 mph	
	Level of service	HCM level of service	*Code of Virginia* (§ 33.1-198.1); Transportation Research Board, 2000
	Emissions	*Not a Candidate Measure*	*Code of Virginia* (§ 33.1-198.1); Rose et al., 2000
Enhance Safety	Crash rate	Crashes per million VMT	*Code of Virginia* (§ 33.1-198.1); Gluck, Levinson, and Stover, 1999; Rose et al., 2000
		Crashes per mile	
		Crashes per million VMT at an interchange	
	Simulation based safety measure	*Not a Candidate Measure*	*Code of Virginia* (§ 33.1-198.1); Eisele and Toycen, 2005; Gettman and Head, 2003
Support Economic Development	Property values	*Not a Candidate Measure*	*Code of Virginia* (§ 33.1-198.1); Plazak and Preston, 2005
	Business turnover	*Not a Candidate Measure*	*Code of Virginia* (§ 33.1-198.1); Plazak and Preston, 2005
	Income	*Not a Candidate Measure*	*Code of Virginia* (§ 33.1-198.1); Plazak and Preston, 2005
	Employment	*Not a Candidate Measure*	*Code of Virginia* (§ 33.1-198.1); Plazak and Preston, 2005
Reduce Need for New Highways	Highway construction	*Not a Candidate Measure*	*Code of Virginia* (§ 33.1-198.1); Plazak, et al., 2004
	Money spent on highways	*Not a Candidate Measure*	*Code of Virginia* (§ 33.1-198.1); Plazak, et al., 2004
Preserve the Public Investment in Highways	Capacity in relation to the number of lanes on the highway	*Not a Candidate Measure*	*Code of Virginia* (§ 33.1-198.1); Transportation Research Board, 2003
	Change in capacity	*Not a Candidate Measure*	*Code of Virginia* (§ 33.1-198.1); Transportation Research Board, 2003

Table 2.4.2: Catalog of performance measures based on objectives

Performance Measure Objective	Potential Performance Measure	Units Used in Test Application	Supporting Literature
Reduce Conflict Points	Conflict points	Conflict points per mile	Transportation Research Board, 2003; Rose et al., 2000
Provide Adequate Distance between Traffic Signals	Number of signals	Number of signals per mile	Gluck, Levinson, and Stover, 1999
	Percentage of signals at standard spacing	Percentage of signals at standard spacing	Gluck, Levinson, and Stover, 1999
	Bandwidth through signals	*Not a Candidate Measure*	Gluck, Levinson, and Stover, 1999
Provide Adequate Distance between Unsignalized Access Points	Number of driveways	Free flow speed [a]	Gluck, Levinson, and Stover, 1999; Transportation Research Board, 2000
	Driveways within the functional area of an intersection	Number of driveways within the functional area of a signalized intersection	Gluck, Levinson, and Stover, 1999
		Feet from terminal of an interchange ramp to first driveway	
		Number of sub-standard intersections near interchanges	
Use Medians and TWLTLs	Miles of highway with a median	*Not a Candidate Measure*	Gluck, Levinson, and Stover, 1999
	Illegal left turn movements	*Not a Candidate Measure*	Gluck, Levinson, and Stover, 1999
Use Dedicated Left Turn Lanes	Use of left turn lanes	Percentage of median openings with left turn lanes	Thomas, 1966; Gluck, Levinson, and Stover, 1999
		Number of directional median openings [b]	
	Length of left turn lanes	*Not a Candidate Measure*	Gluck, Levinson, and Stover, 1999
Restrict Median Openings to Appropriate Locations	Number of median openings	Number of median openings per mile	Levinson, et al., 2005
	Sight distance at median openings	*Not a Candidate Measure*	Levinson, et al., 2005
	Full median openings which could be converted to directional median openings	*Not a Candidate Measure*	Levinson, et al., 2005

Performance Measure Objective	Potential Performance Measure	Units Used in Test Application	Supporting Literature
	Number of unsignalized locations with high volumes of crossing and left turning traffic	*Not a Candidate Measure*	Levinson, et al., 2005
Use Frontage Roads and Supporting Streets	Inter-connectivity along a corridor	*Not a Candidate Measure*	AASHTO, 2004; Gluck, Levinson and Stover, 1999; Transportation Research Board, 2003
	Number of interparcel connections	*Not a Candidate Measure*	AASHTO, 2004; Gluck, Levinson and Stover, 1999; Transportation Research Board, 2003
Multiple objectives and performance measures		Percentage of interchanges meeting access standards	Gluck, Levinson, and Stover, 1999
Cooperation	Agreements between VDOT and localities	*Not a Candidate Measure*	Williams, 2004; Urban Land Institute, 1994; Rose et al., 2000
	Disputes between VDOT and a local agency or developer	Percentage of entrance permits approved on first submittal	Williams, 2004; Urban Land Institute, 1994
	Disputes resolved through collaboration rather than legal action	*Not a Candidate Measure*	Williams, 2004; Urban Land Institute, 1994
	VDOT observation of development by attending local meetings	*Not a Candidate Measure*	Williams, 2004; Urban Land Institute, 1994
	Assistance provided to localities	*Not a Candidate Measure*	Williams, 2004; Urban Land Institute, 1994
	Compliance with regulations	Percentage of commercial entrance permits issued that meet entrance standards	Rose et al., 2000; Rose et al., 2005
Planning	Amount of time since the access classification of a highway has been reviewed	*Not a Candidate Measure*	Plazak et al., 2004

Performance Measure Objective	Potential Performance Measure	Units Used in Test Application	Supporting Literature
	Planning in developing rural areas	*Not a Candidate Measure*	Plazak et al., 2004
	Localities with an up to date land use plan	*Not a Candidate Measure*	Plazak et al., 2004; Rose et al., 2000
	VDOT ownership of access rights	*Not a Candidate Measure*	Plazak et al., 2004; Rose, et al., 2005
	Access management corridor plans	Percentage of localities with a corridor access management plan	Plazak et al., 2004; Rose et al., 2000

[a] Also relates to the "Travel Time" performance measure.
[b] Also relates to the "Number of Median Openings" performance measure.

2.5 TEST APPLICATION OF CANDIDATE MEASURES

Test Application Methods

The VDOT Fredericksburg District was the site used to validate the feasibility the 23 candidate measures. Highway facilities and administrative subdivisions within the district were chosen which exhibited characteristics represented in an access management program. The performance measure test application was implemented at the following locations shown in Figure 2.5.1.

- *A Highway Corridor*: State Route 3 between Route 1942-Big Ben Boulevard (West Endpoint) and the border of Spotsylvania County/City of Fredericksburg (East Endpoint).

- *Arterial Highways at an Interchange Area*: the arterials intersecting Interstate Route 95 at Interchanges 126 and 133 (Route 1 and Route 17 respectively).

- *An Administrative District*: either the entire Fredericksburg District or select counties within the district depending on the candidate measure being tested.

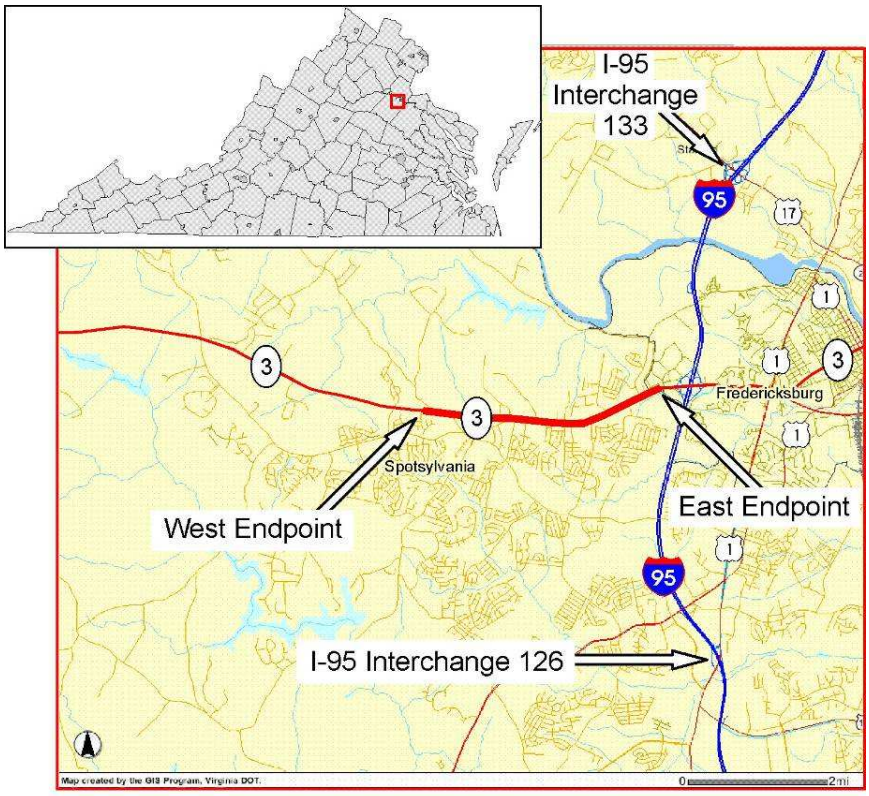

Figure 2.5.1: Location of State Route 3 and I-95 Interchanges, Fredericksburg District.

Data to compute the measures were acquired from several sources. They are (1) databases and internet resources, (2) field data collected at the site, (3) interviews with VDOT officials, and (4) personal contact with VDOT and county staff.

Databases and Internet Resources

Data were collected from the following databases and internet resources: (1) VDOT GIS Integrator (Virginia Department of Transportation, 2008c), (2) VDOT Statewide Planning System (SPS), (3) VDOT Traffic Monitoring System (TMS) Database (Virginia Department of Transportation, 2008d), (4) VDOT Crash Database (Virginia Department of Transportation, 2008b), (5) Google Maps (Google), and (6) County Web Sites (Caroline County, 2008; Gloucester County, 2001; Stafford County, 2008).

Field Data

In addition to the Fredericksburg site, data were also collected on US Route 250 in Albemarle County. Photographs or video were taken of the highway facilities and the adjacent driveways. The US Route 250 site visit was added because it provided an opportunity to collect data at a location close to the University of Virginia. At both sites, travel time data were collected using a test vehicle.

Interviews with VDOT Staff

Two additional meetings were conducted with VDOT Fredericksburg District staff to discuss the feasibility of the proposed administrative performance measures. The staff who participated in these meetings have expertise in transportation planning, engineering, land development, and information systems used to track requests for entrance permits

and consequently these staff provided insights into the strengths and weaknesses of potential administrative performance measures. These staff included Harry Lee, Stephen Haynes, Barbara Mullins, Margaret Niemann, and Eric Vogel.

Personal Contact with County Staff

Contacts were made with selected VDOT residencies and Virginia counties to obtain information explaining how access management was incorporated into specific ordinances, county comprehensive plans, and corridor studies.

Results of Test Application

The test application provided information about the effort needed to collect data for each of the measures. Measures of administrative elements of the access management program—*disputes between VDOT and a local agency or developer, compliance with regulations, and access management corridor plans*—generally required more preliminary work and were less precisely defined than the other measures. For these measures, the test application focused more on the feasibility of implementing the measures than obtaining actual values.

Measures with Easy Data Collection

For a measure to require an "easy" data collection effort, the data are readily available, and little experience is necessary to tabulate the data. For an average highway segment, an inexperienced person would need a maximum of ¼ day to tabulate the data. *Crashes per mile*, *number of signals per mile*, *number of median openings per mile*, and *percentage of median openings with left turn lanes* were rated as requiring an easy data collection effort. *Crashes per million vehicle miles traveled* was rated as requiring an medium/easy data collection effort since the traffic volume was needed in addition to the number of crashes and the roadway length. The *number of directional median openings* was assumed to require an easy effort, but this could not be verified because there were very few directional median openings in the highway segment studied.

Measures with Medium Data Collection

For a measure to require a "medium" data collection effort, the data are available but harder to find than for "easy" measures. Some experience is necessary to tabulate the data. For an average highway segment, a person could tabulate the data in a maximum of ½ day. *Percentage of signals at standard spacing*, *crashes per million vehicle miles traveled at an interchange*, *feet from the terminal of an interchange ramp to the first driveway*, *percentage of commercial entrance permits issued that meet entrance standards*, and *percentage of localities with a corridor access management plan* were rated as requiring a medium data collection effort. *Percentage of interchanges meeting*

access standards was rated as requiring a medium data collection effort, but this may be harder to find if the interchanges meet or fail to meet the standards by a small margin, making it more difficult to determine whether the standards are met.

Conflict points per mile and *number of driveways within the functional area of a signalized intersection* was rated as requiring a medium/hard data collection effort. *HCM level of service* and *free flow speed* were also rated as requiring a medium/hard effort, but this may vary depending on the source of the data since multiple sources are available for these measures.

Measures with Hard Data Collection

For a measure to require a "hard" data collection effort the data must be organized and tabulated from multiple sources. Experience is necessary to understand formulas and notations for the measure. For an average highway segment, the measure can be tabulated in a maximum of 1 day. The *number of sub-standard intersections near interchanges* was hard to obtain because each interchange has a unique design and it is difficult to apply uniform standards to each interchange. The *percentage of entrance permits approved on the first submittal* was hard to obtain because consultations prior to an official submittal generally result in an acceptable plan being submitted on the first try. It would be infeasible, on a district wide basis with multiple access permit applications, to determine how many changes VDOT staff suggested to a each proposed design before the first official submittal was made.

Measures Requiring a Site Visit

Five measures required a site visit to acquire. These are measures of travel time and speed variation.

2.6 Establish Criteria and Evaluate Measures Using these Criteria

Establishment of a Rating System

Using the literature and input from the steering committee, five criteria were established to evaluate each candidate performance measure. For each performance measure and criterion, it was determined the extent to which the measure met, partially met, or did not meet the criterion.

Rating System

The following five criteria were used to evaluate candidate measures.

Criterion 1: Does VDOT Control the Measure?

For a performance measure to be useful to an agency, that agency must be able to connect its specific actions with the observed value, and be able to make changes as needed. As noted by Meyer and Miller (2001, p. 226), a performance measure should provide both

"insensitivity to exogenous factors" and "discrimination between influences." Performance measures for a transportation program should provide an indication of the effect of *that* program. According to Cambridge Systematics Inc. (2006, p. 27) a performance measure should "reflect characteristic(s) that can be controlled by the implementing agency." An understanding of the factors which control a performance measure can help an agency link it to actions they undertake. The effects of various scenarios can be predicted and the best course of action can be taken.

If VDOT has power to control the measure, a score of 1.00 was awarded. If VDOT has power to control the measure, but cost and political power make this difficult, a score of 0.50 was awarded. If the measure is influenced by numerous factors outside VDOT's control, a score of 0.00 was awarded.

Criterion 2: Is Improvement Likely?

As noted by Wye (2002), if the values of a performance measure are not put into the correct context, they may construe an unintended meaning. The VDOT steering committee members cautioned that measures based on absolute values may communicate that the commercial access problems in Virginia are worsening. Measures such as the number of traffic signals per mile or the number of intersections per mile are not expected to be reduced even with a new access management program. Cambridge Systematics Inc. (2006) notes that it is important to be able establish baseline values to which the measure can be compared. Since Virginia's access management program

typically regulates new connections to the highway network, the number access points can be expected to increase, but at a slower rate. Thus, the use of absolute baseline values should be avoided.

If improvement is possible and likely, a score of 1.00 was awarded. If improvement is possible, but it is difficult to predict, a score of 0.50 was awarded. If improvement is not expected, a score of 0.00 was awarded.

Criterion 3: Is the Measure an Outcome, Output, or Input?

Outcomes are the final goals of a program. Outputs are the intermediate results related to those goals. Inputs are the resources used to achieve outputs and outcomes. Many sources (Keel, O'Brien, and Morrissey, 2006; Cambridge Systematics Inc., 2006; Meyer and Miller, 2001) recommend that performance measures be related to the goals of the program. Cambridge Systematics Inc. (2006, p. 29) states, "The common wisdom today is that it is preferable to measure 'outcomes' rather than 'outputs' (and either of these is certainly better than measuring 'inputs') to achieve results oriented performance monitoring." Wye (2002) makes the point that while a measure of outcomes is desirable, if they cannot be measured, it is still possible to measure intermediate results.

Measures of outcomes were awarded a score of 1.00, outputs were awarded 0.50, and inputs were awarded 0.00.

Criterion 4: Does the Survey Show Support for Measure?

If a performance measure is not easily understood, it will be of little value. As noted by Wye (2002), the audience for a performance measure should be identified, and a communication strategy developed considering that audience. The characteristics of a good performance measure include, "clarity" (Meyer and Miller, 2001, p. 226) and being "useful" (Keel, O'Brien, and Morrissey, 2006, p. 11). Performance measures for both technical and non-technical audiences are desirable (Cambridge Systematics Inc., 2006).

For each measure, the results of the survey were interpreted as *strong support*, *support*, *indifferent, N/A*¸ or *oppose*. Table 2.6.1 aligns these ratings to the data analysis. Because the survey was conducted early in the study, the measures included in this survey vary from those tested and recommended. Support for a measure in the survey was assumed to align with support for other measures of similar characteristics. For example, the survey showed strong support for a measure based on highway performance. This was used to establish strong support for "travel time" and "level of service" as performance measures.

Table 2.6.1: Rating of measures based on survey results.

Rating (score awarded) [a]	Ranking Questions (Test 1)[b]	Ranking Questions (Test 2)[c]	Rating Questions[d]	Open Ended Questions
Strong Support (1.50)	Over 50% ranked measure as 4	Over 66% ranked measure as 4 or 3	Average rating of 3.7 or greater	Not used for rating of strong support
Support (1.00)	Between 33% and 50% ranked measure as 4	Statistically more than 50% ranked measure as 4 or 3	Average rating of 3.2 to 3.6	Potential measures not included in the survey, but referenced in these responses were rated as having support.
Indifferent (0.50)	Between 10% and 33% ranked measure ad 4	Statistically 50% of respondents raked measure 4 or 3 (and 50% ranked it 2 or 1)	Average rating below 3.2	Not used for rating of indifferent
Oppose (0.00)	Less than 10% ranked measure as 4	Statistically less than 50% of respondents ranked measure 4 or 3	Not used for rating of oppose	Not used for rating of oppose
N/A (0.50)	Survey did not provide adequate information regarding measure			

[a] These ratings are qualitative in nature and are intended to compare the performance measures on the survey with other measures on the survey. The highest rating was given based on all four columns in this table.
[b] The ranges in this column (Over 50%; 33% to 50%; 10% to 33%; Less than 33%) do not have a statistical basis, but instead reflect the judgment that proportion of respondents ranking a measure as 4 indicates its relative level of support for that measure.
[c] The levels used in this column have a statistical basis as described in Appendix A.
[d] The ranges in this column (3.7 or greater; 3.2 to 3.7; below 3.2) were developed at the discretion of the research team and do not have a statistical basis.

Criterion 5: How Much Data Collection Effort is Required?

The cost of collecting data for a performance measure should not exceed the value of the measure to the implementing agency (Keel, O'Brien, and Morrissey, 2006; Cambridge Systematics Inc., 2006; Meyer and Miller, 2001). Wye (2002) states that absolute scientific precision is not necessary, and in most cases a simple indication of whether the program is on or off course will be sufficient.

If the test application showed data collection for the measure was “easy,” then a score of 1.00 was awarded. If data collection was of “medium” difficulty, a score of 0.50 was awarded. Measures requiring “hard” data collection or a site visit were awarded a score of 0.00.

Other possible criteria

While the majority of the requirements for a successful performance measure presented by the literature are represented in the 5 criteria described above, there are some which are not specifically addressed. While these other requirements were not included, they were recognized when considering the strengths and weaknesses various measures.

Rating of Measures

Each measure received a combined rating based on the five criteria. The performance measures were listed in descending order and the measures receiving higher ratings were selected for further analysis. The weights of the various criteria were adjusted to determine if there was a bias introduced due to the weighting system.

The nine performance measures receiving the highest ratings are shown in Table 2.6.2.

Table 2.6.2: Nine highest rated performance measures

PM Name	Score for each Criterion [a]					Total Score
	1	2	3	4	5	
Use of Left Turn Lanes (percentage of median openings with left turn lanes)	1	1	0.5	1	1	4.50
Access Management Corridor Plans (percentage of localities with a corridor access management plan)	0.5	1	0.5	1.5	0.5	4.00
Crash Rate (crashes per mile)	0	0.5	1	1.5	1	
Number of Median Openings (number of median openings per mile)	1	1	0.5	0.5	1	
Use of Left Turn Lanes; Number of Median Openings (number of directional median openings)	1	1	0.5	0.5	1	
Crash Rate (crashes per Million VMT)	0	0.5	1	1.5	0.75	3.75
Crash Rate (crashes per million VMT at an Interchange)	0	0.5	1	1.5	0.5	3.50
Compliance with Regulations (percentage of commercial entrance permits issued that meet access management spacing standards)	1	0.5	0.5	1	0.5	
Level of Service (HCM level of service scale)	0	0.5	1	1.5	0.25	3.25

[a] 1=Does VDOT control the measure?, 2=Is improvement likely?, 3=Is the measure an outcome, output, or input? 4=Does the survey show support for the measure?, 5=How much data collection effort is required?

2.7 Present Measures to VDOT Steering Committee and Refine Measures

Presentation of Measures to Steering Committee

In order to further refine measures so they could be used by VDOT, a set of seven recommended performance measures was presented to the steering committee. These measures differ from the highest rated measures based on the five criteria for the following reasons. Only one of the three possible median opening related measures was recommended. Similarly, only one of the three possible crash related measures was recommended. Due to the strong relationship between traffic signals and highway operations and safety, two measures related to traffic signals were added, since they were rated just below the highest rated measures.

The following performance measures were presented to the steering committee in October of 2008. These represent early versions of the measures and thus are different than those listed in Tables 2.4.1 and 2.4.2:

- Arterial *Level of Service* (LOS) as obtained from the State Planning System (SPS) database.
- *Crashes per Mile* as obtained from the State Planning System (SPS) database.
- *Signals per mile* as obtained from sampling at specific sites and from the District Traffic Engineer.
- *Percentage of signals with substandard spacing* as obtained from approval of access permits.
- *Median openings per mile* as obtained from sampling at specific sites and from the District Traffic Engineer.
- *Waivers granted to Access Management Standards* as obtained from the approval of access permits.
- *Corridor miles with an access management plan* as obtained from the District planner.

Incorporation of Committee's Comments

The recommendations of the steering committee were used to modify the selected measures and to determine which of these had the potential for immediate implementation. The steering committee reiterated two key principles. First, any measures requiring a site visit were not feasible to implement. Second, the committee

expressed a desire that the wording of performance measures be portrayed positively. For example, *Percentage of Signals with Substandard Spacing* was changed to *Percentage of Signals with Spacing at or Above Standard Distance.* The change in the definition of the measure allows it to quantify the proportion of signalized intersections meeting the standards rather than the proportion failing to meet the standards. This change does not alter the information provided since the revised measure is the inverse of the original measure.

Based on the steering committee's input, the following changes were made to the recommended measures:

- *Level of Service* was excluded for two reasons: (1) it can be affected by too many outside factors and (2) data collection may be too difficult
- *Crashes per Mile* was changed to *Crashes per Million VMT* since the latter was expected to be more easily understood.
- Only one traffic signal measure was carried forward. This measure is *Percentage of Signals with Spacing at or Above Standard Distance*.
- The measure related to median openings was modified to *Percentage of Median Openings with Left Turn Lanes*. This was done to (1) relate to VDOT standards, (2) make the measure more likely to improve, and (3) more closely relate the measure to the survey results. This is further discussed in Section 3.2 of this report.

- *Waivers Granted to Access Management Standards* was modified to *Percentage of Commercial Entrance Permits Issued that Meet Access Management Spacing Standards.* This was done to (1) phrase the measure as a percentage, (2) relate the wording to the VDOT permitting system, and (3) specify only spacing standards should be considered.
- The Number of *Corridor Miles with an Access Management Plan* was changed to the *Percentage of Localities with a Corridor Access Management Plan.* This is further discussed in Section 3.2 of this report.

2.8 MEASURES RECOMMENDED FOR USE BY VDOT

The measures were recommended for use by VDOT are:

- *Crashes per Million Vehicle Miles Traveled.*
- *Percentage of Signals with Spacing at or Above Standard Distance.*
- *Percentage of Commercial Entrance Permits Issued that meet Access Management Spacing Standards.*
- *Percentage of Median Openings with Left Turn Lanes.*
- *Percentage of Localities with a Corridor Access Management Plan.*

More information about these measures and the process used to identify them can be found in *Access Management Performance Measures for Virginia: A Practical Approach for Public Accountability* (Connelly, Hoel, and Miller, 2009).

CHAPTER 3: IMPACTS AND CHALLENGES OF INVOLVING STAKEHOLDERS IN PERFORMANCE MEASURE DEVELOPMENT

3.1 INTRODUCTION

Two major groups of stakeholders are associated with performance measures: (1) the people who will implement the measures and (2) the people who will use the measures. The VDOT steering committee represented the people who will implement the measures and affected the measures in four major ways: (1) the selection criteria were based on the steering committee's requirements, (2) the final form of the measures was tailored to Virginia's access management program, (3) multiple measures were recommended rather than one single measure, and (4) a *de facto* target of improvement over time was set for all measures. The survey respondents represented the people who will use the measures and the results of the survey affected the recommended measures in three ways: (1) improved safety is important to measure, (2) all measures should involve a tangible result, and (3) a measure of whether standards are uniformly applied would be useful.

While it is essential to tailor performance measures to the people using and implementing them, involving stakeholders in performance measure development can be time consuming, and requires proper planning. Cambridge Systematics, Inc. (2006) warns, "Although stakeholders should be given the opportunity to participate in all stages of performance measure identification, evaluation, and implementation, it is important to make sure that the overall implementation moves forward at a reasonable pace" (p. 20).

Four challenges associated with involving stakeholders were encountered in this study: (1) surveys are helpful but time consuming, (2) selection criteria must be chosen carefully, (3) adequate preparation is needed for all interaction with stakeholders, and (4) ability to compare to established standards should not be lost.

The following sections detail the effect of stakeholder involvement (Section 3.2) and the challenges associated with involving stakeholders (Section 3.3).

3.2 Impacts of Involving Stakeholders

Steering Committee's effect on Selection Criteria

The five criteria used to evaluate candidate performance measures were developed in close consultation with the steering committee. Two of the criteria were directly affected by the steering committee. Criterion 2, *is improvement likely*, was added because the committee indicated that measures should be likely to improve. Criterion 5, *how much data collection effort is required*, was influenced when the committee requested that measures should be implementable with minimal resources. The committee also specifically stated that the need for a site visit made a measure much less favorable.

Two measures heavily impacted by these criteria were *travel time* and *use of left turn lanes*. Travel time was originally highly supported by the steering committee. At the committee meeting held just before the test application of measures was conducted, it

was remarked that congestion measures are critical. However, for *travel time*, it was expected that improvements in its value are possible but not likely. Therefore, the travel time measures received a score of 0.50 for *is improvement likely.* Additionally, no simple method of finding travel time data was found. This caused the travel time measures to receive a score of 0.00 for *how much data collection effort is required.* Therefore, despite strong support on the survey and strong early support from the steering committee, *travel time* was not supported by the five criteria. When measures were recommended for use, the steering committee was satisfied that travel time should not be included. *Use of left turn lanes* was supported by criteria 2 and 5. It is not likely that left turn lanes will be removed from a highway; therefore these measures should improve over time. Left turn lanes are easily identified from aerial photographs, making data collection easy.

Steering Committee Influenced Measures' Final Forms

The form of two measures was influenced by the steering committee: (1) *percentage of median openings with left turn lanes* and (2) *percentage of localities with a corridor access management plan. Percentage of median openings with left turn lanes* was originally proposed as *median openings per mile*. The VDOT steering committee favored the new version of the measure for the following three reasons. First, in their opinion, it is more under the control of VDOT and more likely to improve. Second, left turn lanes at crossovers are specifically referenced in the access management standards (Virginia Department of Transportation, 2008a, p. 36). Third, the average rating for

"using dedicated turning lanes" by survey respondents is 3.2, the second highest rated design element (see survey question 9).

Percentage of localities with a corridor access management plan was originally proposed as *corridor miles with an access management plan.* "Corridor miles" was changed to "localities" to capture whether localities are supporting access management. The steering committee felt a proportion of localities would be more easily understood units than a length of highway. The word "corridor" was added to more precisely define the type of plan and exclude general plans which are not focused on a specific highway.

Multiple Performance Measures may be a better Option than one Single Measure

Despite a catalog of 42 performance measures, no universal measure was identified. This is because a successful access management program involves success in three interrelated areas: administration (e.g. the appropriate authority reviews requests for entrances to the highway network); design (e.g. access points are constructed to accepted standards); and outcomes (e.g. the crash rate is reduced). Assessing the entire program with a single measure is not possible unless some type of aggregate measure is developed. This could take the form of a index score or a grade based on numerous other measures. An example of an aggregate measure is the "Level of Compatibility" which assigns an index score to a roadway by dividing the annual average daily traffic (AADT) by the average distance between driveways (Benware and Jukins, 1995, p. 3). This index score is correlated to an A through F grade with higher scores receiving lower grades.

Using an aggregate performance measure presents a significant challenge. The literature makes it clear that performance measures must be understood by their users. A measure's calculation steps should be defined "clearly and specifically" (Keel, O'Brien, and Morrissey, 2006, p. 15). Hranac and Petty (2007) found that, "Managers want to see relatively simple graphical visualizations of key data metrics, [and] engineers want to see the extreme details of data mining involved in aggregating these metrics" (p. 40). A aggregate performance measure would be not be able to achieve either of these standards. This was supported by the steering committee's comments. The steering committee requested that all measures included in the test application have a clear definition with a description of the data collection process. The measures should relate to specific standards which are optimally either the VDOT access management standards or a VDOT approved corridor plan. A composite measure would not be able to have a precise definition which is easy to quickly understand and communicate. Therefore, for this study, composite measures were not used.

While a composite performance measure was not recommended in this study, all of the recommended measures require some calculations, and two of the measures require data to be combined from multiple sources. However, these measures were accepted by the steering committee because they could easily follow the calculation steps, and they accepted the legitimacy of the data sources. For example, the measure *percentage of commercial entrance permits issued that meet access management spacing standards* requires data to be taken from two databases. The Land Use Permit System (LUPS)

shows the number of entrance permits issued, and the number of exceptions granted will be tracked using the *Exception Request Form.* Another aggregate performance measure, the Level of Service, was rejected by the steering committee. The Level of Service was originally proposed to the steering committee, but data collection for that measure would be difficult. Values for this performance measure are available on the Statewide Planning System (SPS) program. However, the steering committee felt use of the SPS program was not preferred, making data collection considerably more difficult. Therefore, for a composite performance measure to be useful, the stakeholders must (1) understand its definition and (2) accept the legitimacy of the data sources.

A Target was Set for all Measures to Improve over Time

Although the development of forecasts and targets was beyond the scope of this study, a *de facto* target was set by the steering committee. The committee emphasized the need for all measures to improve over time. All of the recommended measures have the potential for improvement over time. For two of the recommended measures, *percentage of median openings with left turn lanes* and *percentage of localities with a corridor access management plan*, improvement can be expected. For the remaining three, improvement is possible, but is hard to predict.

Improved Safety is Very Important to Measure

The Virginia access management program was established with 5 goals defined in the *Code of Virginia* (§ 33.1-198.1). Since it would not be cost effective to measure progress towards all of these goals directly, the most important goals must be chosen for direct measurement. If a "most important" goal were chosen by reading the *Code*, it would likely be improved traffic operations. Four of the five goals in the code can be related to traffic operations while only one goal specifically mentions safety. However, the survey results show a preference for safety measure. 56% of respondents ranked "crashes" as most useful whereas only 39% ranked "highway performance" most useful (There is a very slight overlap of the 95% confidence intervals for these values). Therefore, it is important to adequately seek input from the people who will be using a performance measure. Without the benefit of the survey results, it would have been difficult to determine the most useful outcome to measure.

All Measures Should Involve a Tangible Result

Survey respondents showed that measures of a tangible result are more useful than measures unrelated to a tangible result. This was clearly shown when only 11% of survey respondents chose administrative procedures as most useful to measure. When forced to choose a most useful and least useful administrative procedure to measure, respondents overwhelmingly disliked a measure of "Observation of Development." This was defined as the "Number of local planning meetings attended by VDOT employees."

78 of the 125 respondents (62%) to survey question 5 ranked this administrative procedure as least useful of the four presented. This is significantly different than 50 percent of respondents ($p = 0.006$), and 50% is double the 25% which would be expected from chance alone. The following four open ended responses illustrate the need for tangible results:

- "Don't you understand that VDOT is developing the reputation as an organization that is good at meetings and public relations, but poor at getting things done?"
- "As indicated [in the questions dealing with administrative procedures], it is very helpful to localities to have support and cooperation with VDOT on standards and planning."
- "Assistance for smaller towns and cities is vital provided the limited budgets we operate under."
- "Small local governments in the commonwealth do not have the expertise in-house to deal with [these types] of issues."

As shown by these comments, survey respondents want VDOT to assist them, not just monitor them. Therefore the administrative procedures with tangible results (i.e. "Planning by VDOT" and "Providing Assistance") received much higher rankings than a measure of an action with no concrete outcome (i.e. "Observation of Development").

Uniform Application of Standards is Important to Measure

Open ended responses called for the consistent application of access management. The performance measure, *Percentage of Commercial Entrance Permits Issued that Meet*

Access Management Spacing Standards, is closely related to this objective. That measure was not among the four administrative measures originally included in the survey, and it was not included in the original drafts of the catalog of performance measures. However, when the importance of uniform application of access standards was highlighted in the survey results, the usefulness of the performance measure *Percentage of Commercial Entrance Permits Issued that Meet Access Management Spacing Standards* became more apparent.

3.3 Challenges Associated with Involving Stakeholders

Surveys are Helpful but Time Consuming

The survey provided invaluable information in this study. However, the implementation and analysis of the survey was very time consuming, and this should be anticipated for future surveys. Challenges can occur before, during, and after the implementation of a survey.

Before Conducting a Survey

It is essential to have an up to date list of contacts for a survey. In this study, the list of potential respondents was compiled from numerous other lists of people VDOT usually associates with. Six potential groups of survey respondents were considered: (1) officials from cities, (2) officials from counties, (3) officials from towns, (4) officials from MPOs

and PDCs, (5) VDOT employees, and (6) employees of private firms. While these six groups of stakeholders represent people who may use the performance measures developed in this project, other potential users are left out. For example, even though they have the final jurisdiction over Virginia's access management program, members of the General Assembly were not included in the survey. They were not included for two reasons. First, it may be difficult to achieve a high response rate from General Assembly members. Second, the respondents included in the survey, such a VDOT employees, were expected to use the performance measures and communicate their values to the members of the General Assembly. Another group of stakeholders which were not included in the survey are business owners. Similar to the General Assembly members, these stakeholders were not expected to use the measures directly. However, transportation professionals such as the employees of private firms may use the measures and communicate their values to business owners.

While Conducting a Survey

An adequate number of respondents will be needed ensure the results of the survey are valid. Some steps which were taken in this study to increase the number of respondents are: (1) The survey was designed with a professional look. (2) Paper letters were sent to many of the respondents in addition to e-mails. (3) Phone calls were made to some of the respondents asking them to respond. Of the 443 potential respondents to the survey, 143 responses were received (32%). Some reasons for a non-response may be: (1) The paper letter sent to counties, cities, and towns was not clear. (2) The paper letter sent by U.S.

mail was lost or not deliverable. (3) The e-mail address used to send the McIntire School of Commerce version of the survey was incorrect. (4) The respondent declined to complete the survey. Reasons for a non-response, such as these, should be accounted for before conducting the survey.

After Conducting a Survey

After conducting the survey it may be necessary to thank the survey respondents for participating. In this study, respondents were offered a copy of the survey results and the final VDOT report if they participated. 19 of the 143 respondents accepted this offer.

Also, after conducting a survey it will be necessary to analyze the results. It is important to consider this early in the survey process while questions are being developed.

Criteria to Compare Measures Must be Chosen Carefully

Two factors should be considered when choosing criteria to compare performance measures: (1) The selection of criteria is somewhat arbitrary and therefore should be done with careful coordination with the stakeholders. (2) Some criteria will be similar, and any bias caused by multiple criteria evaluating the same characteristic should be avoided.

Selection of Criteria is Arbitrary

The input of the steering committee was used to select criteria to evaluate performance measures. While the five criteria used in this study align with the requirements of VDOT, other criteria are suggested in the literature and may be useful for another group. For example, according to Meyer and Miller (2001, p. 226) a measure should possess "sensitivity and responsiveness" and should quantify something at the "appropriate level of detail." Keel, O'Brien, and Morrissey (2006, p. 12) recommend that a measure "incorporate significant aspects of agency operations." Some recommended measures quantify only a small aspect of an access management program. Cambridge Systematics Inc. (2006) and Meyer and Miller (2001) recommend that a performance measure be somewhat universal. Measures which are applicable to one situation are less desirable then measures which can be applied many places. For example, a measure which can be applied across multiple modes of transportation is more desirable than a measure of only highways. These criteria were not used because the VDOT steering committee did not stress the importance of these criteria.

An agency with different objectives may use other than the ones used in this study to evaluate potential performance measures. For example, if the ability to compare the effects of an access management program to the effects of another transportation initiative is desired, many of the potential measures in Tables 2.4.1 and 2.4.2, such as *travel time* or *money spent on highways,* may provide the basis for this task. Many measures which were eliminated early in this study may be very useful to another

audience. For example, measures derived from a computer simulation of traffic conditions were disregarded, but may be very useful for a more theoretical audience. Measures with very complicated definitions which would not be easily communicated to a non-technical audience were also eliminated.

Bias in Criteria Should be Avoided

Since multiple criteria may assess similar objectives, it may be necessary to use a weighting system to identify bias. For example, in this study the criteria *does VDOT control the measure* and *is improvement likely* represent similar objectives. Therefore, the comparison of measures was tested with these criteria scaled down by 50 percent. This weighting showed that in general the same measures received high scores.

Adequate Preparation and Follow-Up is Needed for All Interaction with Stakeholders

Working with stakeholders requires effort both before and after any interaction. Before interacting with stakeholders it is important to adequately prepare any materials which will be presented to them. After interacting with stakeholders, adequate follow-up activities should be conducted.

Preparation for Stakeholder Interaction

Two important groups of stakeholders must be identified: (1) the people who will be using a performance measure and (2) the people who will be implementing the measure. The essential stakeholders should be identified, and priority should be given to their input.

All communication with stakeholders should be straightforward. Since they may not have the same background information as the people developing performance measures, any information presented to stakeholders should include clear explanations and definitions. For example, an access management performance measure could be developed using a micro-simulation program (Eisele and Toycen, 2005). When this was presented to the committee, it was somewhat confusing, and a better definition could have been used.

Follow-Up after Stakeholder Interaction

After interacting with stakeholders, it is important to adequately address their concerns. A clear record should be kept of all interaction with stakeholders as this may be needed to explain how measures were developed. While all recommendations of stakeholders cannot be implemented, an effort should be made to address the relevant comments. Comments from stakeholders whose direct approval is needed for the implementation of performance measures should be given special attention. Also, after working with

stakeholders, they should be updated to ensure that they understand how the project will move forward. This will help prepare them for future interaction.

Ability to Compare to National Standards Should not be Lost

Since no nationally accepted performance measures were found for access management programs, it was not a concern of this study that measures should provide a comparison to national standards. Furthermore, the steering committee did not express a need to compare Virginia's access management program to other states' programs. The literature makes it clear that performance measures must be defined to serve specific groups of people (Cambridge Systematics, Inc., 2006; Wye, 2002). However, if measures are too closely tailored to a specific agency and audience, the ability to compare to national standards may be lost. Serving the stakeholders should not be sacrificed in order to align the measure with an established standard measure. While no national standards were found to evaluate Virginia's access management program, the steering committee did set a standard that all measures should improve over time.

CHAPTER 4: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

4.1 SUMMARY AND DISCUSSION

When performance measures were developed for Virginia's access management program, two groups of stakeholders were included: the people who will implement the measures and the people who will use the measures. A steering committee of VDOT officials represented the people who will implement the measures. A survey of transportation professionals was conducted to assess the views of the people using the measures. Including these stakeholders affected the recommended measures in seven ways. The steering committee caused the following changes:

- The selection criteria were influenced by the committee.
- The form of the measures was tailored to Virginia's access management program.
- Multiple measures were recommended rather than one single measure.
- A *de facto* target of improvement over time was set for all measures.

The survey respondents caused the following changes:

- Improved safety is important to measure.
- All measures should involve a tangible result.
- A measure of whether standards are uniformly applied would be useful.

While including these stakeholders was somewhat time consuming, it produced measures which are more likely to be useful to them. Each of the seven modifications caused by stakeholder involvement has resulted in measures which are more practical. While

stakeholder involvement has improved the set of recommended measures, four challenges were identified:

- Surveys are helpful, but time consuming.
- Selection criteria must be chosen carefully.
- Adequate preparation is needed for all interaction with stakeholders.
- Ability to compare to established standards should not be lost.

4.2 CONCLUSIONS

Stakeholder involvement changed the recommended performance measures. The performance measures recommended for use by VDOT were influenced by the two groups of stakeholders involved in their development. Seven examples of stakeholder influence were identified in this study. The steering committee affected the selection criteria, the final form of the measures, the number of measures recommended, and the "target" used for all measures. The survey results emphasized the need for improved safety, measures of a tangible result, and uniform application of standards.

Challenges exist when involving stakeholders. Four challenges were identified in this study. First, surveys are helpful but time consuming. Second, selection of the criteria to compare measures can be arbitrary and must be done with stakeholder involvement. Third, stakeholder interaction requires preparation and follow-up. Fourth, if measures are tailored to a specific agency, it may be difficult to compare to accepted standards.

4.3 Recommendations

When Performance Measures are Developed, Involve the People who will be Using Them. The people who will be using performance measures should be included to ensure that the measures provide them useful information.

When Performance Measures are Developed, Involve the People who will be Implementing Them. The people who will be implementing performance measures to ensure: (1) the recommended measures meet their criteria, (2) the phrasing of the measures is tailored to the specific program, and (3) the measures align with specific goals and targets of the program.

Adequately Prepare for all Interaction with Stakeholders. To ensure that all interaction with stakeholders is worthwhile, adequate preparation is needed before the interaction, and adequate follow-up is needed afterwards.

4.4 Recommended Methodology to Include Stakeholders

The following four steps should be conducted to include stakeholders in performance measure development: (1) Identify stakeholders and develop a communication strategy for each group. (2) Use stakeholders to learn the background of the program. (3) Align the selection criteria to the needs of the stakeholders. (4) Tailor the form of recommended measures to the specific situation.

Identify Stakeholders and Develop a Communication Strategy for each Group

Identify two important groups of stakeholders: (1) people who will use the measures and (2) people within the agency that will implement the measure. Many times the stakeholders who will use the measure are outside the agency developing the measure, but an effort should be made to consult them for input. Methods of obtaining information from stakeholders include (Urban Land Institute, 1994, p. 52-56):

- Surveys—Polls and surveys require skill to implement and analyze, and they can become time consuming. "Strict objectivity" should be maintained to uphold the integrity of the results (p. 55).
- Meetings—Meetings can take many forms depending on the objective and number of participants. Some strategies include hearings, workshops, and roundtable discussions.
- Interviews—Interviews allow people to be more open than in a public meeting.
- Focus groups—A trained facilitator should conduct these meetings where a small group discusses their views on a topic.
- Hot lines and written comments—If a large number of comments are expected, a hot line can be used. Written comments allow for a message to be conveyed with less risk of misinterpretation.

Determine which stakeholders are essential for the implementation of the recommended performance measures. While all relevant input from stakeholders should be accepted, it may be necessary to limit the amount of stakeholder interaction if the project must move

forward quickly. Therefore, stakeholders whose approval is essential should be identified, and stakeholder involvement should focus on those parties.

Use Stakeholders to Learn the Background of the Program

Begin the process of identifying performance measures by investigating the background of the program being measured. At a minimum, this background should include two components: (1) what are the goals of the program and (2) how does the program achieve these goals. This investigation should include consultation with people involved in the program. For example, to identify potential administrative measures, meetings were held with officials from the VDOT Fredericksburg District.

Align Selection Criteria to the Needs of Stakeholders

Use input from stakeholders to establish criteria to compare candidate measures. A table similar to Figure 4.4.1 can be used to organize the measures for comparison.

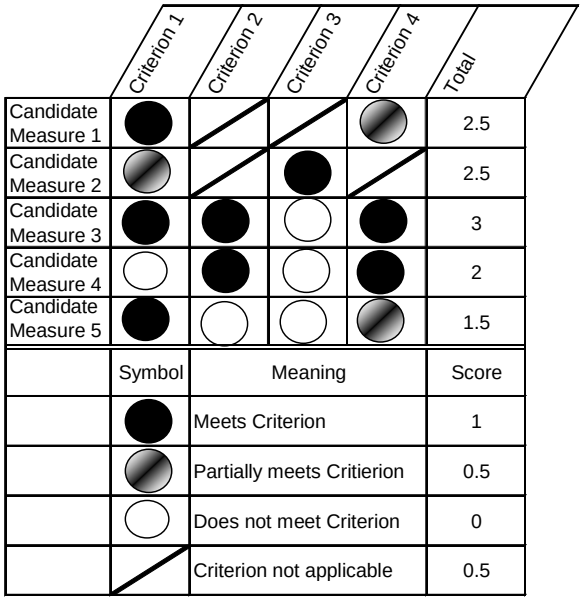

Figure 4.4.1: Table to compare candidate measures.

Figure 4.4.1 gives a total score for each measure based on 4 criteria. While these scores are helpful in screening measures, they should not be the ultimate determination of which measures to recommend. Rather they should act as a guide. Since the selection of criteria is arbitrary they should be based on consultation with the stakeholders.

Tailor the Form of Recommended Measures to the Specific Situation

Refine measures to a form which can be used by the stakeholders. Consider the following when defining a measure:

- A clear explanation of a measure is necessary for each group of stakeholders (Wye, 2002).
- The form of the measure should be understood by the people using it. For example, rates and ratios can make measures easier to understand and put into

context (Cambridge Systematics, Inc., 2006) and higher numbers are associated with better performance (Fielding, et al., 2007).

- Targets and thresholds should align with the goals of a program and the message intended by the people implementing the measure. Thresholds and indexes can be used to make a measure more understandable (Cambridge Systematics, Inc., 2006).
- Measures should align with the specific standards and regulations of a program.

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APPENDIX A: SURVEY AND SURVEY RESULTS ANALYSIS

A.1 FINAL SURVEY QUESTIONS

The final survey included the following thirteen questions:

1. What is your job title?
2. What city, county, or town do you work for?
3. A performance measure could be developed for each outcome listed below. Please rank the outcomes based on their usefulness (1 = least useful; 4 = most useful). Use each rank (1, 2, 3, 4) only once.
    - Air Pollution (Example: Change in Emissions attributed to access management)
    - Crashes (Example: Change is crash rate attributed to access management).
    - Property Values (Example: Change in value of property along a highway attributed to access management)
    - Highway Performance (Example: Change in travel time attributed to access management)
4. A performance measure could be developed for each design element listed below. Please rank the design elements based on their usefulness (1 = least useful; 4 = most useful). Use each rank (1, 2, 3, 4) only once.
    - Conflict points (Example: Number of conflict points along a highway)
    - Traffic signals (Example: Number of signals per mile of highway)
    - Driveways (Example: Number of commercial driveways per mile of highway)
    - Supporting Streets (Example: Number of parallel roadways supporting a highway)
5. A performance measure could be developed for each administrative procedure listed below. Please rank the procedures based on their usefulness (1 = least useful; 4 = most useful). Use each rank (1, 2, 3, 4) only once.
    - Cooperation (Example: Percentage of localities which promote access management)
    - Observation of development (Example: Number of local planning meetings attended by VDOT employees)
    - Planning by VDOT (Example: Percentage of highways in developing areas with an access management plan)
    - Providing assistance (Example: Number of development plans reviewed by VDOT)
6. Which ***set*** of measures from questions 3, 4, and 5 are most useful?
    - Outcomes in Question 3
    - Design elements in Question 4
    - Administrative procedures in Question 5
7. What other measures would also help to describe the performance of Virginia's access management program?
8. The following are six goals of Virginia's access management program. Please rate the importance of each goal (1 = not important; 4 = very important).
    - Reduced congestion
    - Reduced air pollution
    - Improved highway safety
    - Improved economy
    - Lowered need for new roadway construction
    - Preservation of the investment in the highway network
9. The following are seven design elements of an access management program. Please rate the importance of each element (1 = not important; 4 = very important).

- Designing highways with a minimum number of conflict points
- Spacing signals at long uniform distances
- Spacing unsignalized access points at long distances
- Using medians and two way left turn lanes
- Using dedicated turning lanes
- Restricting movements at median openings
- Constructing a supporting roadway network

10. The following are seven administrative elements of an access management program. Please rate the importance of each element (1 = not important; 4 = very important).
    - Developing agreements between the state DOT and local municipalities regarding the development of a highway corridor.
    - Promoting cooperation between the state DOT and local governments
    - Developing an up-to-date land use plan at the local level
    - Creating a plan for the development of a corridor in a rapidly growing area
    - Providing up-to-date access management standards
    - Assisting to localities
    - Reviewing development plans to determine the current access management situation in the area
11. In general, what percentage of your time is devoted to access management issues?
12. Please describe your activities in the area of access management?
13. What other comments do you have?

A.2 Analysis of Survey Results

A total of 443 surveys were sent of which there were 143 responses. The responses were analyzed as described in the following section.

Analysis of Questions about the Background of the Respondent (Questions 1 and 2)

Respondents were asked to provide their job title and employer. This information was used to determine whether the respondent is an engineer, a planner, or some other professional and to determine whether the respondent works for a county, a city, a town, VDOT, an MPO or PDC, or a private firm.

Analysis of Ranking Questions (Questions 3, 4, 5, and 6)

Only responses which *ranked* all four possible performance measures were included in the analysis. Responses where all four rankings were not used were excluded. Two statistical tests were performed for these questions.

First, for each question, the percentage of respondents ranking each performance measures with a *4 (most useful)* was calculated. Then Eq. 1 was used to calculate a 95% confidence interval for the proportion of respondents ranking that performance measure as *4 (most useful)* (Hogg and Ledolter, 1992, p. 179).

$$\hat{p} \pm Z_{\alpha/2}\sqrt{\frac{\hat{p}(1-\hat{p})}{n}} \qquad (1)$$

Where:

$\hat{p}$ = y/n

y = number of respondents ranking a measure with a *4 (most useful)*

n = number of respondents

$z_{\alpha/2}$ = 1.96

Second, for questions 3, 4, and 5, the following statistical test was also performed. For each measure, the percentage of people ranking the measure either 4 (most useful) or 3 (second most useful) was calculated. Then, using a two tailed test, it was determined

whether there is a statistical difference between this value and 50%. Fifty percent was chosen because if the respondents were indifferent about a measure, then it can be assumed that 50% of respondents would rank it 4 or 3 and 50% would rank it 2 or 1. If respondents favor a measure, then the percentage of respondents ranking it 4 or 3 should be above 50%.

Eq. 3 is used to calculate the test statistic $z_{\alpha/2}$ (Freund and Wilson, 1997, p. 164).

$$z_{\alpha/2} = \frac{\hat{p} - p_o}{\sqrt{p_o(1-p_o)/n}} \tag{3}$$

Where:

$\hat{p}$ = Percentage of respondents ranking a performance measure 4 or 3

p_o = 50%

$z_{\alpha/2}$ = test statistic

n = number of respondents

The value *p* (known as the "*p* value" or "probability value" (Hogg and Ledolter, 1992, p. 230)), is the probability that the test statistic $z_{\alpha/2}$ in equation 3 will be greater than the observed value of this statistic when the null hypothesis is that $\hat{p} = p_o = 50\%$. Large values of $z_{\alpha/2}$ correspond to smaller values of *p*. Equation 5 shows that for a two-tailed test, $z_{\alpha/2}$ values of 1.645, 1.96, and 2.576 correspond to *p* values of 0.10, 0.05, and 0.01. Smaller values of *p* suggest it is more likely that the null hypothesis ($\hat{p} = 50\%$) should be rejected; conventional practice is that *p* values below 0.05 (or Z values above 1.96) indicate a significant difference.

$$p = 2(1 - \Phi(Z)) \quad (5)$$

where

Z is the test statistic computed from Eq. 3

$\Phi(Z)$ is the percentage of area at point Z for the standard normal distribution.

Analysis of Rating Questions (Questions 8, 9, and 10)

For questions asking respondents to rate the importance of various aspects of an access management program, the average rating for each goal or element was calculated. The responses were compiled based on the employer of the respondent, and the highest rated goal or element was found for each type of employer.

Analysis of Open Ended Questions (Questions 7 and 13)

The written responses to the open ended questions were used to identify unique views of the respondents. The responses were grouped into categories which reflect similar viewpoints. Some of the views expressed by respondents added new information not included in the other survey questions, and they were incorporated into the final results.

APPENDIX B: PERFORMANCE MEASURES RECOMMENDED IN THE LITERATURE

While there is no widely accepted performance measure for access management, many have been suggested in the literature. Most of these are not refined to a level where they could be immediately implemented by VDOT. However, they do provide an excellent base from which useable performance measures can be developed. Thirteen measures which are not addressed in the catalog of performance measures are marked with an asterisk (*). The measures come from four sources:

1. *NCHRP Report 548: A Guidebook for Including Access Management in Transportation Planning* (Rose, et al., 2005)
2. *Review of SDDOT's Highway Access Control Program* (Rose, et al., 2000)
3. *Identifying and Quantifying Operational and Safety Performance Measures for Access Management: Micro-Simulation Results* (Eilele and Toycen, 2005)
4. *Development of an Arterial Corridor Management Strategy for the Capital District: Land Use/Traffic Conflict Index* (Benware and Jukins, 1995)

NCHRP Report 548: A Guidebook for Including Access Management in Transportation Planning (Rose, et al., 2005, p. 34-35)

- * "Determining the rate at which access management is implemented when opportunities emerge."
- "Measuring impacts on speeds and accident rates where access management has been implemented."
- "Tracking the number of variances granted."
- * "Tracking the number of driveways consolidated."
- "Tracking the number of miles of access rights acquired or controlled."
- * "Learning the reasons access management could not be implemented where an apparent opportunity existed."

Review of SDDOT's Highway Access Control Program (Rose, et al., 2000, pVIII-17—VIII-18)

- "Total accident rate in accidents per million vehicle miles."
- * "Number of rear-end or other types of collisions per million vehicle miles or per mile as a function of access density."
- "Number of conflicts (i.e. evidenced by braking or evasive maneuvers) or conflict points (i.e. movements crossing, merging, or diverging)."
- "Number and type of exceptions to the adopted access criteria."
- * "Average number of approaches approved per application (involving developments that exceed a threshold to be established)"
- "System-wide travel speed, delays, and/or signal progression efficiency."
- * "Number of driveways consolidated as part of retrofit activity."

- "Local jurisdictions with ordinances that support access policy objectives."
- * "Dollars spent annually on retrofit projects."
- * "Gallons of motor vehicle fuel saved through improved system operations."
- "Emissions reduced through improved traffic operations by type of emission."
- * "Road user benefits dollar value through reduced delay."
- * "Average number/percent of permit requests processed within established turnaround time."
- * "Customer service rating for permit process."
- * "Applications processed per employee."
- * "Number of individuals participating in training and other on going activities."
- "Miles of state highway system with access plans."

Identifying and Quantifying Operational and Safety Performance Measures for Access Management: Micro-Simulation Results (Eilele and Toycen, 2005, p. 14)

- "Time-to-Collision"—"Time it would take for a vehicle to collide into another if they continue at the same speed without trying to avoid each other."
- "Postencroachment Time"—"Time between the first vehicle and following vehicle to cross the avoided conflict location."
- "Deceleration Rate"—"Rate at which a vehicle decelerates to evade a potential collision with another vehicle."
- "Maximum speed of the two vehicles"—"Calculated by first calculating the maximum speed of each vehicle. Then each of those speeds is compared to determine the maximum speed."
- "Maximum relative speed of the two vehicles"—"Calculated as the difference in velocity for every time slice during the time of the conflict event. The maximum value of the time slice is recorded as DeltaS."

Development of an Arterial Corridor Management Strategy for the Capital District: Land Use/Traffic Conflict Index (Benware and Jukins, 1995)

* The Capital District Transportation Committee of Albany, New York developed a measure called the "Level of Compatibility" (p. 3). It assigns a grade to a roadway based on its average annual daily traffic (AADT) and the average distance between driveways. The AADT is divided by the average distance between driveways to produce an index score. This score is then correlated to a letter grade with separate grading scales for commercial and residential areas. Higher scores produce worse grades (Benware and Jukins, 1995).