FINAL
CONTRACT REPORT

EXTENDED COMPARISON TOOL FOR MAJOR HIGHWAY PROJECTS

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Supplementary Notes

Abstract

Under the Virginia Transportation Act signed into law in April 2000, more than $10 billion would have been invested in highway construction, public transportation, airports, and ports during the following 6 years. However, recent budgetary constraints will result in a delay in investing more than $2 billion in road projects for more than a decade. In the current study, a previously developed comparison tool was extended to bring quantitative evidence of safety and categorical evidence of broad motivations to planners, engineers, and the public in comparing the benefits of proposed transportation projects.

The extended tool developed in the current study provides visual devices for presenting multifaceted information about project attributes. Policymakers and planners may find the presentation useful in assessing what types of projects are being undertaken and what projects to prefer to others. The extended tool represents project information including cost, average daily traffic, and crash rates for comparison and prioritization of the 1,500 candidate projects that constitute the development plan of Virginia highways. The extended tool is flexible to accommodate applications such as project selection (planning) and programming. Several sources of information include the crash databases of the Virginia Department of Transportation (VDOT) and project plans for districts and localities. The extended tool enables planners to identify principal motivations for various projects based on categories defined by the Transportation Equity Act for the 21st Century. The tool introduces summary reports of criteria including project aggregate costs and counts of projects with particular motivations, facilitating system-level analyses and project ranking. The summary reports can be useful to interpret outcomes of human deliberation or multicriteria rating and ranking processes, some of which are demonstrated in this study in the body of the report and in a substantial appendix.

The major innovation of the extended comparison tool is its ability to synthesize the relevant quantitative and categorical information on a large and diverse portfolio of highway investments, bringing more evidence to the table earlier in the planning process. Three case studies demonstrate the application of the extended comparison tool in short-, medium-, and long-term transportation plans. These case studies are the VDOT-Culpeper District Transportation Development Plan (a 6-year plan), long-range financially constrained plans of selected small Virginia localities, and the long-range plan of the Thomas Jefferson Planning District Commission. The incremental data to assess over 100 projects in a VDOT District Six-Year Plan were collected in 90 minutes, providing an advantage over typical methods that can require several hours or more per project. Recommendations are given for implementation of the extended comparison tool and further development of the software prototype.

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INTRODUCTION

Transportation agencies face the following two challenges: (1) allocating limited public funds among potential transportation improvement projects, and (2) determining the order in which selected projects should be undertaken. Within the Virginia Department of Transportation (VDOT), there has been a call for a process for prioritizing potential improvement projects on regional and statewide scales. The Governor's Commission on Transportation Policy suggested that the Six-Year Improvement Program document has the following weaknesses: lack of stakeholder confidence that proposed improvements will be fully funded and constructed within a defined timeframe, lack of a prioritization method for programming improvement projects, lack of objective criteria to enable decisionmakers to select transportation projects to go into the program, and lack of coherent information for stakeholders (Governor's Commission on Transportation Policy, 2000).

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and its reauthorization, the 1998 Transportation Equity Act for the 21st Century (TEA-21), have envisioned a transportation planning and programming process that is multimodal, user-oriented, and flexible in its approach to project selection. TEA-21 specified seven classes of planning factors: support of economic vitality; safety and security; accessibility and mobility; energy conservation and environmental protection; integration and connectivity; efficient system management; and system preservation. The Federal Highway Administration (FHWA) specified the goals of improved safety, mobility, productivity, consideration of human and natural environments, and national security (FHWA, 2000). The Governor's Commission on Transportation Policy set the criteria: safety, leveraging options, economic development, quantitative measures of use, land use or environmental considerations, and innovation. A review of VDOT programs by the American Association of State Highway and Transportation Officials (AASHTO) in 2002 suggested the following actions for a six-year program: establish meaningful criteria for project inclusion in the six-year program, build on positive characteristics of the secondary system process, and create a long-term plan to address issues voiced in the legislature and by citizens.

PURPOSE AND SCOPE

The purpose of this study was to develop a comparison and prioritization tool to aid VDOT in comparing major highway infrastructure investment projects. The study develops a multifaceted approach for assessing the potential for transportation improvement projects. It presents information in a way that summarizes project attributes across multiple dimensions while avoiding (a) a time- and resource-intensive process of multicriteria rating, and (b) collection of infeasibly large data sets. With a few simple project attributes -- ADT, crashes, cost, and a qualitative understanding of which one or two TEA-21 factors motivate the project -- one can have a broad view of how hundreds of projects compare to one another. Such a view can be useful early in the planning process, at the point where TIP and STIP submissions are being considered but not resolved, or much later at the point of program review and auditing. The scope of the effort included reviewing the literature and other agencies' experiences; identifying useful performance measures in the comparison of major projects; developing tools for displaying project information, including quantitative and qualitative factors; developing prototypes of databases, spreadsheets, and web-based tools; and presenting case studies.

This report is organized as follows. First, a review of the prioritization methods of other transportation agencies is presented. Second, an extended comparison tool is developed based on the combination of quantitative and categorical project data. Third, three case studies are presented to demonstrate the use of the tool for project portfolios with various planning horizons. Fourth, conclusions and recommendations are based on user reviews of the software prototype and case studies.

METHODS

Some Multicriteria Methods Applied to Transportation Projects

Saaty (1995) illustrated applying the analytic hierarchy process (AHP) to transport planning with multiple criteria. Tabucanon and Lee (1995) used the AHP to evaluate rural highway improvement projects using tangible and intangible criteria. Kulkarni et al. (1993) used a multiattribute penalty function to evaluate and rank the overall impact of alternative highway alignments. Tsamboulas et al. (1999) applied five multicriteria methods: REGIME, ELECTRE, MAUT, AHP, and ADAM to the assessment of transportation. A comparative analysis of the methods was performed in terms of transparency, simplicity, robustness, and accountability. The review identified the need for a methodology, which would be open and conducive to education instead of a black box, to support the synthesis of quantitative and categorical evidence in comparing and prioritizing portfolios of more than 1,000 highway investments.

The Comparison Tool: A Foundation of the Current Effort

In an earlier effort, the Center for Risk Management of Engineering Systems of the University of Virginia (CRMES) developed a graphical tool that enables comparing different road construction projects on a common ground (Baker and Lambert, 2001; Frohwein et al., 1999). The tool presents tradeoffs among three major factors: risk reduction, performance gain, and cost. Examples of risk measures are crashes per year, crashes per vehicle, crashes avoided per vehicle, crashes avoided per year, and lives lost or injuries. Examples of performance measures are daily traffic, travel time saved per vehicle, and total travel time savings. Examples of cost measures are right of way, preliminary engineering, construction engineering, life cycle, and length of road section. The method uses readily available data and structured engineering assessments. The tradeoffs are shown graphically in multiobjective charts and tables representing project portfolios. The overall approach aims to be an aid for project portfolio inspection and evaluation rather than producing decisions in an automated computation. The comparison tool brings relevant available information to the table and encourages transparency in decisionmaking. Figure 1 illustrates comparing the risk measure *crashes avoided* with the performance measure *travel time saved*, where *range bars* can be used to show the precision of the available estimates. Figure 2 shows the comparison of multiple projects from the Richmond District development plan. Further examples of the use of this earlier comparison tool are described by Baker and Lambert (2001) and Lambert et al. (2000).

The review of prioritization methods being used to perform transportation planning shows that several issues and concerns must be considered before funding is approved (see Appendix A for prioritization methods collected from other states; also see Fontaine and Miller, 2002). Transportation planning does not involve traffic considerations only (e.g., congestion, travel time, and mileage); it also includes economic development, accessibility, mobility, safety, environmental, and management issues. From the criteria developed by different transportation agencies, it can be seen that each state or jurisdiction has its own goals and objectives. For example, the Alaska Department of Transportation (DOT) is more concerned with environment and system management, and the Ohio DOT gives importance to transportation efficiency and economic development (Alaska DOT and Public Facilities, 2001; Ohio DOT, 2001). The prioritization methods used do not necessarily give equal weight to all criteria. The criteria usually given more importance are economic development and those related to mobility. It can also be noted that some evaluation criteria apply to specific project types only, such as bridges and highway systems.

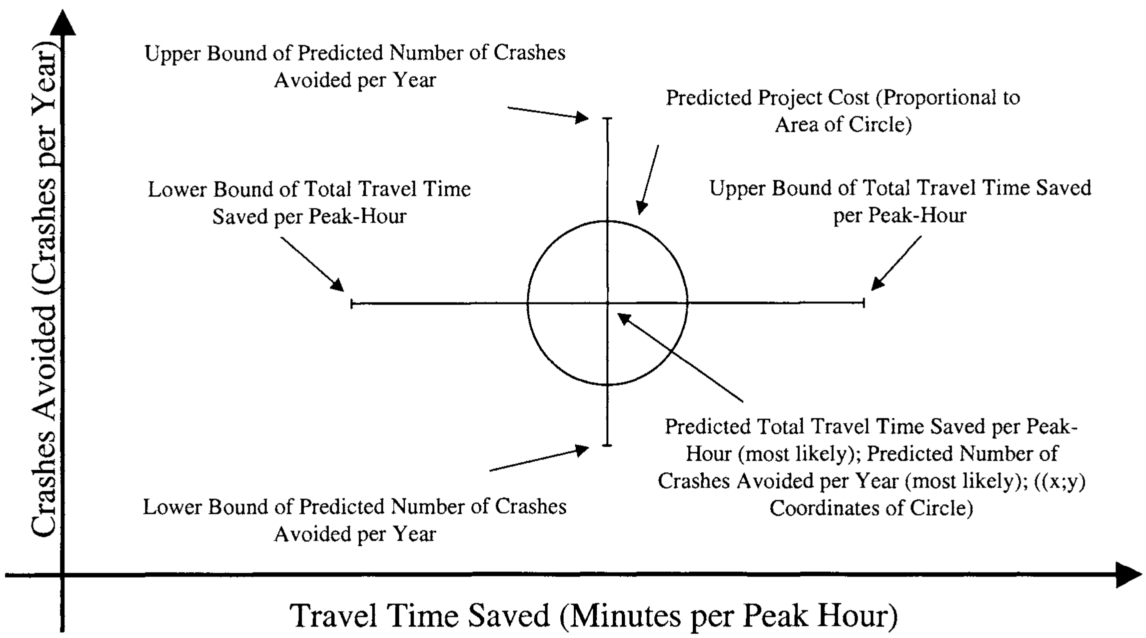


Figure 1. Comparison chart using range bars to show precision of the available assessment.

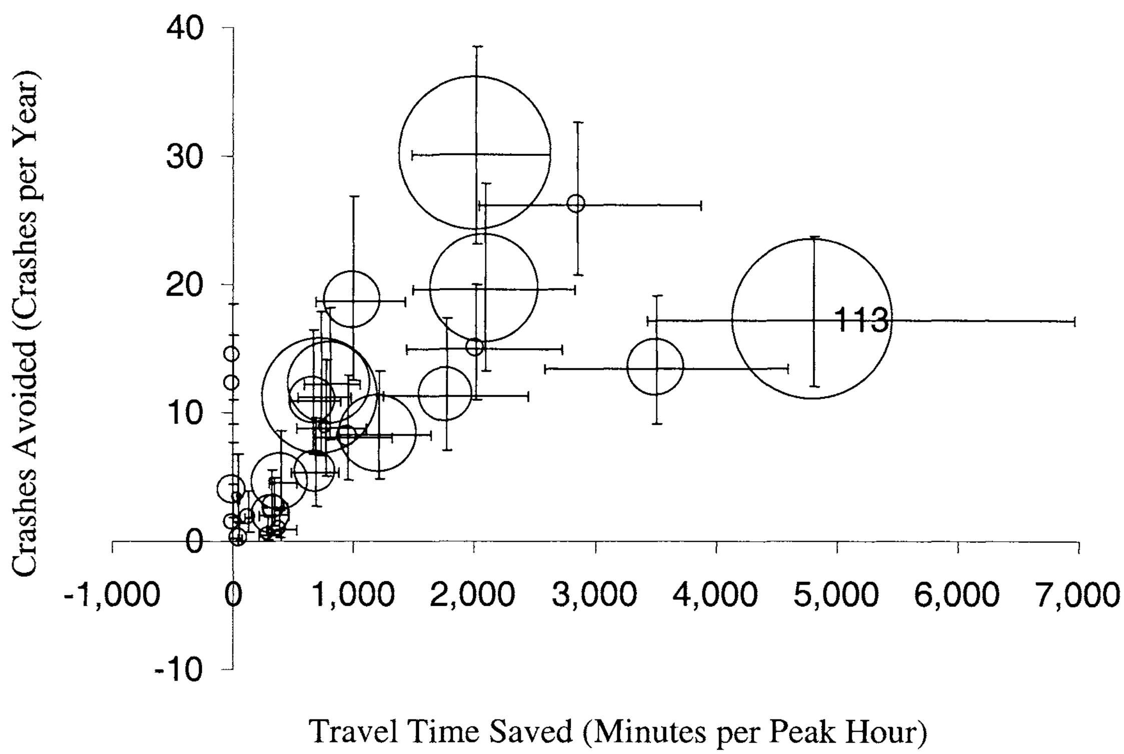


Figure 2. Comparison tool of a prior effort showing multiple projects in charts with error bars.

The need to have quantifiable criteria is apparent. It is, however, apparent that qualitative, categorical performance metrics are useful because of the presence of non-quantifiable goals or objectives. The prioritization methods used by the various transportation agencies have criteria that address both quantitative and categorical concerns. The quantitative criteria commonly used are average daily traffic (ADT), accident rate, volume-to-capacity ratio, and cost. Categorical criteria such as community support, investment sustainability, and quality of life may be difficult to use in evaluating transportation projects. To minimize biased evaluations, specific guidelines are formulated to assist in project assessment. The evaluation scales developed by the Alaska DOT are examples of such guidelines (see Appendix A).

An examination of prioritization methods used by other state agencies (e.g., City of Sacramento, 2001; Delaware DOT, 2001; Montana DOT, 2000) and of principles in decisionmaking with multiple criteria suggests a need for comparison and prioritization methodology that:

- supports the visions and goals of the transportation agency
- meets the needs of diverse stakeholders
- provides flexibility in dealing with different transportation alternatives
- considers a variety of transportation planning criteria
- is easy to understand and implement
- makes use of existing relevant data at appropriate levels of precision
- deals with sparse or missing data
- handles qualitative and quantitative factors
- displays the tradeoffs among potentially conflicting criteria
- allows for treatment of uncertainty
- provides accountability of results and decisions
- accommodates a large number of projects and criteria.

The extended comparison tool developed in the current effort aims to address these issues and needs.

Extended Comparison Tool for Highway Improvement Projects

Some features of the extended tool located at http://www.virginia.edu/crmes/comparison/ are described below. Additional important features are described in the later case studies.

The extended comparison tool was developed to aid VDOT transportation planners to allocate project resources under the TEA-21 guidelines. The comparison of projects is guided primarily by the TEA-21 factors of accessibility/mobility, economic development, operations and management, environmental protection, safety and security, intermodal connectivity, and system preservation. Figure 3 shows the steps undertaken in applying the extended comparison tool. For each candidate project, the description, costs, ADT, crash rates, and pair of primary TEA-21 motivations are assessed.

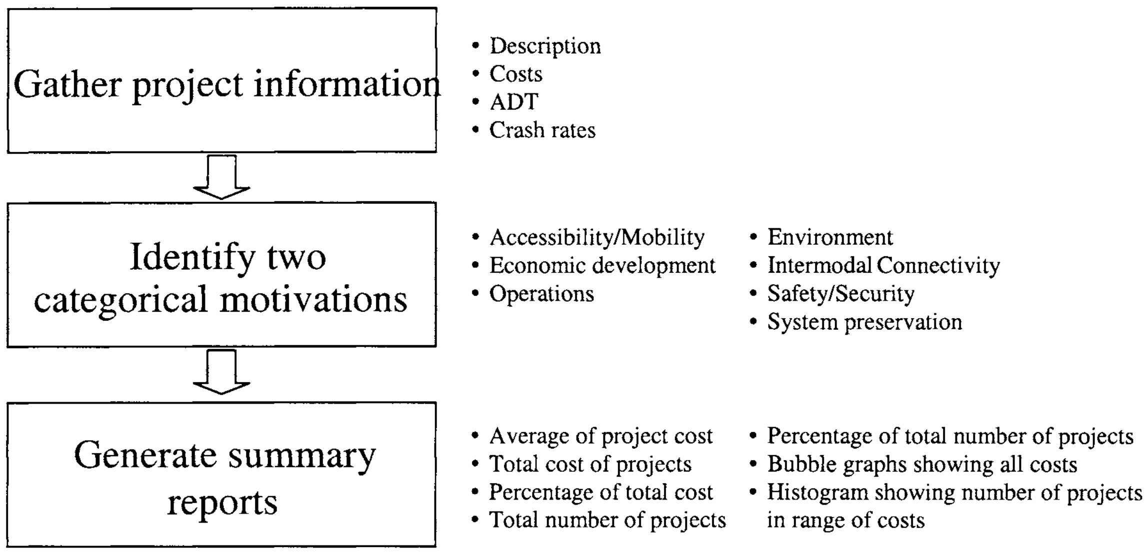


Figure 3. Steps in applying the extended comparison tool.

Taking the available data of crash rates, ADT, and costs, the projects are grouped according to their motivations. Projects with identical primary motivations are described alternately by aggregate statistics in the appropriate box-sectors of Figures 4 and 5 in terms of:

- Number of projects
- Costs
- Average cost
- Federal funds
- State funds
- % non-state funding
- % state funding
- ADT
- ADT per $
- ADT per state $
- ADT per federal $.

The user/decision maker can choose the metric labels and obtain descriptions of such metrics. The data on specific projects can also be displayed.

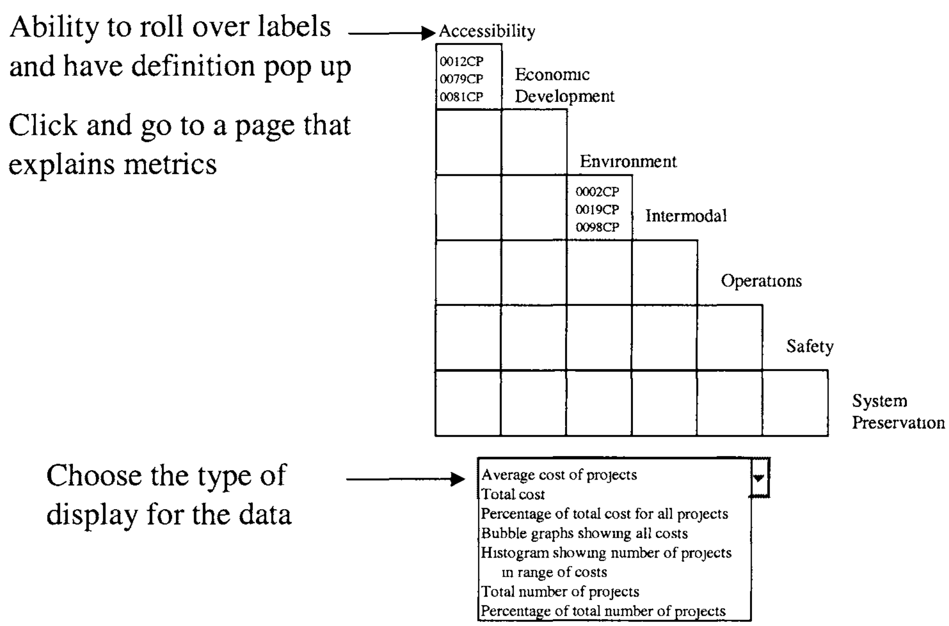


Figure 4. Design of interface showing information on projects.

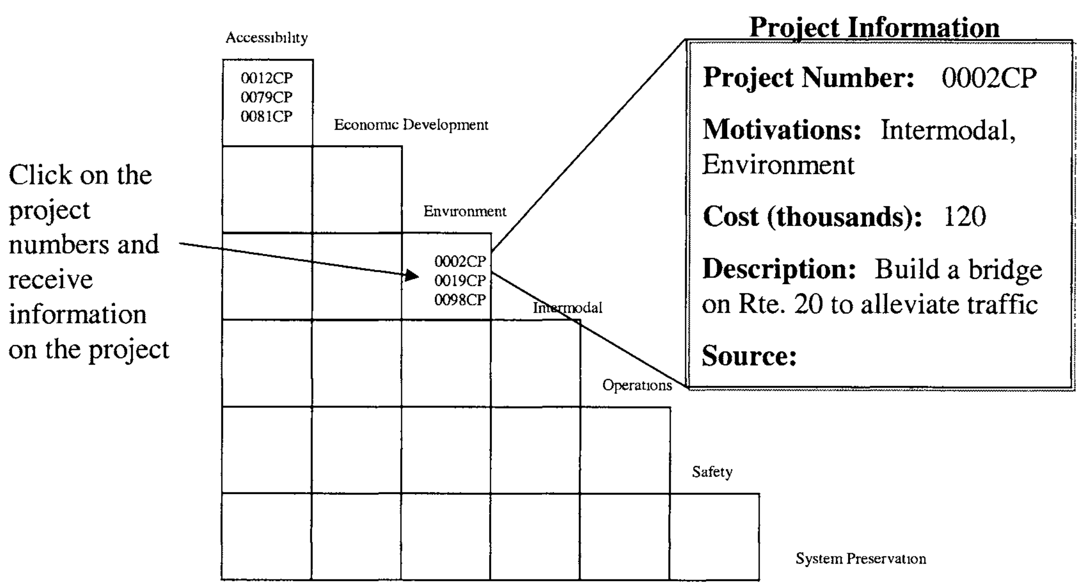


Figure 5. Information displayed when project ID is chosen.

Metrics and Ranking

The developed extended comparison tool supports the ranking of projects according to alternative criteria, including:

- ADT
- Cost
- Non-state share of cost %
- Non-state funds ($)
- ADT per $
- ADT per state $
- Median of the above rankings.

A review was performed of metrics used in other cities, states, and federal agencies. The metrics were grouped according to TEA-21 factors, with sub-groups within each factor (see Appendix B). Distinct scoring levels were developed and, when possible, quantitative scores were developed. Since there can be numerous metrics, the factor lists were checked to limit overlap and redundancy.

Prototype of Web Interface

A prototype web interface was developed to enhance communication regarding the development plan between VDOT and Virginia citizens. Providing detailed information on funded projects' goals, costs, and locations will promote a higher level of citizen awareness and support. Citizens will be able to better understand the complexity and inherent tradeoffs associated with the selection process and see how the projects selected contribute to larger goals for the state.

The interface will allow users to search for projects according to location and initiative. The search would lead to more detailed project information such as description, cost, and project timeline.

Figure 6 shows an interface to the Six-Year Program on the current VDOT website.

Figure 7 describes how visitors might use pull-down menus to select the district, county, or city of particular projects.

Site visitors might be enabled to search as well by categorical initiative, that is, by selecting to view projects with major *environment* or *economic* impacts.

Visitors might in this way be guided to the detailed descriptions of projects, including local area maps and interpretive graphics highlighting the project impacts as depicted in Figure 8.

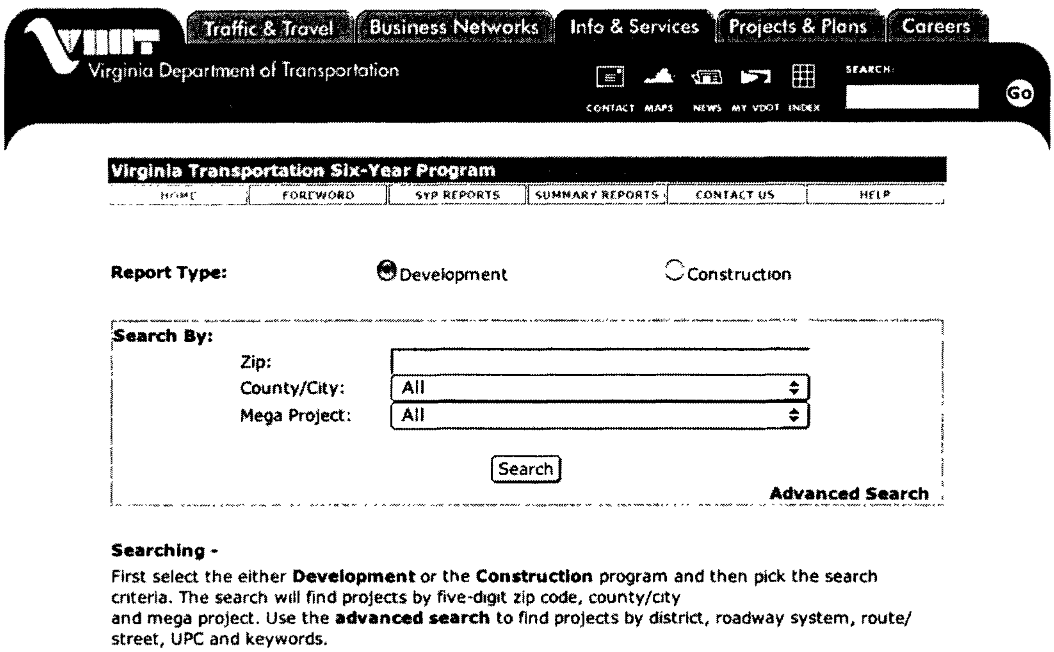


Figure 6. A current interface to the Six-Year Program (www.virginiadot.org).

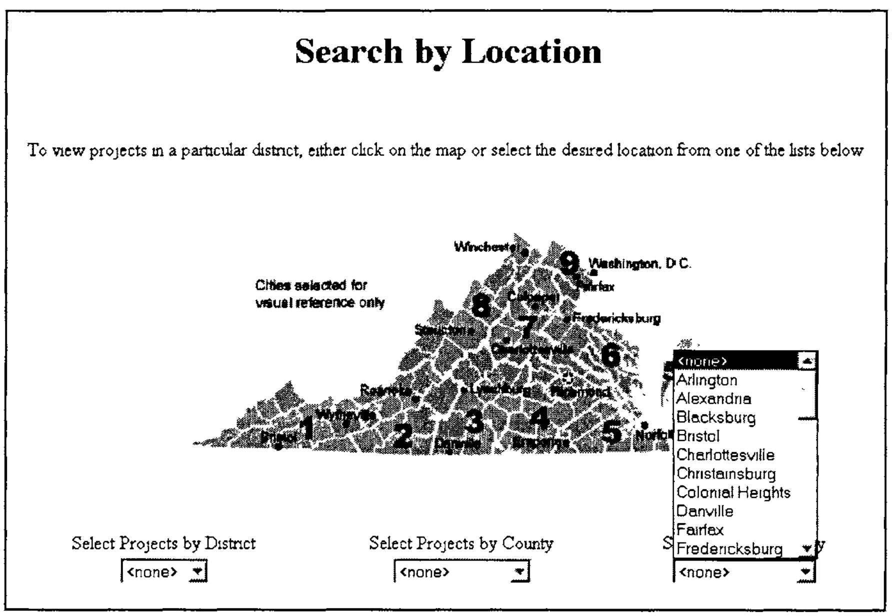


Figure 7. "Search by Location" page where users can select projects from specific areas.

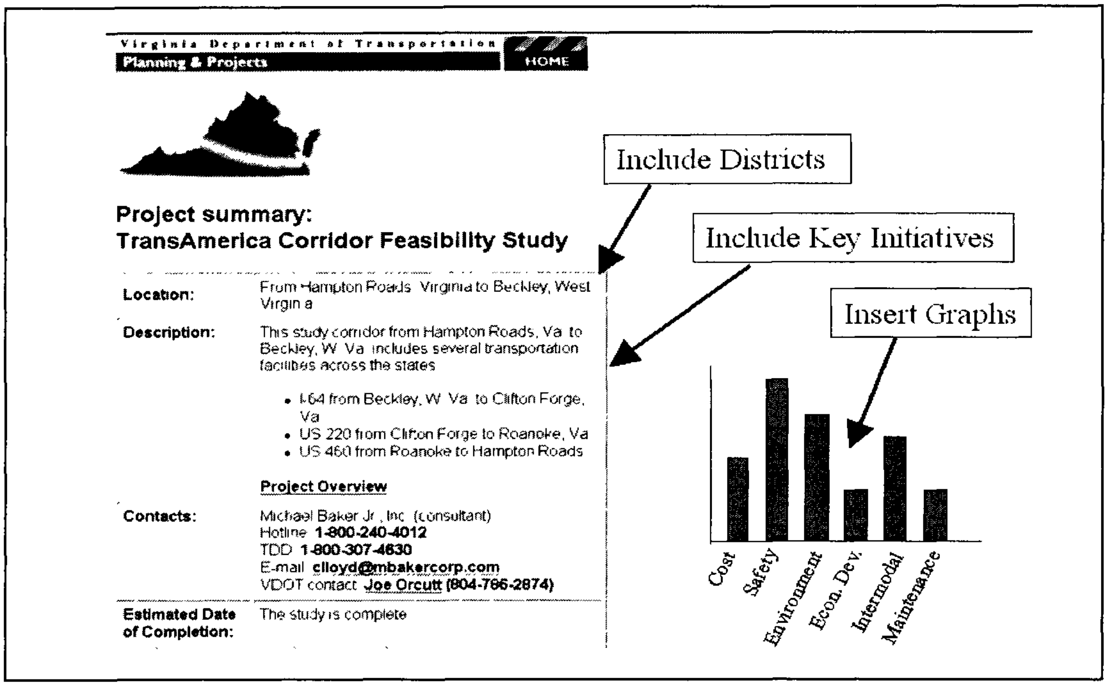


Figure 8. Project description page where users can view project location, details, and graphics portraying performance goals.

Prototype in an Excel Spreadsheet

A prototype of the extended comparison tool in an Excel spreadsheet has been available for review by potential users at http://www.virginia.edu/crmes/comparison. The prototype has functions that facilitate entering project information and creating comparison charts. Specifically, the functions of the prototype include:

- Data input for project name and identification number, and two primary motivations for each project
- Choice of which projects to include in the comparison
- Graphical comparison of the projects based on chosen motivations and criteria (crash rate and average daily traffic were used for prototype)
- Statistical results of the project based on primary motivations
- Ranking of projects based on a selection among ADT, Cost, Non-State Share of Cost %, State Cost ($), ADT per $, ADT per State $, Crash Rate (crashes per million VMT), Crash Rate per $, and Crash Rate per State $.

CASE STUDY RESULTS

Three case studies show the application of the extended comparison tool to the long-, medium-, and short-term planning of major infrastructure investment projects. The case studies are VDOT's transportation development plan for its Culpeper District, the Metropolitan Planning Organization/Thomas Jefferson Planning District Commission, and the Virginia localities of Blackstone and Big Stone Gap. To identify the TEA-21 motivations for each project for a District's section of the Six Year Improvement Program required only 90 minutes of interview with the District Engineer. The crash-rate and ADT data are pre-existing or able to be collected by automated tools. This 90 minutes is far less than would be required to do numerical computations for attributes that quantify impacts in TEA-21 categories. Specifically, we asked the engineer such questions as "Did economic development issues motivate this project more strongly than environmental issues?" A resource-intensive (possibly infeasible) approach might require metrics of unemployment rate and air quality to quantify a project's impact in the same TEA-21 categories. The quick turnaround time of the three case studies is suggestive that our approach can provide comparative views of the many projects of the TIP or STIP efficiently and meaningfully. The case studies can be viewed on a prototype of the software at http://www.virginia.edu/~risk/comparison/. This software prototype provides an excellent stand-alone introduction to the extended comparison tool.

The processes for the case studies were as follows:

- For each relevant project, determine ADT, crash rate, cost, and TEA-21 motivations. (The choice to use crash rate rather than "crashes avoided" as in a previous version of the comparison tool is that the "crashes avoided" methods are too intensive to apply to 1,500 project locations in a year. The crash rate is a readily available upper bound on "crashes avoided.")

- Use these data to apply the extended comparison tool to the project set.

Assumptions common to the three case studies are:

1. *Intersections have a 150-ft radius of influence for the purpose of crash rate and exposure computation.* DVMT (daily vehicle-miles traveled) is equal to the DEV (daily entering vehicles) multiplied by (300 ft/(5,280 ft/mi)). Crash rates for segments longer than 5 mi can be obtained by modifying the data or upon request to VDOT.

2. *Crashes associated with a bridge include those accidents that occur right before entering and right after exiting the bridge.* To find the crash rates, DVMT, etc., for bridges, the two closest nodes surrounding the bridge were used. The resources currently available make it difficult to accurately establish the exact location of the reference nodes with respect to the length of the bridge in the Highway Traffic Records Inventory System (HTRIS).

Case Study 1: VDOT's Transportation Development Plan for Culpeper District

This case study examined a subset of projects for VDOT's Culpeper District in the Transportation Development Plan. Project data from HTRIS that were recorded for this case study were: *project number from prior case study, "to and from" node numbers, project length (miles), DVMT, crashes per 3 years (1998-2000),* and *accident rate (accidents per 100 million miles traveled).* Some projects were difficult to locate in HTRIS due to a lack of route number or a node that could not be located. Table 1 shows the project information used for the case. Projects motivated by accessibility/mobility and safety/security are shown in Figure 9. An icon of small area (relatively lower cost) that is high and right in the figure is associated with potentially large efficiency of investment to affect either or both of current crash rate and traffic users. An icon of large area that is low and left in the figure is associated with potentially small efficiency of investment to affect either or both of current crash rate and traffic users. But the investment represented by the large icon may be preferred to investment represented by the small icon for unquantified reasons, such as an overriding *security* concern. Moreover, the smaller investment may be ineffective to reduce crash rate and delay/congestion, while the large investment may be effective to achieve both. The figure highlights when such questions should be posed, whether for pairwise comparison of projects, for comparison of a single project to a portfolio of projects, or for comparison of multiple portfolios. Projects can be highlighted with shadings to facilitate such comparisons.

The number of projects under specific motivations, the sum of the costs, and total ADT of these projects are summarized in Figure 10.

Table 1. Project Information for Case Study on Culpeper District.

Project ID #	Cost ($ thousands)	ADT (average daily traffic)	Crash Rate (crashes per million VMT)	Primary Attributes
000001	525	4470	159	Accessibility/Mobility
000002	1881.6	10000	18	Accessibility/Mobility
000012	25	4400	10	Accessibility/Mobility
000013	2.9	3210	10	Accessibility/Mobility
000014	318.7	3120	10	Accessibility/Mobility
000015	682.9	1580	714	Accessibility/Mobility
000016	760.6	1580	10	Accessibility/Mobility
000017	202.7	1930	10	Accessibility/Mobility
000019	3840	8200	62	Accessibility/Mobility
000003	100	10490	131	Safety/Security
000004	96	9900	50	Safety/Security
000005	77.1	10200	10	Safety/Security
000006	44.5	8980	10	Safety/Security
000007	29.7	8980	10	Safety/Security
000008	95.4	9150	85	Safety/Security
000018	572.4	9650	409	Safety/Security
000020	31.2	6600	143	Safety/Security
000021	15.6	7400	10	Safety/Security
000009	1.3	9150	645	Intermodal Connectivity
000010	32.8	7180	25	Intermodal Connectivity
000011	64.5	4930	71	Intermodal Connectivity

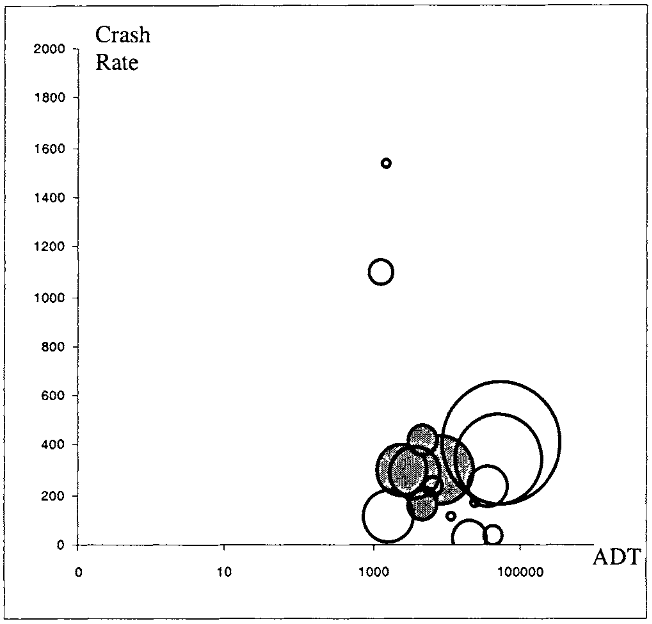


Figure 9. Comparison of projects motivated by *accessibility/mobility* and *safety/security* (of the seven TEA-21 motivations) with individual projects highlighted to facilitate comparison (size of bubble represents project cost).

	Accessibility/Mobility	Economic Development	Operations	Environment	Intermodal Connectivity	Safety/Security
Economic Development	—					
Operations	—	—				
Environment	—	—	—			
Intermodal Connectivity	—	—	—	—		
Safety/Security	18 78,976 296,818	—	—	—	—	
System Preservation	—	—	2 4,346 12,669	1 1,615 6,535	—	2 14,844 50,971

Figure 10. Several projects under specific motivations, showing the number of projects, the sum of the costs ($ thousands), and total ADT, respectively.

Case Study 2: MPO/Thomas Jefferson Planning District Commission

This case study examined a subset of projects for the Thomas Jefferson Planning District Commission. The projects for this case were documented from the Charlottesville and Albemarle (CHART) 2021 Plan Update. Project data include the project ID, location, task, type, ADT (1997 and 2001), cost, to-and-from mile markers, to-and-from node numbers, project length (miles), DVMT, crashes (1998-2000), crash rate (crashes per 100 million miles traveled), fatality rate (fatalities per 100 million miles traveled), injury rate (injuries per 100 million miles traveled), property damage (PD) accidents and amount of PD and accident data (January 1, 1998-December 31, 2000). Planned new roads were not evaluated because of the lack of data, including the Meadow Creek Parkway, Southern Parkway, and Hillsdale Drive Connector. Table 2 shows the project information for the Metropolitan Planning Organization (MPO) case study.

The projects are shown in Figure 11, grouped in 21 quadrants according to their two identified primary attributes. For example, the projects in the uppermost and leftmost quadrant are those with *Accessibility/Mobility* and *Economic Development* as their primary TEA-21 attributes. The crash rates and average daily traffic are also represented in Figure 11. The inset legend gives the scales of the chart axes, locating the center of each project icon within its quadrant. The area of the project icon shows the relative cost of each project. In aggregate terms, the group of projects can be evaluated in terms of the ratio between the cumulative (sum over the quadrant of projects) accident rate and cumulative cost, as shown in Figure 12. The ratio between cumulative ADT and cumulative cost can also be generated for each group of projects as shown in Figure 13. Such aggregate statistics can suggest the potential gross efficiencies of investments in projects with identical TEA-21 motivations.

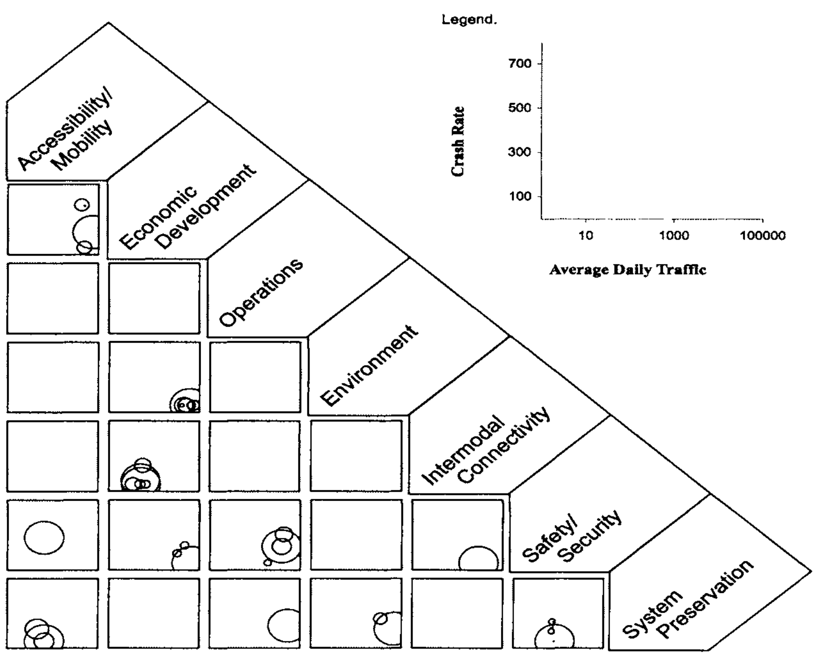


Figure 11. Projects for the Thomas Jefferson Planning District grouped according to primary attributes, with the project costs represented by the size of the bubbles.

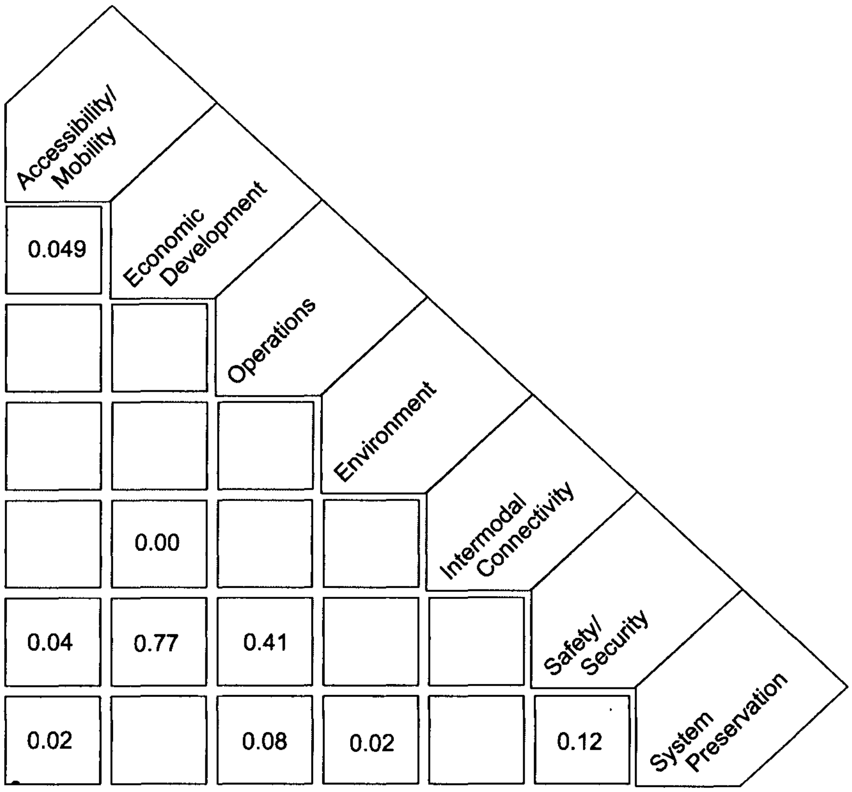


Figure 12. Ratios between cumulative accident rate and cumulative cost for projects for the Thomas Jefferson Planning District, grouped according to primary attributes.

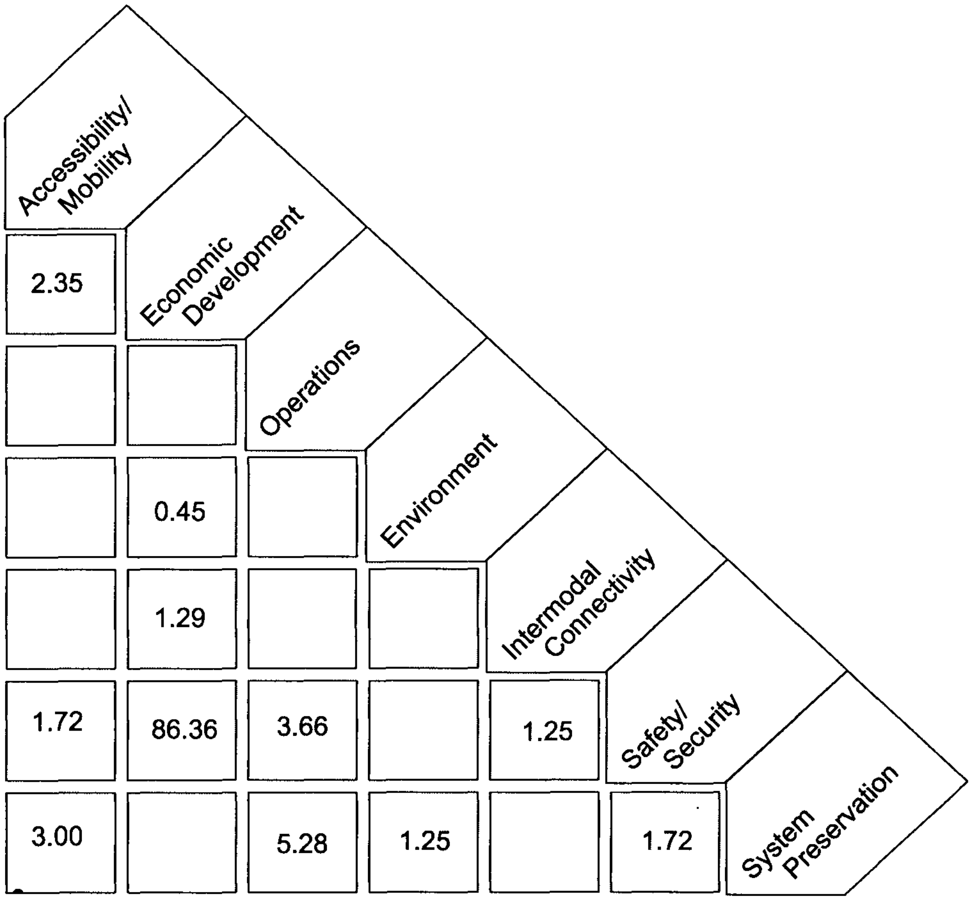


Figure 13. Ratios between cumulative ADT and cumulative cost for projects for the Thomas Jefferson Planning District, grouped according to primary attributes.

Case Study 3: Blackstone and Big Stone Gap Localities

The third case studied projects in the Blackstone and Big Stone Gap localities. Data for this case study were gathered from HTRIS and from the VDOT Small Urban Area Transportation Plans (VDOT Small Urban Area Transportation Plans, 2002). Table 3 gives the ADT, crash rate, and cost in year 2000 dollars used in this case study.

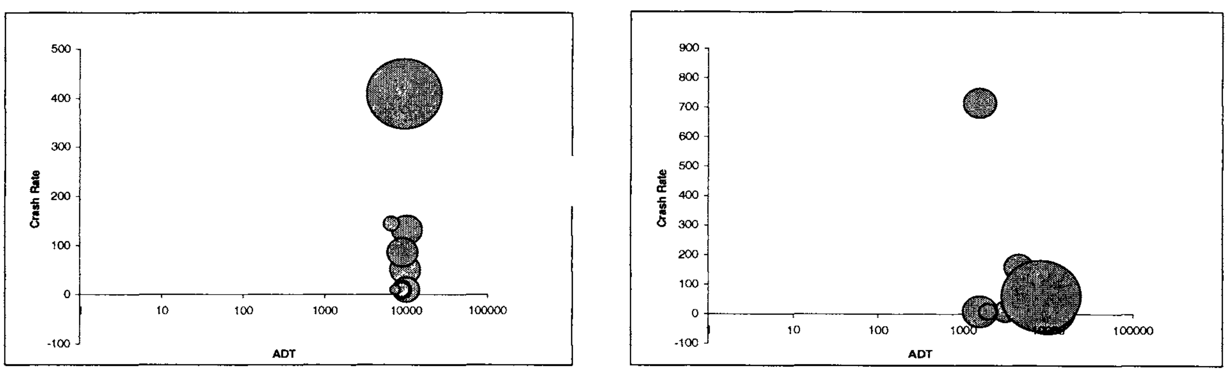
The extended comparison tool was used specifically for projects that have as primary attributes accessibility/mobility, safety/security, and system preservation (Figure 14). This third case study is of interest because unlike the Culpeper Case study or that of the Thomas Jefferson Planning District Commission, it shows proposed projects from small urban areas, which are typically for locations with a population under 50,000.

Table 2. Project Information for Case Study on Thomas Jefferson Planning District.

Project ID #	Cost ($thousand)	ADT (average daily traffic)	Crash Rate (crashes per 100 million VMT)	Primary Attributes	
000002	16711	41500	0	Economic Development	Environment
000003	31300	13300	0	Economic Development	Environment
000004	3985	9800	0	Economic Development	Intermodal
000005	41480	9500	0	Economic Development	Environment
000006	2332.85	7100	0	Economic Development	Environment
000007	25000	41000	239	Economic Development	Accessibility/Mobility
000008	180000	23900	0	Economic Development	Environment
000009	2250	7300	194	System Preservation	Accessibility/Mobility
000010	2992.2	15800	240	System Preservation	Operations/Management
000011	3335.95	7400	665	Economic Development	Accessibility/Mobility
000012	1875	18500	0	Economic Development	Intermodal
000013	23775	22500	61	Economic Development	Intermodal
000014	24250	18700	0	Economic Development	Intermodal
000015	38125	32600	194	System Preservation	Environment
000016	5000	4200	352	System Preservation	Environment
000018	4720	8200	292	Intermodal	Economic Development
000019	1200	5800	260	Safety/Security	Operations/Management
000020	1000	8300	450	Safety/Security	Operations/Management
000021	4866.875	5800	260	Safety/Security	Operations/Management
000022	8594	11000	71	Accessibility/Mobility	Safety/Security
000024	10126	30700	0	Economic Development	Environment
000025	8797	15100	397	Safety/Security	Accessibility/Mobility
000026	3630	11600	0	Economic Development	Accessibility/Mobility
000027	1575	N/A	0	System Preservation	Accessibility/Mobility
000028	5950	22000	0	System Preservation	Accessibility/Mobility
000029	1500	N/A	0	Economic Development	Intermodal
000031	10350	25000	292	Operations/Management	Intermodal
000032	50	15800	211	System Preservation	Safety/Security
000033	2000	2500	0	Intermodal	Safety/Security
000034	2000	14000	157	System Preservation	Safety/Security
000036	350	7300	2192	Safety/Security	Operations/Management
000037	40	12000	653	Economic Development	Accessibility/Mobility
000038	40	26000	1198	Safety/Security	System Preservation
000039	2500	6600	307	System Preservation	Safety/Security
000040	40	2300	3087	Safety/Security	System Preservation
000041	40	6400	1608	Safety/Security	System Preservation
000042	200	700	0	Safety/Security	Operations/Management
000043	40	3200	2483	Safety/Security	System Preservation
000044	500	33000	0	Safety/Security	Economic Development
000045	25	6400	221	System Preservation	Safety/Security
000046	25	6200	305	System Preservation	Safety/Security
000047	25	3500	153	Economic Development	Safety/Security
000048	25	11000	273	Economic Development	Safety/Security
000049	40	N/A	0	Safety/Security	System Preservation
000053	40	N/A	0	Safety/Security	System Preservation
000059	75000	N/A	0	Safety/Security	System Preservation

Table 3. Project Information for Blackstone and Big Stone Gap Localities.

Project ID #	Cost ($thousands)	ADT (average daily traffic)	Crash Rate (crashes per million VMT)	Primary Attributes	
002459	7065	8368	298	Safety/Security	Operations/Management
018899	4260	2480	292	Safety/Security	Operations/Management
056777	978	5394	174	Safety/Security	Operations/Management
018897	1615	6536	168	System Preservation	Environment
056195	8383	2954	169	Safety/Security	System Preservation
052283	65	99125	301	Intermodal	Environment
016419	1568	4904	417	Safety/Security	Operations/Management
057489	1600	4905	148	Operations/Management	Safety/Security
052341	4062	1633	108	Safety/Security	Operations/Management
018900	268	25996	163	Operations/Management	Safety/Security
015424	2393	22083	27	Operations/Management	Safety/Security
002304	11502	54595	335	Operations/Management	Safety/Security
003160	3005	38143	232	Operations/Management	Safety/Security
017621	200	778745	98	Accessibility/Mobility	Economic Development
015998	6461	48016	285	System Preservation	Safety/Security
058474	175	1536	1534	Safety/Security	Operations/Management
015997	3918	3933	281	Safety/Security	Operations/Management
56131	14159	2933	252	System Preservation	Operations/Management
13348	21195	54780	402	Operations/Management	Safety/Security
050546	665	44950	31	Safety/Security	Operations/Management
017619	1000	1366	1096	Operations/Management	Safety/Security
052494	903	6741	228	Safety/Security	Operations/Management
018902	260	12071	110	Safety/Security	Operations/Management
16536	3666	6908	260	System Preservation	Operations/Management
017019	680	5760	152	System Preservation	Operations/Management



(a) **(b)**

Figure 14. **Projects for Blackstone and Big Stone Gap localities motivated by (a) safety/security and system preservation, and (b) accessibility/mobility and safety, with the bubble size representing project cost.**

Ranking Projects of Case Studies

Projects can be ranked based on their attributes: ADT, cost, crash rates, and length. The various ranking methods used for this case study are shown in Table 4. When several methods are used, aggregate rankings of projects should be reported. Table 5 shows the median, best, and worst rankings of projects over several methods.

Table 4. Various Ranking Methods

Ranking Methods	Computational Method	Units
RM1	$\frac{ADT}{cost}$	Daily vehicles per dollar
RM2	$\frac{crash\ rate}{cost}$	Crashes per 100 million VMT per dollar
RM3	$\frac{(crashes)}{(100\ million\ miles)(cost)}$	Crashes per 100 million miles per dollar
RM4	$\frac{crashes}{cost}$	Crashes per dollar
RM5	$\frac{ADT}{sector\ cost}$	Daily vehicles per sector dollar

In Table 4, ADT is the average number of vehicles passing a given point over a 24-hour period. AADT is the average annual daily traffic, which is also the average number of vehicles passing a given point over a 24-hour period. The only difference between AADT and ADT is that an AADT is collected for 1 year from a continuous count station whereas an ADT is collected for a period of less than 1 year and then "adjusted" in order to be a reasonable estimate of an AADT. Thus, aside from the fact that an AADT is more accurate than an ADT, they are indistinguishable. VMT is the vehicle miles traveled, which is the product of the ADT and the length of the roadway section. Crash Rate is the number of crashes per 100 million VMT. Computational notes for RM3 and RM4 are:

$$RM\,3 = \frac{(crash\ rate)ADT}{cost} = \frac{(crashes)ADT}{(100\ million\ VMT)(cost)} = \frac{(crashes)ADT}{(ADT)(100\ million\ miles)(cost)} = \frac{(crashes)}{(100\ million\ miles)(cost)}$$

$$RM\,4 = \frac{(crash\ rate)ADT(length)}{cost} = \frac{(crashes)ADT(length)}{(100\ million\ VMT)(cost)} = \frac{(crashes)ADT(length)}{(ADT)(100\ million\ miles)(cost)} = \frac{(crashes)}{(cost)}$$

Note that in the RM4 calculation, it is assumed that the *length* and *100 million miles* units can be dropped through the use of a multiplier.

Table 5. Aggregate Rankings of 21 Projects When Several Alternative Ranking Methods Are Used.

Project ID	Median Rank	Best Rank	Worst Rank
000001	15	14	17
000002	18	5	21
000003	5	3	10
000004	9	3	11
000005	11	7	16
000006	12	7	15
000007	11	4	14
000008	5	3	12
000009	1	1	9
000010	7	1	8
000011	5	2	13
000012	12	8	16
000013	4	2	17
000014	18	15	19
000015	16	6	20
000016	21	20	21
000017	19	16	20
000018	8	6	14
000019	17	12	20
000020	2	2	14
000021	10	3	13

Integrating the Three Case Studies

Three case studies were conducted to test the flexibility of the extended comparison tool in comparing major transportation projects. The analyses were performed using a prototype of the tool (see http://www.virginia.edu/~risk/comparison/) and shows that it can be used for projects in both the localities and districts. Some key observations include:

- Project information can be obtained from various sources, some of which are HTRIS, CHART 2021 Plan Update, and VDOT Small Urban Area Transportation Plans.

- The planning horizon (short-, medium-, and long-term) determines the sources and types of project information.

- Certain project information can be difficult to obtain due to absent or incomplete data, requiring assumptions to facilitate comparison.

- Ranking of projects can be performed using various methods, the choice depending on the nature of the projects, the motivations for the projects, and the concerns of the analyst.

Figure 15 shows the application of the extended comparison tool to projects in VDOT's Transportation Development Plan for the Culpeper District, the MPO/Thomas Jefferson Planning District Commission, and the localities of Blackstone and Big Stone Gap. A user of the extended comparison tool can discern various features of the project portfolios, including variations in TEA-21 motivations, project costs, ADT rates, and crash rates. For example, it is apparent that the identified TEA-21 motivations of the projects of the Thomas Jefferson Planning District Commission (TJPDC) are more diverse than those of the other two case studies. Such feature may be attributed to the TJPDC projects being of a long-range plan (twenty years) and pre-selected for community and regional significance. A policymaker may be motivated by the case study of the Culpeper District to give more attention to *Economic Development* or *Intermodal Connectivity*, since no projects are associated with these two TEA-21 motivations. Or a policymaker may be motivated by the Blackstone and Big Stone Gap study to give more attention to *Economic Development* and *Environment*. Across several case studies, projects with higher ADT tend to be associated with the motivations of *Accessibility/Mobility*, *Economic Development*, and *Operations*. Projects motivated by *Safety/Security* are not necessarily associated to higher existing crash rates. From the Blackstone and Big Stone Gap study, it is apparent that projects motivated by *System Preservation* are exclusively also motivated by *Safety/Security*. Moreover such projects tend to be lower in cost than projects motivated by *Accessibility/Mobility*. A user may be motivated by the TJPDC case study to inquire what are the projects motivated in tandem by *Economic Development* and *Environment*, and moreover why these same projects tend to be of highest ADT.

CONCLUSIONS

This study was initiated, in part, in response to a mandate within Chapter 349 of the 2001 Acts of Assembly, amending §33.1-23.03 (see Appendix C) with an additional duty for the Commonwealth Transportation Board: "To recommend to the General Assembly for their consideration at the next session of the General Assembly, objective criteria to be used by the Board in selecting those transportation projects to be advanced from the feasibility to the construction stage." The methodology submitted here provides a partial answer. Its fundamental contribution is to present meaningful attributes of projects graphically, in contrast to other methods that use only text or numerical format (which, for TIP/STIP and other applications involving comparison of hundreds or thousands of projects, can be overwhelming and inscrutable), and that can require inordinate or infeasible resources for data collection.

In view of stricter budgetary constraints, decisions on which projects should be prioritized for funding are essential for the continuous and effective implementation of major transportation projects. The extended comparison tool helps planners, engineers, and the public to compare and discuss the benefits and costs of proposed transportation projects. The methodology is flexible in that it allows projects to be compared on different levels of specificity, allowing comparison of projects with similar purposes but different implementation, as shown in the three case studies. The comparison tool can support and integrate current methodologies within VDOT while still allowing for consistency throughout the agency.

An assumption is implied that any particular project will address or have a significant effect on the existing crash rates and ADT. However it is clearer to view the existing crash rates and ADT as needs, or potential project impacts, rather than as forecasts of impacts. Consider the crash rate, crash rate/$, and, to a lesser extent, the ADT and ADT/$ ranking methods. In the first two cases, even projects that have little or no effect on the crashes on a portion of roadway would benefit from the crash-rate ranking methods. ADT measures the number of customers who would be served in some manner by the proposed projects; however, ADT measures do not reveal how well those customers would be served. Actual forecasts of project impacts would require intensive data collection and analysis. Further study should be done to determine whether intersections or road sections might be unfairly favored for attention by the use of the crash rate statistic suggested herein.

A study of VDOT by the Auditor of Public Accounts (Auditor of Public Accounts, 2002) recommended a definitive ranking of projects to move forward for funding. However, the effort to develop the extended comparison tool described herein here does not aim to produce a definitive ranking. A "definitive ranking," both insensitive to the addition or removal of individual projects and accommodating of all interests and stakeholders, is probably unachievable. The extended tool has been used to study several alternative methods of ranking projects, each of which makes use of readily available project information. The extended tool is thus demonstrated to be effective to complement the application of alternative ranking, scoring, or voting methods. The extended tool can be useful to illuminate the costs and impact areas of projects that rank highly by one or several methods.

The project classification process, while tied to TEA-21 categories, is ultimately subjective. The TEA-21 categories are political in nature rather than technical, as there is a significant area of overlap in some of the categories. Attention should be given to substituting technical categories for the TEA-21 categories in further development of the method. The flexibility offered by the extended comparison tool should not prevent analysts from developing specific criteria and project motivations. A guideline should be developed that prescribes the best criteria and overall project motivations to use under specific situations. The guideline would help in an objective ranking of projects.

RECOMMENDATIONS

The following are recommendations associated with implementation of the extended comparison tool developed in the current effort:

1. *Provide comprehensive instruction for using the tool.* The extended comparison tool should be accompanied by a training program. The program should include project information entry, choosing motivations and criteria, ranking, and interpretations of the resulting graphs and charts. In particular, the instruction should be clear on which parameters of the tool can be modified by the users and which have permanent and default values.

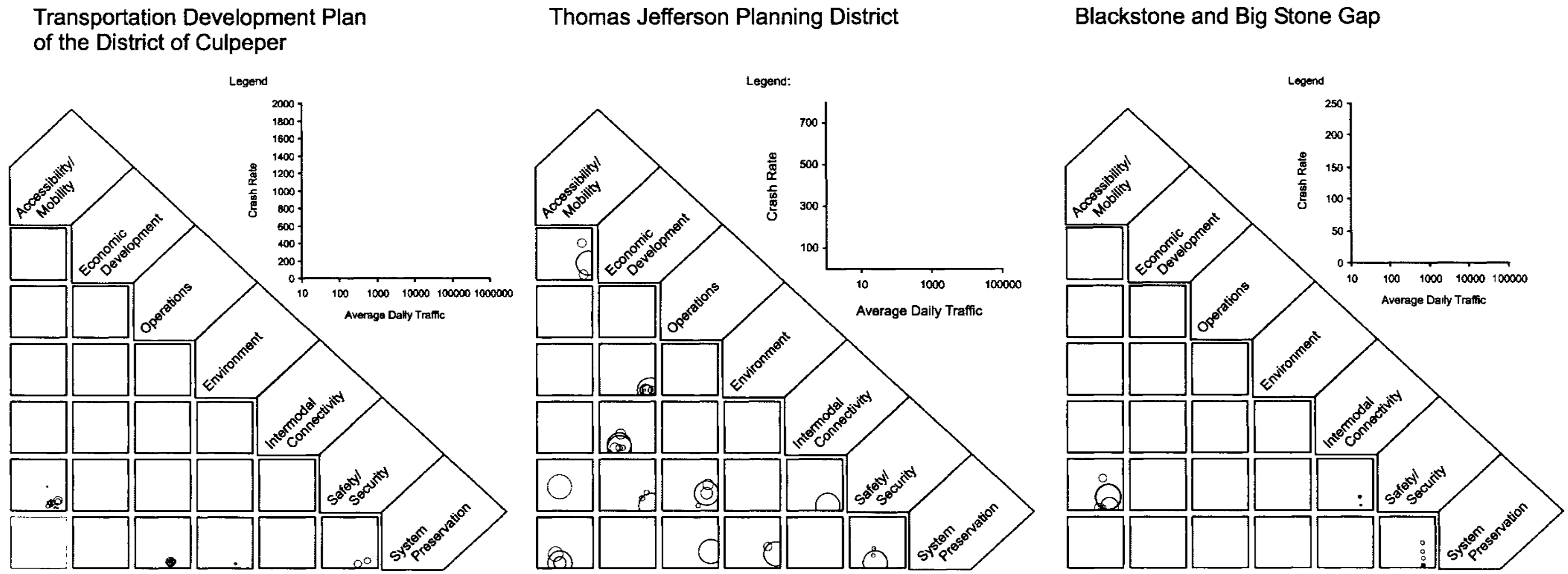


Figure 15. Summary of the application of the comparison tool to projects in VDOT's transportation development plans for the Culpeper District, Virginia, the MPO/Thomas Jefferson Planning District, and the localities of Blackstone and Big Stone Gap.

2. *Use the tool to compare across planning horizons, regions, and past and future plans.* As the three case studies showed, information on short- and medium-plan projects is readily available. However, information may not be available for projects in long-term plans, especially if the projects are still in the early stages of design. Information for such projects can be adopted from similar projects or past experiences. However, if assumptions have to be made, this may result in inaccurate project information and an ultimately skewed and technically incorrect analysis.

3. *Involve stakeholders in the assignment and interpretation of categorical motivations.* System-specific criteria that encompass concerns of many stakeholders should be used in determining the feasibility of a project (e.g., air quality for projects with an *environmental* motivation). The choice and application of problem-specific categories will involve the analysts and stakeholders in useful dialogue.

4. *Increase the number of possible categorical motivations.* In future applications, the user should be enabled to select and include more than two motivations in the analysis. Such analysis requires a three-dimensional visual presentation but would provide a more comprehensive comparison of projects.

5. *Use Appendices A and B to improve prioritization of projects.* These appendices provide a compilation of resources for further research, specifically a synopsis of prioritization methods of highway agencies of other states and a selection of the prioritization metrics that are used in the same.

6. *Extend the comparison tool to multimodal planning and programming.* The applicability of the extended comparison tool to improve multimodal project planning (involving rail, ports, air, roads, and transit) and programming should be explored. In this direction, Appendix C gives a contemporary mandate to address the multimodal transportation needs of Virginia.

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APPENDIX A. PRIORITIZATION METHODS USED BY VARIOUS TRANSPORTATION AGENCIES

This appendix presents summaries of some prioritization efforts developed by selected transportation agencies.

Ohio

The Ohio Transportation Review Advisory Council (TRAC) has determined policies and procedures for selecting major new capacity projects (Ohio Department of Transportation, 2001). By definition, these are projects that cost the agency more than $5 million and that do one or more of the following: increase mobility, provide connectivity, increase the accessibility of a region for economic development, increase the capacity of a transportation facility, and reduce congestion. The TRAC is tasked with the responsibility of approving major statewide and regional transportation projects for funding.

The TRAC is guided by fifteen policies and considerations:

1. Open, fair, criteria-driven process
2. Long-range, statewide planning with local approval
3. Preservation first
4. Transportation and development factors
5. Transportation efficiency criteria
6. Safety criterion
7. Non-ODOT participation
8. Interchange participation
9. Intermodal connectivity
10. Economic development criteria
11. Retail and tourism
12. Fixed transit-line evaluation
13. Non-traditional projects
14. Bypass projects
15. Urban revitalization.

The TRAC adopted a selection process that gives scores to the projects under evaluation. The scoring system takes into account transportation and economic guidelines to compare projects competing for funding. The transportation guidelines constitute 70% of a project's score, and the economic guidelines constitute the remaining 30%. Bonus points are also given. The factors considered in the selection process are found in Table A-1. The TRAC method uses an objective scale for the assignment of project scores.

Table A-1. Major new project selection criteria developed by Ohio TRAC.

Goal	Factors	Maximum Score
Transportation efficiency	Average daily traffic	20
	Volume to capacity ratio	20
	Roadway classification	5
	Macro corridor completion	10
Safety	Accident rate	15
Transportation points account for at least 70% of a project's base score.		70
Economic development	Job creation	10
	Job retention	5
	Economic distress	5
	Cost-effectiveness of investment	5
	Level of investment	5
Economic development points account for up to 30% of a project's base score.		30
Additional points (bonus)		
Funding	Public/private/local participation	15
Unique multi-modal impacts		5
Urban revitalization		10
Total possible points including transportation, economic development, and bonus categories		130

The ranking process does not lend itself to non-traditional projects such as intermodal transfer facilities, transit stations, intelligent transportation systems (ITS), or water port improvements. The DOT evaluates these projects using the following criteria:

- Cost
- Consistency with local transportation plans
- Stated preference of local officials for the project in comparison with other local requests
- Effect of the project on the movement of goods and people
- Whether the project advances other transportation goals
- Estimated volume of usage and comparison of that usage to the ability of other transportation projects to transport goods and people.

The TRAC method is applicable only to large-scale projects. The ranking of the projects is used to show the transportation and economic benefits that can be obtained with each project. The funding of the projects may not necessarily follow the numeric ranking of projects. It is not necessary for a project to have a rank in order to be funded. The TRAC recognizes that intangible or subjective factors exist.

Montana

The Montana DOT has implemented the Performance Programming Process (P^3) for determining the transportation projects that are recommended for funding in the interstate, national highway, and primary systems (Montana Department of Transportation, 2000). The process ensures that transportation-related activities are moving toward the achievement of specific goals. The key P^3 concepts are:

- Customer-driven
- Incremental development
- High level of accountability
- Supports sound investment
- Cross-cutting

Four program areas have been identified: pavement, bridge, safety, and congestion. The objectives of the Montana DOT for each program area are to preserve highway pavement conditions at existing or higher levels on the interstate, National Highway System (NHS), and primary systems; to improve the condition of the bridges on the state highway system; to improve the safety of the state highway system; to maintain and improve the congestion levels on the rural portions of the highway system; and to improve major interchanges and system operations within urban areas. The performance measures that are used in the P^3 are ride index, number of deficient bridges, number of correctable crash sites, and congestion index.

The prioritization process is highly subjective since the performance targets are not clearly specified and no point or evaluation system is presented. The performance measures are mostly concentrated on the improvement of safety and congestion levels.

Alaska

The Alaska Department of Transportation and Public Facilities has developed several criteria that are used in the evaluation of community projects and Trails and Recreational Access for Alaska (TRAAK) projects (Alaska Department of Transportation and Public Facilities, 2001). Scores are assigned to each project, with higher-scoring projects funded before lower-scoring ones. Sets of evaluation criteria have been developed for different project groups. These are:

- Remote roads and trails–roads isolated from the continental network of highways
- Rural and urban streets and roads–community roads connected to the continental network of highways
- TRAAK–pedestrian and bicycle paths, interpretive sites, and other transportation enhancement projects
- Transit–buses, bus shelters, and transit facility projects
- Aviation–airports, airport equipment, and airport facilities
- Harbors–state-owned harbor facilities other than marine highway facilities.

For each project group, there are different criteria and weighting schemes used. The criteria cover a broad range of issues. Some of the factors considered are economic benefits following construction, health and quality of life, safety, improvement of intermodal transportation, public support, environmental approval readiness, and local or other agency contribution. Each factor can obtain a score of +5, +3, 0, -3, or –5. A description is provided to help the user apply and understand these scores.

The prioritization method used by Alaska contains specific guidelines on when a project could obtain a given score. Most of the criteria are not quantifiable, but the guidelines provided are specific enough to facilitate assigning scores.

Oregon

The prioritization model used by the Oregon DOT has two steps (Oregon Department of Transportation, 2002). In the first step, individual projects undergo screening with yes/no criteria. Projects that do not meet the criteria are removed from consideration. In the second step, further data collection and analysis may be needed, and numerical scores are assigned for each project. The weighted cumulative scores of the projects determine the funding priority.

The screening and evaluation criteria are classified into the following broad categories:

- Land use
- Environment and resources
- Transportation efficiency
- Economic development
- Multi-modal choice
- Community support
- Accessibility

Several evaluation criteria are included in the prioritization process. In some instances, when the project does not rate high in a criterion, it is eliminated from further consideration. The method used is relatively easy to implement due to specific questions and descriptions on how to assign points to a project.

Delaware

The Delaware DOT evaluates each project according to nine factors, as in Table A-2 (Delaware Department of Transportation, 2002). For each factor, there may be several criteria included. The project is given a score of –5, –3, 0, +3, or +5 for each criterion. The average of the criteria scores is obtained for each factor. The total points a project obtains for all factor averages make up the project score.

Table A-2. Evaluation Criteria Developed by Delaware DOT.

Factor	Criteria	Description
Safety	High-accident locations	Severity of existing conditions
	Project scope	Extent or comprehensiveness of project on safety
Mobility	Travel flow	Degree to which traffic travels at speeds posted nearby
	Access management	Extent access management policy is addressed
Transit	Location	Type of investment area designation
	Service level	Number and variety of transit and support amenities
Bike	Location	Type of investment area designation
	Type	Type of bikeway improvement
	Access/connections	Extent of bikeway connections
Pedestrian	Location	Type of investment area designation
	Effective length	Extent of pedestrian area connections
	Access connections	Types of land uses interconnected
Support for existing communities	Plan consistency	State, county, MPO, local plans
	Right-of-way	Existing vs. new right-of-way
	Traffic volumes	Increase vs. decrease of traffic
Other community/ environmental impacts	Right-of-way category	Type of right-of-way utilized
	Travel patterns	Diversion of "thru traffic"
	Summary of location and environmental impacts	
Other economic impacts	Freight mobility	Commercial issues
	Passenger mobility	Commuter issues
	Economic benefits	
Sustainability	Project duration	Years before additional investment required
	Intermodal support	Number of modes access by project
Mitigation	Project source	Consistent with other plans
	Intersection level of service	Locational ("hot spot") congestion
	Corridor delay	Corridor or area-wide congestion

The criteria used by the Delaware DOT address a variety of issues. Most of the criteria are not easy to measure or quantify. Guidelines on how to score the project with respect to each criterion are not provided.

Texas

The Texas DOT has established categories through which funds are allocated (Texas Department of Transportation, 2002). The categories in the Unified Transportation Program (UTP) reflect the program areas outlined by TEA-21. Each category has its own set of selection criteria that is used to evaluate and rank proposed transportation projects. The categories are:

1. High-priority interstate corridors
2. Interstate maintenance

3a. National highway system (NHS) mobility
3b. Texas trunk system
3c. NHS rehabilitation

3d. NHS traffic management systems
3e. NHS miscellaneous
4a. Surface transportation program (STP) safety
4b. STP transportation enhancements
4c. STP metropolitan mobility and rehabilitation
4d. STP urban mobility and rehabilitation
4e. STP rural mobility and rehabilitation
4f. STP rehabilitation in urban and rural areas
4g. STP railroad grade separations
5. Congestion mitigation and air quality improvement (CMAQ)
6a. Bridge replacement and rehabilitation on state highway system
6b. Bridge replacement and rehabilitation off state highway system
7. State preventive maintenance
8a. Rehabilitation of Texas farm-to-market roads
8b. Texas farm-to-market roads system expansion
9. State park roads
10a. Traffic control devices
10b. Rehabilitation of traffic management systems
11. State district discretionary
12. Strategic priority
13a. State-funded mobility
13b. Hurricane evacuation routes
13c. Border trade transportation projects
13d. Urban streets
14. State rehabilitation
15. Congressional high priority projects
16. Miscellaneous
17. State principal arterial street system (PASAFETY/SECURITY)
18. Candidate turnpike projects.

Projects compete for the program amounts made available by the TDOT for each category.

Louisiana

The Louisiana Department of Transportation and Development has developed a project selection process that it utilizes in preparing a Transportation Enhancement Program (Louisiana Department of Transportation and Development, 2001).

Only projects in one of the categories listed below are eligible for consideration in the enhancement program:

- Provision of facilities for pedestrians and bicycles
- Acquisition of scenic easements and scenic or historic sites
- Scenic or historic highway programs

- Landscaping and other scenic beautification
- Historic preservation
- Rehabilitation and operation of historic transportation buildings, structures, or facilities (including historic railroad facilities and canals)
- Preservation of abandoned railway corridors (including the conversion and use thereof for pedestrian or bicycle trails)
- Control and removal of outdoor advertising
- Archaeological planning and research
- Mitigation of pollution due to highway runoff

There are nine categories under which a project can attain scores.

1. Usage factor
2. Project cost
3. Potential for general mitigation of existing transportation facility impacts
4. Potential for achieving air quality improvements
5. Potential value to community or area
6. Potential for enhancing intermodal transportation system, safety related
7. Potential for enhancing intermodal transportation system, traffic reduction
8. Potential for enhancing intermodal transportation system, the transportation experience in general
9. Transportation utility/function

For each category, a project can obtain a maximum of five unweighted points. The different categories are weighted, with each category getting a weighting factor from one to five. A maximum of 125 total points can be obtained.

Projects that belong to several enhancement categories are scored under each category and all category scores are added. Higher-rated projects are given more priority.

Wisconsin

The Wisconsin DOT developed the TRANSLINKS 21 planning process in order to have a means for selecting cost-effective transportation projects for funding (Wisconsin Department of Transportation, 2001). The goals are: mobility, choice, safety, efficiency, connectivity, economic development, equity, environmental responsibility, and community livability.

An initial screening of candidate projects takes place. The projects must be consistent with local and regional transportation plans and the general goals of ISTEA and DOT. Candidate projects should have reasonable cost estimates and be supported by adequate financial plans. The scope and concept of the projects must be well defined, and the multimodal aspects should be stressed.

A set of factors based on ISTEA legislation has been established for the prioritization process. The groupings of the factors are based on goals established by the DOT, as shown in Table A-3.

Table A-3. Project Scoring Matrix from Wisconsin DOT.

Goal	Performance Metric
Mobility	Congestion relief
	Key component of transportation system
	Promotes implementation of local/regional land use plan(s)
Choice	Multimodal
Safety	Safety and security
Efficiency	Preserves existing system
	Supports efficient land-use patterns
	Cost-effective
	Transportation corridor preservation
Connectivity	Intermodal connectivity
Economic development	Economic development
Environmental responsibility	Air pollution reduction
	Energy conservation
Livable communities	Positive social/community effects
	Negative social/community effects
	Noise reduction
Other	Complexity of project preparation

The criteria effectively address the TEA-21 factors. Most of the metrics are not easy to quantify and score. The possible scores that each project can obtain under each criterion are 6 (high impact), 4 (medium impact), 2 (low impact), and 0 (no relation). TRANSLINKS 21 includes descriptions of when such scores may be given. Road, transit, and bike or pedestrian projects can get scores under each category. The overall project score is the total of the criteria scores.

Sacramento, California

The City of Sacramento, California (2001), developed an evaluation process that places a high value on stakeholder involvement and uses objective criteria for prioritizing investments. The Transportation Programming Guide (TPG) criteria are used in prioritizing projects throughout the city for annual funding allocation. There are eight sets of evaluation criteria used to address a variety of program areas:

1. Major street improvements
2. Street maintenance
3. Street reconstruction
4. Traffic signals
5. Alternate modes
6. Bridge replacement and rehabilitation
7. Streetscape enhancement

8. Sidewalks to schools.

Potential projects that fall under each program area are evaluated using a fixed set of criteria. The criteria are developed by the city staff and the Community Advisory Committee. Most of the criteria are quantifiable and use available data such as ADT, project length, project cost, and population density. Each criterion is assigned a maximum score, and each project is rated according to its performance with respect to the criteria. The point total obtained by the project determines its priority ranking among the projects being considered.

Nashville, Tennessee

The City of Nashville, Tennessee developed a planning process that considered factors such as land use, intermodal connectivity, transit service, congestion, freight movement, and safety (Tennessee Department of Transportation, 2002). The emphasis of the process was to promote benefits to the region as a whole. Congestion relief and environmental preservation were given higher priority.

The criteria used in the ranking process can be grouped into the broad categories of planning consistency, congestion management, traffic circulation, freight, air quality, pavement management, safety management, and public support. The category with the highest weight is planning consistency, followed by congestion management.

North Jersey, New Jersey

The Transportation, Economic and Land Use System (TELUS) is an information and decision support system developed by the New Jersey Institute of Technology, the Center for Urban Policy Research of Rutgers University, and the North Jersey Transportation Planning Authority (Transportation, Economic and Land Use System, 2002). It is a software application that can be used to store and access project information, with a graphical interface that provides understandable information to the user. Information can be retrieved by geographic location, funding source, project types, or project category, among others.

The TELUS can be used to:

- examine individual project profiles
- summarize multiple project data
- view projects based on scoring criteria
- determine interrelated projects
- track the schedules and status of projects
- analyze the breakdown of projects based on TEA-21 factors
- generate federal-format reports summarizing TIP expenditures.

In the project scoring module, there are eight categories by which a project is scored. The first seven categories are obtained from the TEA-21 criteria. The eighth is defined by the

MPO, thereby allowing flexibility in the scoring process. Each category is allocated 100 points. All categories are automatically given equal weights.

Several factors need to be considered for each category. The project is given a score of 0 (no effect), 1 (minor effect), 2 (moderate effect), or 3 (major effect) for each factor. The 100 points allocated to a category are divided equally among the factors. For instance, if the economic vitality category has five factors, each of the five is assigned 20 points. However, the rater can modify the TELUS factors and weights.

Once the project is scored, the TELUS automatically calculates the cumulative project score. A ranking report can be generated that shows the projects in order of their overall scores.

The TELUS has a project interrelationship module that allows for identifying the types of relationships among projects. Projects can be related through commonalities in location, funding source, or mode. They can also have "disturbance" interrelationships, meaning projects that interfere with one another. Projects may exhibit "planning" interrelationships whereby a project already in the Transportation Improvement Program (TIP) is related to a pre-TIP project. "Functional" interrelationships can also exist where projects could reinforce or detract from the efficiency of the entire route or area.

In the interrelationship module, project information in terms of the type of interrelationship, the projects affected, and the degree of the interrelationship is entered. The user can view the relationships and determine their effects on the overall transportation plan.

TELUS also has a Geographic Information System (GIS) that allows the projects to be displayed on a map. The GIS allows the spatial relationship of projects to land use plans to be seen and studied more easily.

Brazos County, Texas

The Bryan-College Station MPO is tasked with providing policy guidance and overall direction in the integrated multimodal transportation planning process. It reviews the Metropolitan Transportation Plan and identifies projects for a 20-year period. The MPO Technical Committee developed a selection method that is used to score projects when necessary. Recommendations are forwarded to the Policy Committee in order of the rankings' priorities (Bryan-College Station MPO, 1999).

The MPO looks at the benefits associated with the projects: safety, gap completion, alternative modes, economic development, travel time, congestion, population benefited, regional significance, and consistency with local comprehensive plans. A set number of points can be given for each benefit. However, no guidelines are provided on how points may be allocated.

Mid-Ohio

The Mid-Ohio Regional Planning Commission (MORPC) is a metropolitan planning organization receiving federal funds by federal law and other federal funds at the discretion of the Ohio DOT. It receives between $12 and $15 million per year.

The MORPC has developed a project-selection process that entails assigning projects to one of four categories (Mid-Ohio Regional Planning Commission, 2002):

1. highway expansion and Transportation System Management (TSM) projects
2. demand reduction projects such as ridesharing and transit
3. system preservation projects such as major pavement rehabilitation, bridge repair or replacement, and transit bus replacement
4. planning projects.

Projects are rated under a set of evaluation criteria and compete with each other within groups. Projects that receive higher scores are usually selected over projects with lower scores. Projects with environmental approval and a detailed design take precedence over those that have not yet started design.

The criteria consist of 22 factors distributed over the following eight categories:

1. Financial/funding
2. Economic development
3. Safety
4. Social impacts
5. Environmental impacts
6. Transportation efficiency
7. Accessibility/connectivity
8. System preservation.

The weights assigned to the factors make up the category weight. The *economic development* and *transportation efficiency* categories are given the most weight (each 25 points of 100). *System preservation* and *accessibility/connectivity* are also weighted more (each assigned 15 points of 100). There are no guidelines as to how to assign the points.

APPENDIX B. METRICS OF PERFORMANCE FOR THE VARIOUS TEA-21 MOTIVATIONS

Metrics of performance for the various TEA-21 motivations were adapted and developed in the current effort as follows:

Table B-1. Accessibility/mobility Metrics.

Metric	Rating (1 = worst, 5 = best) 1	2	3	4	5	Source (adapted)
Alternative Travel						
Alternative Modes (a) The project is on a designated bikeway according to comprehensive plan, (b) on a bus route, (c) improves access to light-rail transit	Satisfies one condition		Satisfies two conditions		Satisfies all conditions	AL
Number and variety of transit and support amenities						DEL
Extent of bike access and connections	Minimal				Substantial	DEL
Extent of pedestrian connections	Minimal				Substantial	DEL
Types and number of land uses connected						DEL
Increase the number of available modes	One		Two		More than two	OR
Improves the level of service of existing	Minimal				Substantial	OR
Pedestrians						
Passenger mode to mode connections	Two or more		Five or more		Eight or more	OR
Freight						
Enhances the range of freight service options available to local business	Minimal				Substantial	TELUS
Freight mode to mode connections	Two or more		Five or more		Eight or more	OR

Table B-2. Economic Development Metrics.

Classification Metric	Rating (1 = worst, 5 = best) 1	2	3	4	5	Source (adapted)
Jobs Created	100-200	200-400	400-600	600-800	>800	OH
Jobs Retained	25-50	50-100	100-150	150-200	>200	OH
Jurisdiction Unemployment Rate	1%-10%	10%-20%	20%-25%	25%-30%	>30%	OH
Passenger Mobility	weak		moderate		strong	DE
Freight Mobility	weak		moderate		strong	DE
Ratio of State DOT costs to jobs created (in $100,000)	>3	1 5-3	1-1 5	0 5-1	<0 5	OH
Economic Development. conditions below ***a)*** *The project is in a designated redevelopment or block grant area* ***b)*** *The project is in a desitnated infill area* ***c)*** *The project is expected to generate new residential or commercial developme*	One Condition satisfied		Two Conditions satisfied		All conditions satisfied	Sac
Economic Benefits following Construction	Minimal speculative or temporary economic benefits, opportunities or non crucial benefit to existing economic activity		Moderate permanent, new identifiable economic benefits, opportunities regionally		Significant permanent, new, identifiable economic benefits, opportunities, statewide or interstate	AL

Table B-3. Operations Metrics.

Metric	Rating (1 = worst, 5 = best) 1	2	3	4	5	Source (adapted)
Cost Efficiency						
Reduces transportation system cost	minimal				substantial	TELUS
Private Investment (in millions)	$0 5-4 99	$5-9.99	$10-14 99	$15-19 99	>$20	OH
Contributes to better vehicle tracking						TELUS
Enhances administrative productivity/ efficiency	minimal				substantial	TELUS
Local/Regional Dollars: Where the local contribution / capita for that project falls as a % of others being ranked.	80-100%	60-80%	40-60%	20-40%	Top 20%	OR
Net Present Value-Cost-Ratio (NPVC) Present Value Benefits-Present Value Costs Present Value Costs						OR

Table B-4. Environment Metrics.

Metric	Rating (1 = worst, 5 = best) 1	2	3	4	5	Source (adapted)
Environmental Planning						
Environmental Approval	Unlikely < 50 % chance	Likely with Environmental Impact Statement	Likely with environmental assessment or draft	Likely with categorical exclusion	Approved	AL
Plan Consistency	Not consistent w/ any plans (MPO, county, and state)	Consistent with one set of plans and MPO applies	Consistent with one set of plans and MPO doesn't apply	Consistent with two sets of plans and MPO applies	Consistent with all applicable plans	DE
Deliverability and Readiness: (a) Environmental determination has been approved for project, (b) Project Study Report has been approved for this project; (c) Preliminary design (30% design) is	None of conditions (a), (b), and (c)		Any one of conditions (a), (b), or (c)		Any two of conditions (a), (b), or (c)	SAC
Investment Area Designation						DE
Right-of-way Impact (Use of new vs. existing)			Existing Right of Way			DE
Ecological Protection						
Wetland Protection - ratio of acres of replaced vs affected	<1 5 1		>1.5.1		> 5.1	US
Species Protected	None		Single		Multiple	
Pollution/ Energy Conservation						
Vehicle Emissions (EPA standard. CO, 1hr ave = 9ppm, PM10, 24hr ave = 150 ug/m^3)			Below standard			EPA
Vehicle Emissions Reduction	None		Noticeable reduction		Reduction from violation to below standard	TELUS
Quality of Life						
Contribution to improved quality of life or removal of existing negative factor	Minor		Moderate		Major	TELUS
Fuel Consumption Decrease	Minor		Moderate		Major	TELUS
Thousands of people exposed to noise levels > 65 decibels (percentile of similar	Minor		Moderate		Major	US
Reduction in people exposed to noise levels > 65 decibels	Minor		Moderate		Major	US
Alternatives to personal vehicle usages						
Bike/ Walking Trails	Widening or improve		Develop a new trail		Develop new trail system	
Transit Access - percent of urban population living w/in 1/4mi of transit stop	None (0%)	<25%	25-50%	50-75%	>75%	US
Gap Closure (a) closes a gap in a corridor or route (b) closes a gap in a bike facility (c) reduces	(b) OR (c)	(b) AND (c)	(a)	(a) AND (b) OR (c)	(a), (b) AND (c)	Sac

Table B-5. Intermodal Connectivity Metrics.

Classification Metric	Rating (1 = worst, 5 = best) 1	2	3	4	5	Source (adapted)
Congestion						
Volume/Capacity Ratio	<0 75		0 75-1 25		>1 25	OH
Reduction in Volume/Capacity Ratio	0 0-0 4		0 4-0 8		>0 8	OH
Degree to which traffic travels at posted speeds	Never		Only at non rush hour times		Always	DE
Areawide congestion relief	None		Moderate		Superior	DE
Traffic Impact (volume decrease)	minimal		moderate		substantial	DEL
Interstate Congestion Index	Desirable 50-59%	60-69%	70-79%	80-89%	Superior 90-100%	MT
Primary Congestion Index	Desirable 50-59%	60-69%	70-79%	80-89%	Superior 90-100%	MT
NHS Congestion Index	Desirable 50-59%	60-69%	70-79%	80-89%	Superior 90-100%	MT
Offers value (congestion) pricing	minimal				substantial	TELUS
Intersection Delay	Low		Moderate		High	DE
ADT						
Auto ADT	0-14,999	15,000-29,999	30,000-44,999	45,000-59,999	>60,000	OH
Truck ADT	0-2,499	2,500-4,999	5,000-7,499	7,500-9,999	>10,000	OH
Highway Pavement Condition Ride Index	Unsatisfactory		Desirable		Superior	MT
Highway Pavement Conditions	No deficiencies		Moderate deficiencies		Major deficiencies	AL
Intermodal Transportation-Mode Connection	Minor improvement of connection between modes for travelers		Moderate improvement of connection between modes for travelers		Major improvement of connection between modes for travelers	SAC
Intermodal Transportation-Redundancy Reduction	Minor reduction in operation costs by reducing redundancy		Moderate reduction in operation costs by reducing redundancy		Major reduction in operation costs by reducing redundancy	AL
Provides enhanced or new accessibility to the transportation system to move freight	Minimal				Substantial	TELUS
Improves the level of service of existing modes	Minimal				Substantial	OR
Provides enhanced or new accessibility to the transportation system to move people	Minimal				Substantial	TELUS

Table B-6. Safety and Security Metrics.

Classification Metric	Rating (1 = worst, 5 = best) 1	2	3	4	5	Source (adapted)
Accident Rate (crashes per million vehicle miles traveled)	0 00-1.5		1 5-3.00		>3.00	OH
Estimated Decrease in Accident Rate per DVMT	0 0-1.0	1 0-2 0	2 0-3 0	3.0-4.0	>4.0	OH
Extent of project scope on safety	Low		Moderate		High	DE
Percentage of project that addresses safety(Highway safety improvement program(HISP) priority)	<5%	5%-20%	20%-60%	60%-80%	>80%	AL
Deficient width/grade/alignment	Significantly deficient width/grade/ alignment relevant to standards		Moderately deficient width/grade/ alignment relevant to standards		No deficiencies width/grade/ alignment relevant to standards	AL
Highway Pavement Conditions	No deficiencies		Moderate deficiencies		Major deficiencies	AL
Estimated Decrease in Fatality Rate per DVMT	0 0-0 1	0.1-0 3	0 3-0 5	0 5-0.7	>0 7	Uva
Estimated Decrease in Injury Rate per DVMT	0 0-0 3	0 3-0.6	0 6-1 0	1 0-1 4	>1 4	Uva
Estimated Decrease in Property Damage per DVMT	$0-$200	$200-$800	$800-$3,200	$3,200-$12,800	>$12,800	Uva
Estimated Decrease in Pedestrian Fatalities per DVMT	0 0-1 0	1 0-2 0	2.0-3.0	3 0-4.0	>4.0	Uva
Highway Pavement Condition Ride Index	Unsatisfactory		Desirable		Superior	MT
Number of Correctable Crash Sites	0		1 0-5 0		>5.0	MT

Table B-7. System Preservation Metrics.

Classification Metric	Rating (1 = worst, 5 = best) 1	2	3	4	5	Source (adapted)
Type of Road System	Other Freeway, Expressway or Principle Artery		National Highway System		Interstate	OH
Investment sustainability (years before additional investment required)	1--5	5--10	10--15	15--20	>20	DE
Surface Rehabilitation	Addresses long range		Serious foundation problems		Badly deteriorated gravel surface or serious surface deformation addressed	AL
Cost/length ratio (divide cost of project in thousands by length in miles)	>$1250	$1000-$1250	$750-$1000	$500-$750	<$500	AL
Repairs/Replaces potentially hazardous system (i.e bridge)	Addresses maintenance/upkeep of critical system		Addresses deficient critical system needing repair		Addresses deficient critical system needing	AL

APPENDIX C. STATE LEGISLATION REQUIRING DEVELOPMENT OF THE STATEWIDE TRANSPORTATION PLAN

The following outlines an opportunity for use of the extended comparison tool to combine quantitative and categorical evidence in support of multimodal statewide planning.

VIRGINIA ACTS OF ASSEMBLY

CHAPTER 639

An Act to amend and reenact § 33.1-23.03 of the Code of Virginia, relating to the Statewide Transportation Plan; preparation to stress statewide perspective.

[H 771]

Approved April 6, 2002

Be it enacted by the General Assembly of Virginia:

1. That § 33.1-23.03 of the Code of Virginia is amended and reenacted as follows:
   § 33.1-23.03. Board to develop and update Statewide Transportation Plan.
   The Commonwealth Transportation Board shall conduct a comprehensive review of statewide transportation needs in a Statewide Transportation Plan setting forth an inventory of all construction needs for all systems, and based upon this inventory, establishing goals, objectives, and priorities covering a twenty-year planning horizon, in accordance with federal transportation planning requirements. This plan shall embrace all modes of transportation and include technological initiatives. This Statewide Transportation Plan shall be updated as needed, but no less than once every five years. The plan will provide consideration of projects and policies affecting all transportation modes and promote economic development, intermodal connectivity, environmental quality, and accessibility for people and freight, and transportation safety. Each such plan shall be summarized in a public document and made available to the general public upon presentation to the Governor and General Assembly.
   It is the intent of the General Assembly that this plan assess transportation needs and assign priorities to projects on a statewide basis, avoiding the production of a plan which is an aggregation of local, district, regional, or modal plans.

2. That the first phase of the plan prepared in accordance with the provisions of this act shall be presented on December 1, 2002, and shall include: the vision, goals, and objectives of the plan; criteria for establishing priorities; identification of major needs; a public involvement plan; a summary of public involvement to date; an interagency coordination plan; an evaluation and recommendation for selection of a highway needs-assessment tool; and a status report on the modal needs assessments. The second phase of the plan shall be presented on December 1, 2003, and include: a status report on the existing transportation

system; a status report on the modal needs assessments; and consideration of policies affecting all transportation modes, including technology, economic development, intermodal connectivity, environmental quality, accessibility for people and freight, transportation safety, and revenue sources and availability. The third phase of the plan shall be presented on July 1, 2005, and include: an inventory and prioritization of statewide multimodal transportation needs; an assessment of intermodal connectivity and accessibility; a summary of public involvement activities and comments; and a final report.