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<p>16. Abstract</p> <p>Across the nation, there are opportunities to improve coordination among transportation modal agencies, including aviation, transit, ports, highway, rail, pedestrian, and bicycle modes. Virginia's statewide multimodal transportation planning effort VTrans2025 addresses multimodal coordination of transportation investments in the state. Virginia's Secretary of Transportation submitted a final report of the VTrans2025 effort to the Virginia General Assembly in November 2004.</p> <p>The purpose of this study was to demonstrate an analytical methodology that could aid efforts such as this to coordinate and prioritize multimodal investments. The methodology developed can help decision makers to identify and prioritize proposed multimodal investment networks (MINs). These are large-scale coordinated investments in transportation projects across modes. The body of this report describes relevant literature and provides an overview of the developed methodology: (1) prioritization of the MINs, and (2) statistical comparison of modal plans. The analytical methodology developed will be of interest to multimodal transportation planning efforts across the nation, particularly where there is a need for systematic evidence-based approaches to coordinating the efforts of modal transportation agencies. Most data in the report are presented solely for purposes of demonstrating the methodology.</p> <p>The methodology developed in this project fosters improved coordination in planning and programming transportation investments across modal agencies. The potential benefits of the methodology include identification of lower-cost investment alternatives when considering multiple modes relative to considering only single modes to meet a particular travel demand; selection and programming of multimodal solutions that have the highest performance relative to the available or required levels of investment; and increased transparency and accountability of the multimodal agencies for the uses of funding that can be allocated across multiple transportation modes.</p> <p>The costs of implementing the methodology developed in this study are minimal and include one-time training of staff of the modal agencies in the use of the identification and priority-setting methodology and software demonstrated in the current study; and regular interaction and dialogue among the staff of the modal agencies that are involved in the identification and prioritization of investments across modes.</p>			
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FINAL CONTRACT REPORT

DEVELOPMENT OF A METHODOLOGY TO COORDINATE AND PRIORITIZE MULTIMODAL INVESTMENT NETWORKS

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NOTICE

The project that is the subject of this report was done under contract for the VTrans2025 effort under the Virginia Transportation Research Council. The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the VTrans2025 Committee, the Commonwealth Transportation Board, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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ABSTRACT

Across the nation, there are opportunities to improve coordination among transportation modal agencies, including aviation, transit, ports, highway, rail, pedestrian, and bicycle modes. Virginia's statewide multimodal transportation planning effort VTrans2025 addresses multimodal coordination of transportation investments in the state. Virginia's Secretary of Transportation submitted a final report of the VTrans2025 effort to the Virginia General Assembly in November 2004.

The purpose of this study was to demonstrate an analytical methodology that could aid efforts such as this to coordinate and prioritize multimodal investments. The methodology developed can help decision makers to identify and prioritize proposed multimodal investment networks (MINs). These are large-scale coordinated investments in transportation projects across modes. The body of this report describes relevant literature and provides an overview of the developed methodology: (1) prioritization of the MINs, and (2) statistical comparison of modal plans. The analytical methodology developed will be of interest to multimodal transportation planning efforts across the nation, particularly where there is a need for systematic evidence-based approaches to coordinating the efforts of modal transportation agencies. Most data in the report are presented solely for purposes of demonstrating the methodology.

The methodology developed in this project fosters improved coordination in planning and programming transportation investments across modal agencies. The potential benefits of the methodology include:

- identification of lower-cost investment alternatives when considering multiple modes relative to considering only single modes to meet a particular travel demand
- selection and programming of multimodal solutions that have the highest performance relative to the available or required levels of investment
- increased transparency and accountability of the multimodal agencies for the uses of funding that can be allocated across multiple transportation modes.

The costs of implementing the methodology developed in this study are minimal and include:

- one-time training of staff of the modal agencies in the use of the identification and priority-setting methodology and software demonstrated in the current study
- regular interaction and dialogue among the staff of the modal agencies that are involved in the identification and prioritization of investments across modes.

INTRODUCTION

Section 33.1-23.03 of the *Code of Virginia* directs Virginia's Commonwealth Transportation Board (CTB) to develop a multimodal long-range transportation plan with a statewide focus. The plan was developed through the Office of the Secretary of Transportation in cooperation with state transportation agencies: the Department of Aviation, the Department of Rail and Public Transportation, the Virginia Port Authority, and the Department of Transportation. Building on recent administrative successes in restoring accountability and implementing sound transportation practices throughout the Commonwealth, Virginia's long-range transportation plan, *VTrans2025*, is aimed at creating a blueprint for shaping the transportation future in Virginia by establishing common visions, goals, and objectives to guide its decision-making across all transportation modes. *VTrans2025* shows the need for systematic, analytical methods to improve the coordination among transportation agencies of the Commonwealth of Virginia. For example, the Intermodal Surface Transportation Efficiency Act (ISTEA, 1991) and the Transportation Equity Act for the 21st Century (TEA-21, 1998) establish the need for states to consider alternate transportation modes when planning and prioritizing projects. This legislation urges states to examine diverse collections of transportation improvement projects that fit together in a holistic and practical multimodal framework.

Figure 1 is derived from the *VTrans2025* Phase III Report. It describes the lifecycle of transportation projects that will receive priority for federal and state funding. The lower left portion of the figure depicts transportation projects being prioritized within agencies. The center portion depicts a coordinated multimodal prioritization of selected projects. By developing an analytical methodology to support the multimodal prioritization that is shown in the figure, the research described in this paper can help ensure that funds of transportation agencies are allocated based on all available evidence of maximum benefits to be achieved.

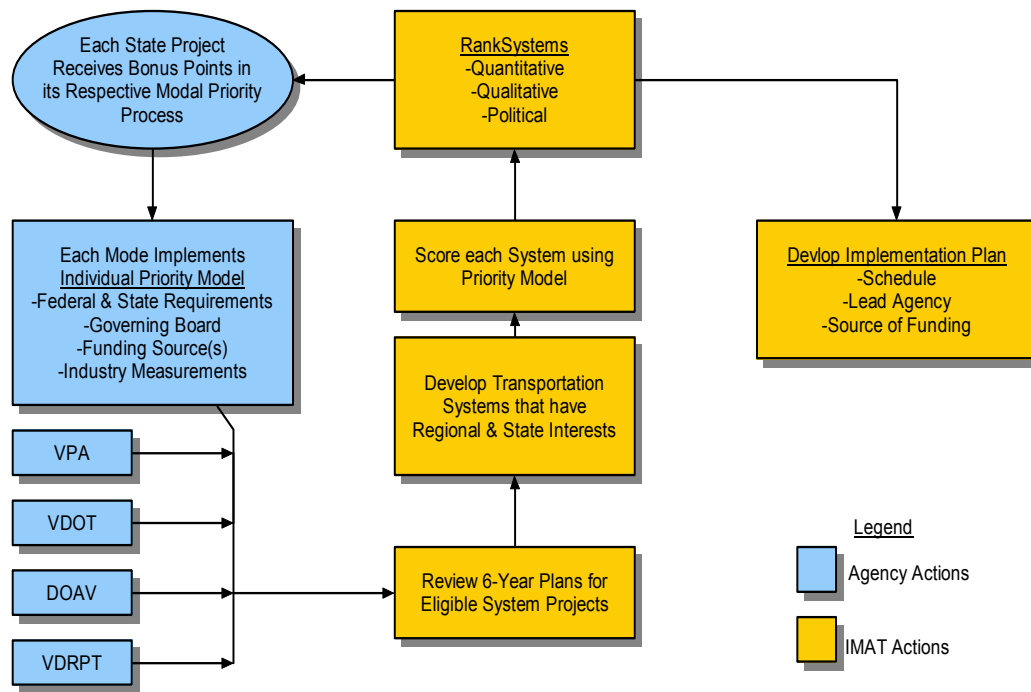


Figure 1. Multimodal Statewide Transportation Planning Process (Source: *VTrans2025*, 2004).

This report is organized as follows. The *Purpose and Scope* section outlines the current efforts to develop a methodology for the coordination and prioritization of Multimodal Investment Networks (MINs), cost analysis of the MINs, and statistical comparison of modal projects across several transportation modes. A MIN was introduced by the VTrans2025 effort as a coordinated investment in projects across transportation modes. The methodology section describes the developed methodology for prioritization of MINs and statistical comparison of modal plans. The *Results and Discussion* section provides a sample of the results obtained from case studies. The *Conclusions* section describes the deliverables of the effort. The *Recommendations* section presents questions that arose in the course of the effort.

PURPOSE AND SCOPE

The purpose of this study was to develop and apply an analytical methodology to support coordination of investments among the state transportation agencies. The objectives of the effort were: (1) to review the relevant literature and the documented experiences of others; (2) to understand multimodal system requirements and participation by the several state transportation agencies; (3) to specify analytical methods and data needs for multimodal systems planning; and (4) to transfer the developed methodology to the transportation agencies, in part by producing case studies of real projects.

REVIEW OF LITERATURE AND PRACTICES

This section summarizes a review of studies and practices that are relevant to the development of analytical methodology to support long-range multimodal transportation planning.

Brown (2002) describes some statewide efforts for multimodal transportation planning outside Virginia that have fallen short of expectations largely because their responses to transportation needs have taken the form of short-term fixes designed to deal with an immediate crisis-at-hand. He further states that a coordinated multi-agency approach is needed.

Pedersen (1999) discusses developing solutions to transportation needs without a modal bias and using the full range of multimodal and intermodal solutions available.

Halvorson (2000) advocates a need for systematic planning and accountability in transportation decisions—whether that is strategic planning, quality initiatives, or performance-based planning.

Pedersen and Jeff (2000) writes that implementing performance-based planning has proven to be more difficult than might have been expected—the major challenge being developing objective, non-mode-specific measures for which data are readily and regularly available. Furthermore, Giorgi and Pearman (2002) note that a disadvantage of many

multicriteria analyses is that performance measurement in several dimensions, which are made comparable by scoring and weighting, is often not transparent.

Cambridge Systematics (1999) describes a multimodal transportation plan that emphasizes establishing causality between program investment and performance measures, noting that this becomes a critically important technical and political issue for future transportation investment.

NCHRP (1997) states that capital programming for transportation projects being responsive to policy needs is one of two key aspects necessary for implementation consideration, adding that "...the second key issue is whether funds are being spent wisely; are the specific types of projects in the program the most cost-effective way of solving problems or meeting identified needs...?" Furthermore, Forkenbrock et al. (1993) comment that transportation cost savings are true benefits to society in that cost reductions act exactly the same as income increases; they make more resources available for other purposes.

Giorgi and Pearman (2002) write that "as cost-benefit analysis began to be applied to much broader fields, and particularly to the comparison of alternative portfolios of projects and to road policy choices, the increasing complexity made it necessary to keep the level of benefits constant and to analyze the problem simply in terms of finding the most effective or 'least-cost' option to meet the desired level of benefits. This has the additional advantage that benefits need not always be explicitly valued."

The TRB and NRC (1998) observe that, "A community or state may want to compare the economic impact of alternative transit investments, or an investment in transit compared to investing in another public works project, or no investment at all". NCHRP (2000) further describes the importance of alternative investment strategies to analyze different modes, or combinations of modes, for meeting process objectives.

METHODOLOGY

This section provides an overview of methodology that was developed in the current effort for the prioritization of MINs and the statistical comparison of modal projects.

Overview of Prioritization of MINs

This section shows how MINs are scored and ranked according to five independent weighting criteria. Six classes of performance measures for prioritizing the MINs are given by Table 1 (Source: *VTrans2025*, 2004). Each MIN is scored relative to the specified performance measures as follows:

- A score of -1 implies that the MIN negatively impacts the performance measure being assessed,

- A score of 0 implies that the MIN has no impact on the performance measure, and
- A score of +1 indicates that the MIN positively impacts the performance measure.

After scoring each of the MINs relative to the specified performance measures, five weighting policies, given in Table 2, are used to explore the sensitivity of MIN priorities to the weights. The *Klinge Commission*, *Stakeholder Feedback*, and *VTrans Public Survey* are several independent efforts that recommended weights across the criteria.

With weights for the six classes of performance criteria assigned for each of the five weighting policies, weights must also be assigned to the performance measures within a criterion. For example, the *Safety and Security* criterion consists of three performance measures (1.1a, 1.2a, and 1.2b). Measures 1.1a and 1.2a pertain to the *Safety* component of the criterion, while performance measure 1.2b correlates to the *Security* portion. Thus, 1.1a and 1.2a aim to evaluate MINs relative to the safety metrics they specify, while 1.2b centers on an evaluation of security provided by the MIN relative to its description. Relative weights can be assigned to each of these (which must total 100%). As a result, while performance measure 1.1a may be of lesser weight (receiving a weight of 20%), measures 1.2a and 1.2b may be seen as critical (with each requiring 40% to fulfill the 100% weight requirement).

Table 1. Six classes of performance criteria used for prioritizing MINs (VTrans2025, 2004)

<i>Safety and Security</i>	Provide a safe, secure, and integrated transportation system that reflects different needs of the Commonwealth.
<i>Preservation and Management</i>	Preserve and manage the existing transportation system through technology and more efficient operations.
<i>Efficient Movement of People and Goods</i>	Facilitate the efficient movement of people and goods and expand choices and improve interconnectivity of all transportation modes.
<i>Economic Vitality</i>	Improve Virginia's economic vitality and facilitate the coordination of transportation, land use, and economic development planning activities.
<i>Quality of Life</i>	Improve environmental quality and the quality of life for Virginians.
<i>Program Delivery</i>	Improve program delivery.

Table 2. Overview of five weighting policies to be used across classes of criteria for prioritizing MINs

Policy 1	Equal Weights, including <i>Program Delivery</i> as a bonus category
Policy 2	<i>Klinge Commission</i>
Policy 3	<i>Stakeholder Feedback</i>
Policy 4	Equal Weights, excluding <i>Program Delivery</i> as a bonus category
Policy 5	<i>VTrans Public Survey</i>

After scoring each MIN relative to the performance criteria, the scoring and ranking results are interpreted. The high, low, and average *scores* and the high, low, and median *ranks* of the MINs across the five weighting policies are each reported in tables and graphs.

Statistical Comparison of Modal Plans

This section describes the statistical comparison of modal plans that could be useful to highlighting the relationship of MINs to modal projects.

For each project in each of four long-range plans, data were obtained for a statistical comparison as follows. Two quantitative metrics were identified for comparing projects within each of the four transportation modes. Project cost is obtained in addition to the degree of leveraged funding (percentage of funding provided by non-state sources). Two nonquantitative motivations for each project are also identified from among seven TEA-21 transportation factors. The TEA-21 factors are nearly identical to the VTrans2025 classes of performance criteria. A coordinate graph is used to compare the projects across modes with respect to their costs and the quantitative and nonquantitative factors.

The methodology of comparing projects across multiple transportation modes has evolved from a highway-only comparison methodology (Lambert et al. 2003). The aim of the multimodal comparison of projects is to provide a visualization of the scope and diversity of investments in transportation projects across modes. This is helpful in coordinating MINs across the modal agencies.

RESULTS AND DISCUSSION

This section provides results and discussion in two parts: prioritization of multimodal investment networks and statistical comparison of modal plans. Further documentation of progress is available at <http://www.virginia.edu/crmes/multimodal>.

Prioritization of Multimodal Investment Networks

The VTrans2025 *MIN Rating and Prioritization Workbook* was developed to prioritize the MINs. It allows users to (1) score the proposed MINs, subject to the defined criteria provided by VTrans 2025; (2) vary the weightings of the six major performance criteria, and their subsequent performance objectives, across five weighting policies; and (3) view and interpret the resulting weighted scores and rankings of the MINs. The workbook is available for downloading at www.virginia.edu/crmes/multimodal. It is composed of several worksheets that are described here.

Workbook Introduction

Figure 2 illustrates the *Introduction* to the MIN Prioritization Workbook. It describes the three worksheets that follow and provides contact information on the developers. On the left are

the names of the members of the 2002-2004 VTrans2025 Technical Committee and several hyperlinks directing the user to the websites of VTrans2025 and of the tool developers.

MIN Scoring Worksheet

Figure 3 depicts the *MIN Scoring Worksheet* of the MIN Prioritization Workbook. Twelve MINs are identified along the top edge of the figure. Each MIN title is a hyperlink to a narrative describing the MIN. The worksheet rows are the performance criteria and performance measures. The user of the worksheet enters scores (-1, 0, +1) to cells that are designated by a shaded background. The user is able to insert a comment justifying the given score. In this report, the purpose of generating the scores is to demonstrate the capability of the prioritization methodology rather than to prioritize real MINs.

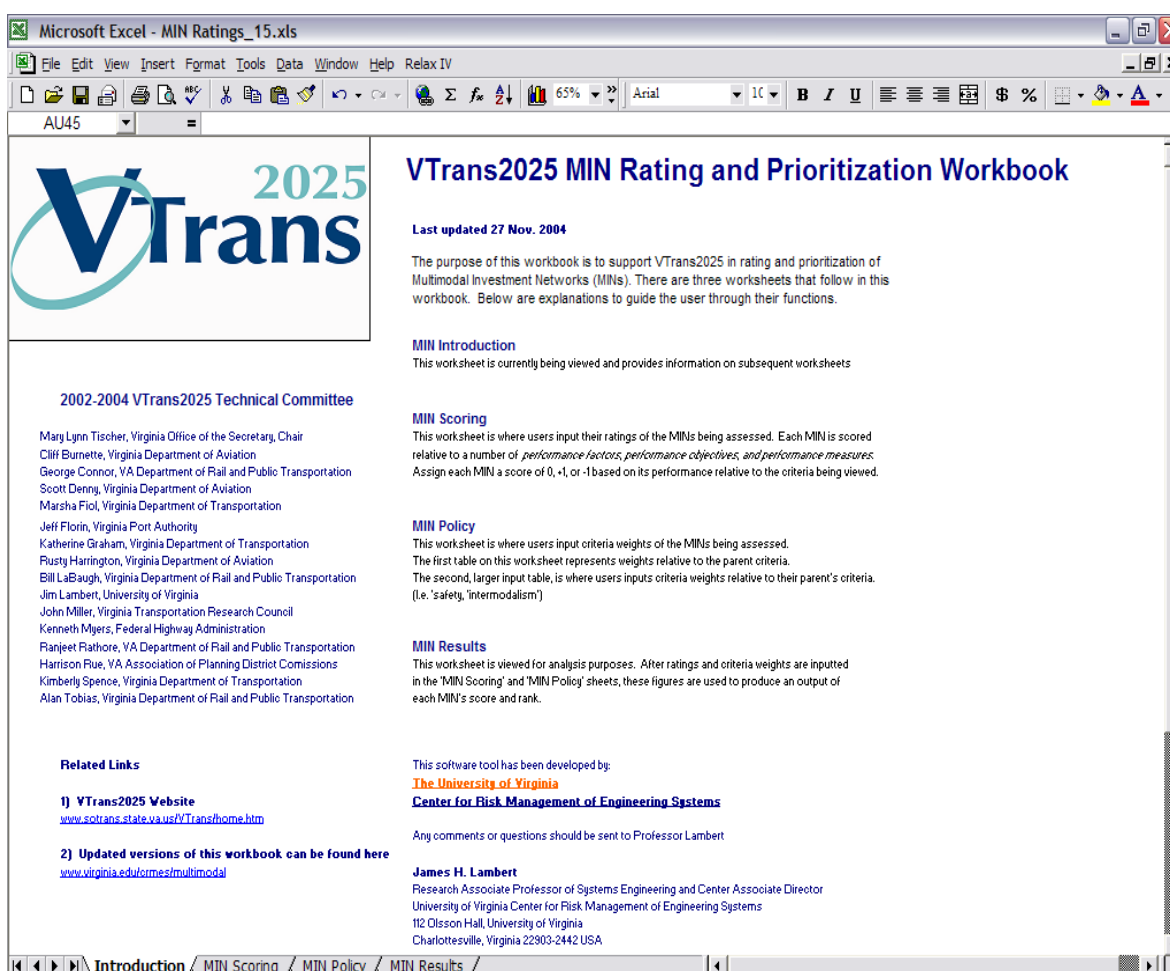


Figure 2. Introduction to the VTrans2025 MIN Rating and Prioritization Workbook.

MIN Scoring Worksheet

Figure 3 depicts the *MIN Scoring Worksheet* of the MIN Prioritization Workbook. Twelve MINs are identified along the top edge of the figure. Each MIN title makes a hyperlink

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B13 Performance Factor

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MIN Scoring Worksheet

LEGEND

+1: MIN has positive impact

0: MIN has no impact

-1: MIN has negative impact

Instructions

- 1) Enter MIN titles and a MIN score (0, 1, or -1) subject to the performance measure
- 2) Insert comments pertaining to MIN scores by right-click and selecting "Insert Comment"

yellow cells = data entry cells

Performance Factor	Performance Objectives	Performance Measures	Performance Measures														
			average MIN	Strategy 1: Transportation	Bike and Pedestrian	Port Accessibility and Mobility	NOVA Connections	Route 28	Coalfields Access	Franklin Airport	I-81 Passenger Goods Movement	I-95 Passenger Goods Movement	Richmond/Hampton Roads Parkway	Hampton Roads			
Criterion 1: Provide a safe, secure, and integrated transportation system that reflects different needs of the Commonwealth																	
1.1. Safety	1.1.a. Improve safety for system users and operators within the system and at mode origins/destinations (e.g., improve safety at at-grade crossings, improve bicycle and pedestrian safety, correct sub-standard (safety) designs and other geometric/pathway (e.g., runaway obstructions, channel depth, bridge clearance, etc.) deficiencies)	1.1.a. Reduction in crashes and/or incidents	1														
1.2. Security	1.2.a. Increase the security of the transportation system and its users	1.2.a. Reduction in security breaches or loss due to theft, vandalism, or other incidents	1														
	1.2.b. Provide infrastructure, facilities, and communications to meet strategic and emergency transportation needs	1.2.b. Ability to meet strategic and emergency transportation needs; ability to perform in the event of an attack or natural disaster	1	1	1	0	1	1	0	0	1	1	1	1			
Criterion 2: Preserve and manage the existing transportation system through technology and more efficient operations																	
2.1. Preservation	2.1.a. Preserve transportation infrastructure to achieve the lowest lifecycle costs (most efficient maintenance cost) and prevent failure	2.1.a. Reduction in long-term capital cost; critical need addressed; bridge condition	0	0	0	1	1	1	-1	0	0	0	1	0			
2.2. Management	2.2.a. Encourage access management techniques that preserve the operational integrity of existing infrastructure while ensuring appropriate access to adjacent land uses	2.2.a. Consistency with local comprehensive plans, MPO plans, or other regional plans; number of access breaks	1	0	0	1	1	1	0	0	0	0	0	0			
	2.2.b. Maximize system utilization by increasing the efficiency of existing facilities and services through use of people moved; ease of transition	2.2.b. Tons of freight move; number of people moved; ease of transition	1	1	1	1	1	1	1	1	1	1	1	1			

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MIN Policy Worksheet

Weighting Six Major Criteria

7

Weighting Performance Measures

The lower table in Figure 4 allows the user to vary weights relative to the specified performance factors within a criterion. The weights assigned to the performance factors (1.1, 1.2, 2.1, 2.2, etc.) within the first three major criteria are displayed in the lower table. (These are: *Safety, Security, Preservation, Management, and Mobility for All*.) The user can change the weights assigned to each of these individual performance factors. However, the sum of the performance factor weights within any of the six major criteria must equal 100%.

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MIN Policy Worksheet

INSTRUCTIONS for Criteria Weight Table

- 1) Enter policy names and criteria weights in the table below
- 2) For policies 1-5, the sum of the criteria weights (each policy column) should equal 100%
- 3) Once criteria weights have been applied to each of the policies, input sub-criteria weights in the table at the bottom of this worksheet

Criteria	Policy 1 Equal Weights (Criteria 1-6)	Policy 2 Klinge Commission	Policy 3 Stakeholder Feedback	Policy 4 Equal (w/o Program Delivery)	Policy 5 VTrans Public Survey
1. Safety and Security	17%	20%	13%	20%	17%
2. Preservation and Management	17%	10%	17%	20%	17%
3. Efficient Movement of People and Goods	17%	20%	23%	20%	17%
4. Economic Vitality	17%	15%	18%	20%	17%
5. Quality of Life	17%	15%	12%	20%	16%
6. Program Delivery	17%	20%	16%	0%	16%

INSTRUCTIONS for Sub-Criteria Weights Table

- 1) Enter sub-criterion weights in the table below
- 2) For policies 1-5, the sum of the performance measure weights for a given criterion should equal 100%

Performance Factors	Performance Measures	Policy 1 Equal Weights (Criteria 1-6)	Policy 2 Klinge Commission	Policy 3 Stakeholder Feedback	Policy 4 Equal (w/o Program Delivery)	Policy 5 VTrans Public Survey
1.1 Safety						
	1.1.a	50.0%	50.0%	50.0%	50.0%	50.0%
1.2 Security						
	1.2.a	25.0%	25.0%	25.0%	25.0%	25.0%
	1.2.b	25.0%	25.0%	25.0%	25.0%	25.0%
2.1 Preservation						
	2.1.a	50.0%	50.0%	50.0%	50.0%	50.0%
2.2 Management						
	2.2.a	12.5%	12.5%	12.5%	12.5%	12.5%
	2.2.b	12.5%	12.5%	12.5%	12.5%	12.5%
	2.2.c	12.5%	12.5%	12.5%	12.5%	12.5%
	2.2.d	12.5%	12.5%	12.5%	12.5%	12.5%
3.1 Mobility for All						
	3.1.a	11.1%	11.1%	11.1%	11.1%	11.1%
	3.1.b	11.1%	11.1%	11.1%	11.1%	11.1%
	3.1.c	11.1%	11.1%	11.1%	11.1%	11.1%

Figure 4. MIN Policy Worksheet of the MIN Prioritization Workbook.

MIN Analysis Worksheet

Output of MIN Scores

Figure 5 illustrates the *MIN Analysis Worksheet* of the MIN Prioritization Workbook. This worksheet reports the scores and rankings of the MINs listed at the top of the table below. The five weighting policies are listed on the left, beginning with the *Equal Weights* policy with bonus points. The table reports the score obtained by each of the MINs for each of the five weighting policies. In addition, an average score is reported in the bottom row. This gives an overall indication of how each MIN performed relative to the others across the five weighting policies.

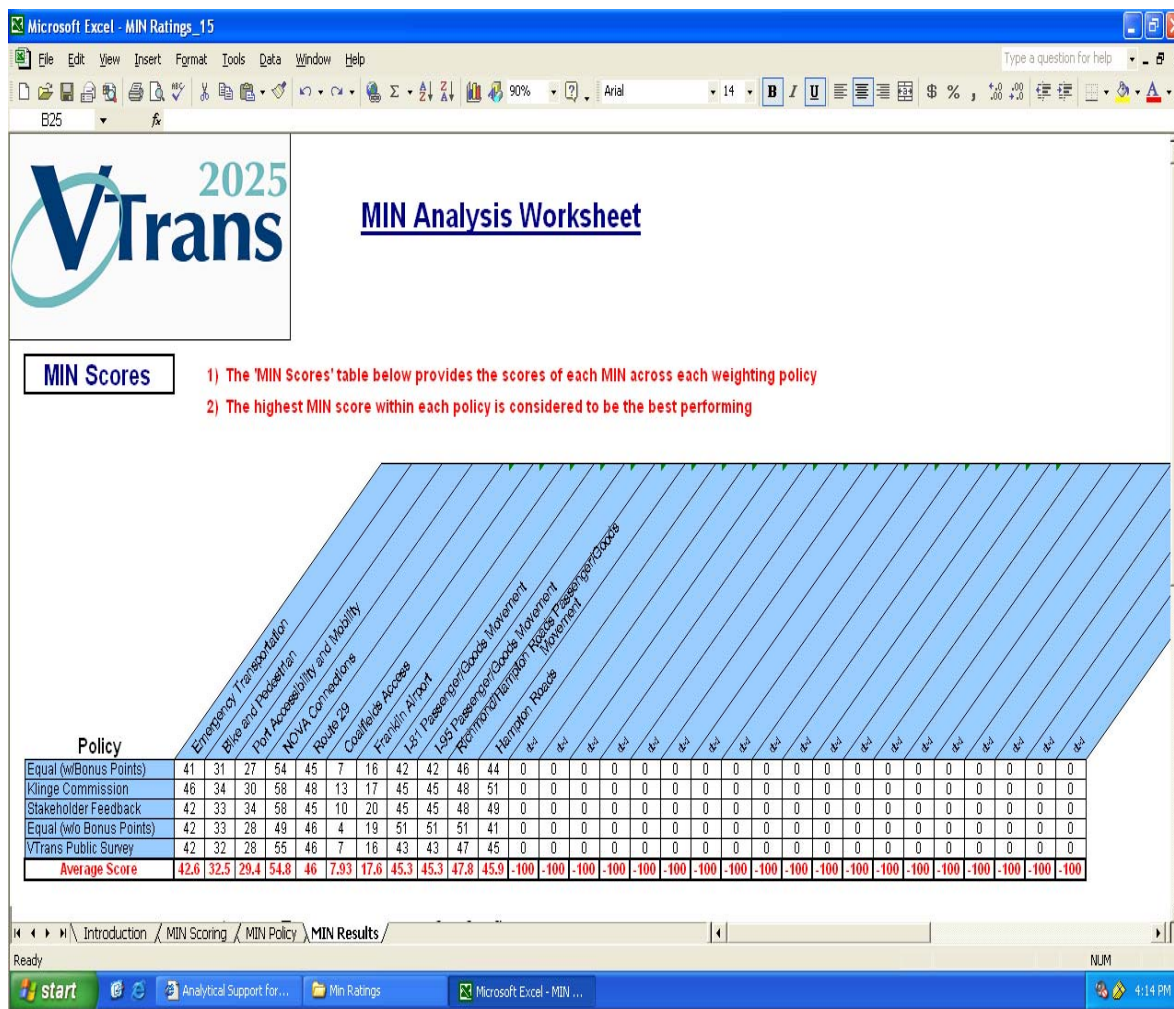


Figure 5. Table Reporting MIN Scoring on the MIN Analysis Worksheet.

Figure 6 illustrates the MINs scores in a graphical format. The scale on the left (from – 100 to 100) provides a comparison of the scores for the MINs listed at the top. The point under each designated MIN represents the average score it received across the five weighting policies. The short line extensions from many of these points indicate the range of scores obtained

(including the minimum and maximum). For example, the *NOVA Connections* MIN slightly exceeds a number of others with respect to its average and range of scores across the five weighting policies.

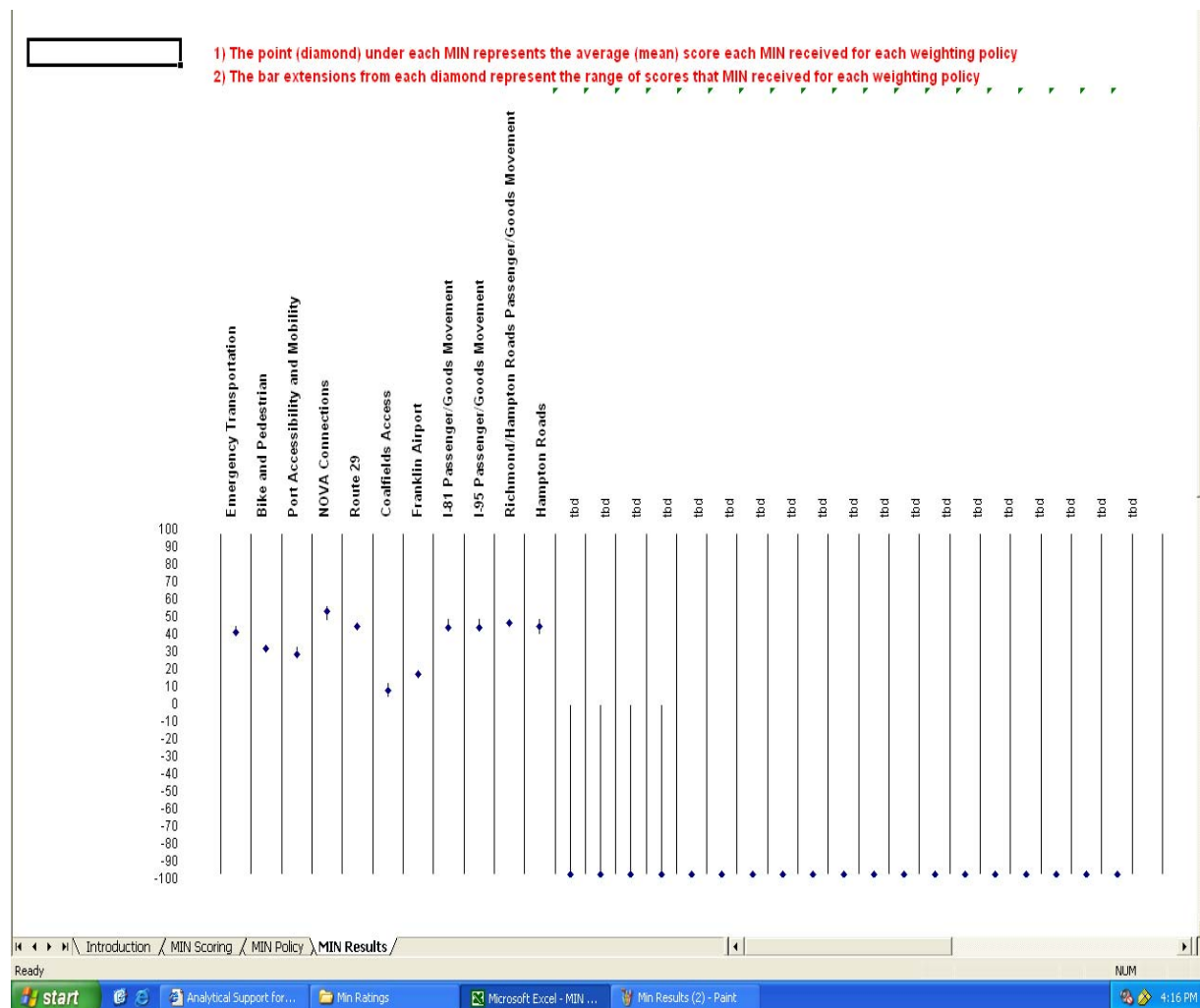


Figure 6. Graph Reporting the MIN Scoring on the MIN Analysis Worksheet.

Output of MIN Rankings

Figure 7 illustrates the rankings for the eleven MINs listed. The five weighting policies are listed at the left. The table provides the rank order of each of the MINs based on the score it obtained for a particular weighting policy. For example, the *NOVA Connections* MIN is ranked the highest for the first three and the fifth weighting policies. However, for the fourth weighting policy (*Equal w/o Bonus Points*), it is outscored by the MINs for the *I-81 Passenger/Goods Movement* and the *I-95 Passenger/Goods Movement*.

The median (middle) rank is reported along the bottom row of the table to give an overall indication of how each MIN ranked relative to the others across the five weighting policies.

Figure 9 shows a variety of DOAV projects configured around different motivations. Shown at the upper right is the horizontal axis, which is *population served* within twenty miles in thousands (on a logarithmic scale), and the vertical axis, which is *annual operations* in thousands (on a linear scale). These are represented on each square; the circles within the squares represent aviation projects. A larger circle implies a more costly project. Studying Figure 9 we see, for example, that the intersection of the *intermodalism and mobility* (IM) field and the *quality of life* (QL) field consists of projects that are motivated jointly by those two factors. The smallest shaded circle in the middle right of this intersection represents a less costly project that has the greatest impact in terms of population served.

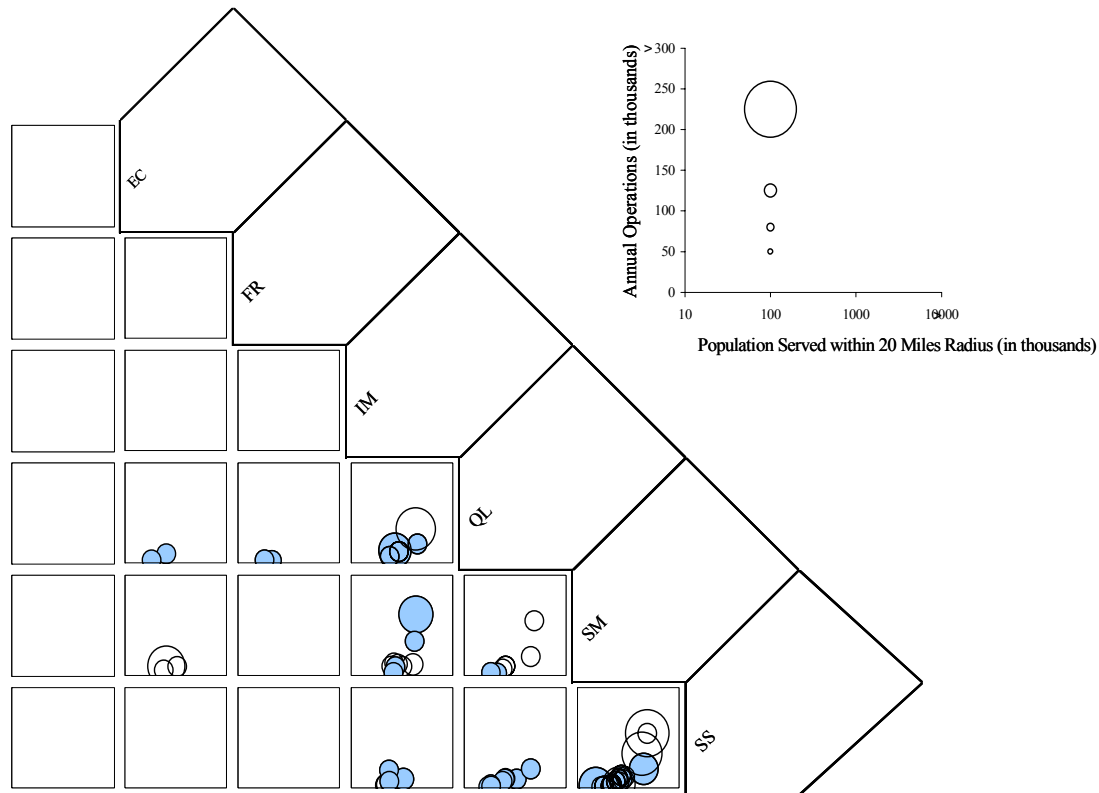


Figure 9. Comparison of 85 Aviation Projects.

(The qualitative motivations of projects are: EC= economic competitiveness, FR=fiscal responsibility, IM=intermodalism and mobility, QL=quality of life, SM=system management, and SS=safety and security.)

Ports

The Virginia Port Authority provided data for this case study on its port projects (Moffatt and Nichol Engineers, 2002; Yochum and Agarwal, 1995). There were project data for the three main ports of Virginia: Norfolk International Terminals, Newport News Marine Terminal, and Portsmouth Marine Terminal.

No statistics were available for individual port projects, so metrics for the port related to that project were used. The two metrics chosen for this case study were the *amount of freight carried per year* (vertical axis) and the *number of acres at an individual port* (horizontal axis). The amount of freight is the total tonnage of freight that passes through a port each year and thus represents the amount of activity for a port. The number of acres at the port allows the geographic footprint of the port to be considered in the comparison.

Economic competitiveness (EC), system management (SM), or intermodalism and mobility (IM) motivated all of the port projects. In Figure 10 (similar to Figure 9), in the cell at the intersection of IM and SM, the smallest (innermost) circle toward the top right of the cell represents one of the most desirable projects.

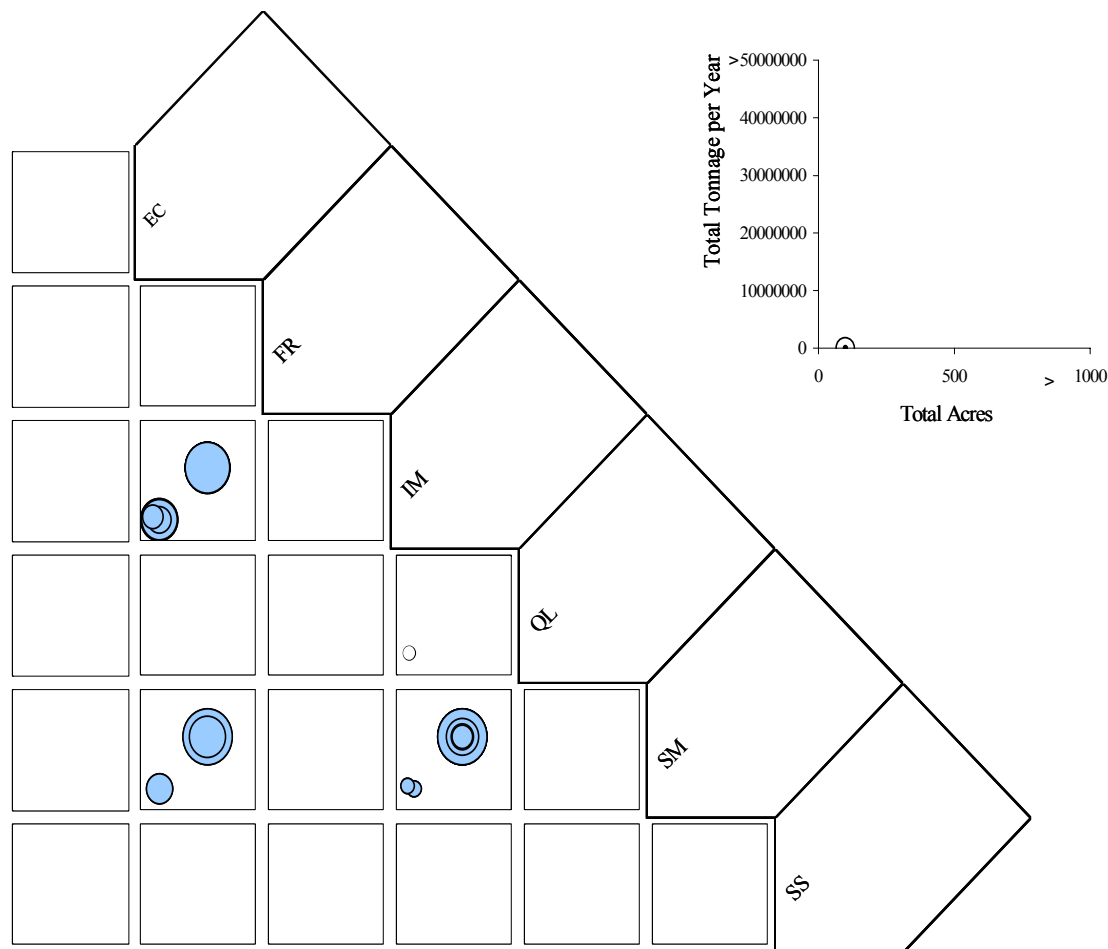


Figure 10. Comparison of 34 Port Projects.

Public Transit

The Virginia Department of Rail and Public Transportation (VDRPT) provided data for this case study on its transit projects (VDRPT, 2002). The 2003 Public Transportation Improvement Program section of the Six-Year Program listed over 100 projects. The listing, classified by transit district and transit agency, included a project description along with federal, state, and local costs.

A study entitled *Distribution of State and Federal Aid to Mass Transit Programs* was completed in 2000 by the Public Transportation Division of the VDRPT and suggested various metrics for prioritizing transit projects and allocating funding (VDRPT, 2000). Data on these metrics were collected for over 40 of the transit systems in Virginia. The case study has included these metrics because they were recommended by the VDRPT and the data was readily available for use. However, because it was collected by transit system and not by project, this case study does not use project-specific data.

After experimenting with the data, *population served* and *revenue hours plus revenue miles* were adopted as the most suitable quantitative metrics. Population served, calculated by counting the number of people in the service area, is a useful performance metric because it provides a measure of the density of potential travelers. Revenue hours plus revenue miles are calculated by adding the hours and the miles of revenue service a transit system provides. In this manner, systems with fewer long, high-speed routes (more revenue miles) as well as systems with more short, low-speed routes (more revenue hours) will be represented. Therefore, this metric describes the size of a transit agency in terms of service provided and is an effective performance measure for quantifying the impact of a project. Figure 11 shows the results of the case study, which concluded that intermodalism and mobility (IM), system management (SM), and safe and secure transportation (SS) motivated the most projects, particularly IM. Projects motivated by fiscal responsibility (FR) and SM had the greatest total cost, while projects motivated by IM and SM impacted the greatest number of people.

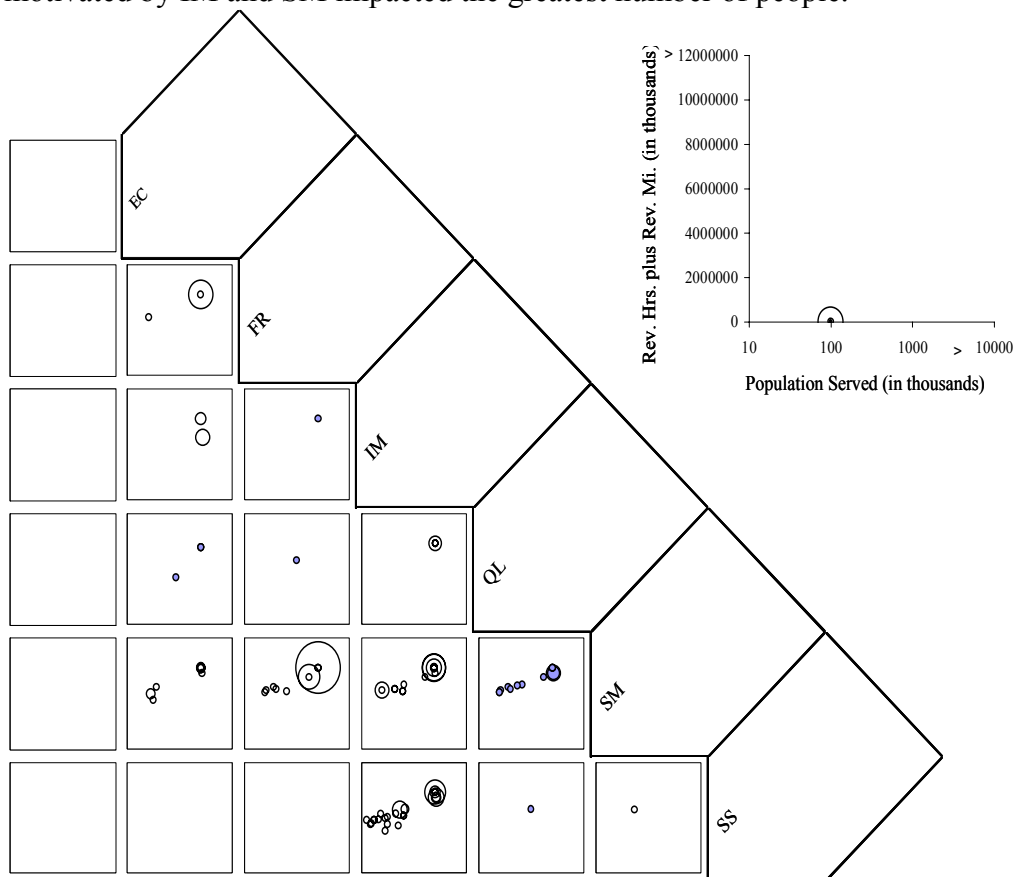


Figure 11. Comparison of 100 Public Transit Projects.

Rail

The Virginia Department of Rail and Public Transportation (VDRPT) provided data for a case study on its rail projects. Included was a list of fiscal-year (FY) 2002 funding allocations and 20-year cost needs for eight rail lines in Virginia, *Rail Industrial Access Funding* from FY 1999 to the present, and a summary of Virginia's passenger and freight rail projects. In addition, the *Virginia High-Speed Rail Six-Year Plan* (VDRPT, 2002) contained data for various improvement project proposals. Further information came from on-line databases at CSX and Norfolk Southern websites (CSX Intermodal, 2002; Norfolk Southern, 2002). CSX and Norfolk Southern are the two largest cargo rail companies in Virginia. From each of these sources, data was extracted in the following areas: description of each project, project cost (\$), leveraging as defined by state funding vs. federal funding, track miles of existing system (miles owned by rail company), and total freight cars on-line in existing system (per year). The data for track miles and total freight cars on-line was collected by the railroad lines and was not project-specific.

The two metrics chosen for this case study were *track miles* and *number of active cars on-line per year*. *Track miles* are defined as the total track distance that is owned by a railroad line. This metric was chosen because it quantitatively specifies the size of the various railroad lines in Virginia. *Cars on-line* is defined as the number of active or moving cars that that complete one trip on any particular railroad track. This metric was chosen because it indicates the size and cargo capacity as well as the track usage of Virginia railroads.

Figure 12 shows the results of the heavy rail case study. The majority of the projects are motivated by *system management* (SM) and *intermodalism and mobility* (IM). These are frequently the two most important factors in freight transportation. The project costs vary by a factor of about ten as indicated by the range of sizes of the bubble icons.

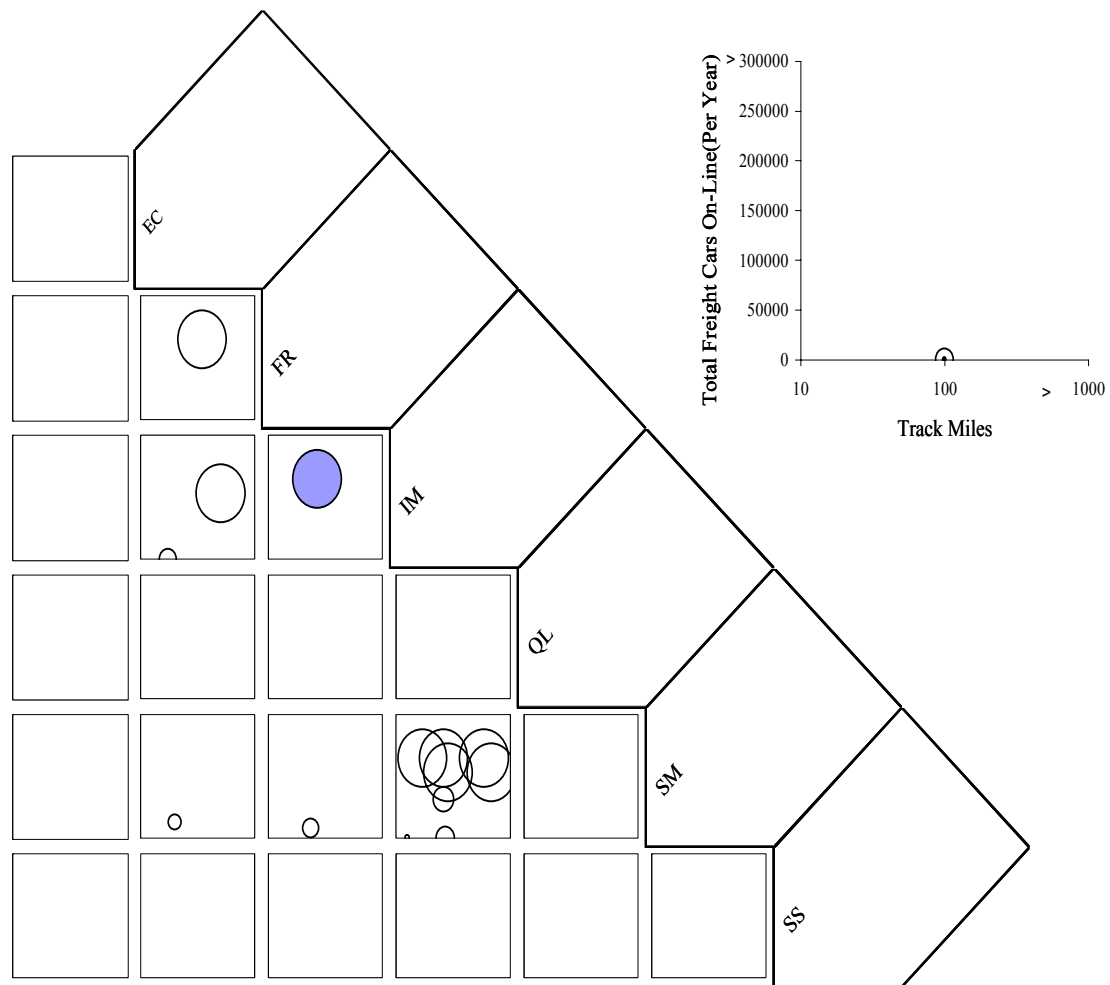


Figure 12. Comparison of 16 Rail Projects.

Figure 13 statistically compares the transportation plans across modes. The modal projects associated with the various MINs are at left, allowing a user the option to select any of the listed MINs.

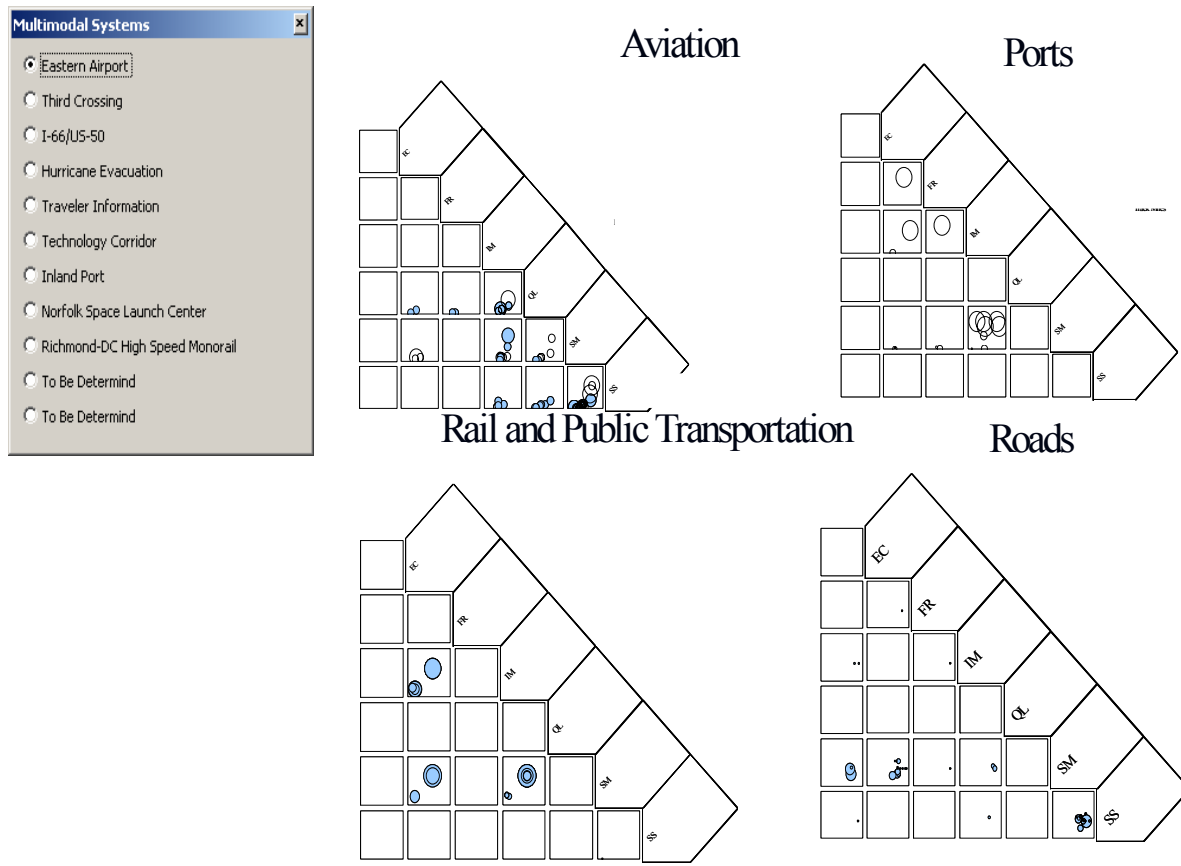


Figure 13. Statistical comparison of modal plans across modes, selectable by the relevant MINs at the left of the figure.

CONCLUSIONS

- Multimodal investment networks (MINs) can be prioritized based on a performance-based scoring and ranking methodology using various weighting policies for analysis.
- The statistical comparison of modal plans can be useful when assembling MINs and comparing the constituent projects according to their costs and associated quantitative and qualitative performance factors.
- Analytical methods that improve coordination among the state and local transportation agencies are critical to multimodal transportation planning.

RECOMMENDATIONS

1. Transportation modal agencies should consider the following questions in multimodal transportation planning and investing:
 - How can coordination among agencies be improved through analytical methods?
 - What agencies other than transportation agencies should be involved in developing analytical methods for multimodal transportation planning?
 - What web-based or other information technologies can be used to improve planning?
 - What are the unique analytical capabilities of the various state agencies?
 - How should the private sector participate in the analysis for multimodal transportation planning?
 - How can analytical methodology help MPOs and PDCs influence planning?
 - How should freight and passenger issues be integrated in analytical methods?
 - What analytical methods can be used for assessing associated benefits, costs, and cost savings?
 - What is the available range of analytical methods for prioritizing investments?
 - How can analytical methods represent federal, state, and local interests and those of the authorities?
 - How can analytical methods represent the unique local and regional issues?

- How responsive are analytical methods to the relevant legislative, executive, and judiciary functions of the government?
2. Continue to consider the analytical methods of other states and jurisdictions in multimodal transportation planning.
 3. Continue to develop analytical methods such as those developed in this effort to benefit the ongoing implementation of multimodal transportation planning in Virginia.

COSTS AND BENEFITS ASSESSMENT

The methodology developed in this project fosters improved coordination in planning and programming transportation investments across modal agencies. The potential benefits of the methodology include:

- identification of lower-cost investment alternatives when considering multiple modes relative to considering only single modes to meet a particular travel demand
- selection and programming of multimodal solutions that have the highest performance relative to the available or required levels of investment
- increased transparency and accountability of the multimodal agencies for the uses of funding that can be allocated across multiple transportation modes.

The costs of implementing the methodology developed in this study are minimal and include:

- one-time training of staff of the modal agencies in the use of the identification and priority-setting methodology and software demonstrated in the current study
- regular interaction and dialogue among the staff of the modal agencies that are involved in the identification and prioritization of investments across modes.

REFERENCES

- Brown, J., 2002. Statewide transportation planning: Lessons from California. *Transportation Quarterly*, Spring, p.52.
- Cambridge Systematics, Inc., 1999. *Final Report—Multimodal Transportation: Development of a Performance-Based Planning Process*. Cambridge, MA.
- Commonwealth Transportation Alliance, Virginia High Speed Rail 6-Year Plan, 2002.

- CSX Intermodal, 2002. Available online at <http://www.csxi.com/content/index.cfm?fuseAction=whoWeAre> [Accessed September 17, 2002].
- Forkenbrock, D, N. Foster, and M. Crum, 1993. *Transportation and Iowa's Economic Future*. Public Policy Center, Iowa City, IA.
- Giorgi, L., and A. Pearman, 2002. *Project and Policy Evaluation in Transport*. Ashgate Publishing, Burlington, VT.
- GIS, 2003. *What Is GIS? Guide to Geographic Information System*. Available online at <http://www.gis.com> [Accessed January 27, 2003].
- Halvorson, R, T. Hatata, M. Tischer, and P. Kolakowski, 2000. Performance-based planning: Asset management, and management systems. Statewide Transportation Planning (Chapter 5). *Transportation Research Circular*, 04, pp. 5-15.
- ISTEA, 1991. Intermodal Surface Transportation Efficiency Act. Available online at <http://www.bts.gov/lawlib/docs/istea5.htm> [Accessed October 10, 2002].
- Lambert, J.H., K.D. Peterson, and C.A. Pinto, 2003. *An Aid to the Comparison of Major Infrastructure Investments*, Submitted to Risk Analysis.
- Lambert, J. H., K.D. Peterson, and C.A. Pinto, 2003. Extended Comparison Tool for Major Highway Projects. VTRC 03-CR13. Virginia Transportation Research Council, Charlottesville.
- Moffatt and Nichol Engineers, 2002. *Virginia Port Authority 2020 Master Plan*. Richmond, VA.
- National Cooperative Highway Research Program, 1997. *Methods for Capital Programming and Project Selection: Synthesis 243*. National Academy Press, Washington, DC.
- National Cooperative Highway Research Program, 2000. Performance Measurement in State Departments of Transportation: Synthesis 238. National Academy Press, Washington, DC, pp. 28-31.
- National Cooperative Highway Research Program), 2000. Multimodal Aspects of Statewide Transportation Planning: Synthesis 286. National Academy Press, Washington, DC, pp. 2, 6.
- Norfolk Southern, 2002. Conrail Transaction Council Measure. Available online at <http://www.nscorp.com/stb/> [Accessed November 15, 2002].
- Page, K., 1999. Rail Access 1999. Virginia Department of Rail and Public Transportation. Email [Accessed November 5, 2002].

- Pedersen, N., 2000. Multimodal Transportation Planning at the State Level, State of the Practice and Future Issues. Transportation in the New Millennium. Transportation Research Board, Washington, DC, pp. 3-4.
- Pedersen, N., and G. Jeff, 2000. Challenge for statewide transportation planning for the 21st Century. Statewide Transportation Planning (Chapter 3). *Transportation Research Circular*, 04, pp. 3-2, 3-3.
- Transportation Equity Act for the 21st Century Plan, 1998. Available online at <http://www.TEA-21.org/guide/sm/htm> [Accessed October 10, 2002].
- Tobias, A. Virginia Passenger Rail Projects. Rail Passenger Project Manager: Virginia Department of Rail and Public Transportation. Email [November 5, 2002].
- Transportation Research Board, 1994. Role of Performance-Based Measures in Allocating Funding for Transit Operations. Washington, DC.
- Virginia Commonwealth Transportation Board, 2002. VTrans2025: Virginia's Statewide Multimodal Long-Range Transportation Plan, Phase 1. Available online at <http://www.sotrans.state.va.us/VTrans/Vtransrpt-GA.pdf> [Accessed February 13, 2003].
- Virginia Department of Transportation. Virginia Airports. Available online at <http://www.doav.virginia.gov> [Accessed October 10, 2002].
- Virginia Department of Rail and Public Transportation, 2000. Distribution of State and Federal Aid to Mass Transit Programs. Public Transportation Division. Available online at <http://www.drpt.state.va.us/resource/downloads/hjr720.pdf> [Accessed November 2, 2002].
- Virginia Department of Rail and Public Transportation, 2002. 2003 Public Transportation Improvement Program. Available online at http://www.drpt.state.va.us/downloads/files/program_of_projects_fy03.pdf [Accessed October 20, 2002].
- VTrans2025, 2004. Virginia's Statewide Multimodal Long-Range Transportation Plan: Phase 3 and Final Report to the General Assembly. <http://www.virginiadot.org/projects/resources/revisedPhase3Reportfortb.pdf>.
- Yochum, G.R., and V.B. Agarwal, 1995. The Economic Impact and Rate of Return of Virginia's Ports on The Commonwealth. Old Dominion University, Norfolk, VA.