ANALYTICAL SUPPORT FOR THE STATEWIDE MULTIMODAL LONG-RANGE TRANSPORTATION PLAN

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ABSTRACT

The goal of this effort is to develop methodology to aid the VTrans2025 Steering Committee in selecting and prioritizing multimodal transportation systems. The comparison tool allows decision makers to compare proposed multimodal projects using both quantitative and qualitative measures. Through case studies of each mode of transportation, aviation, port, public transit, and rail, the capabilities of the comparison tool are demonstrated. The comparison tool displays the motivations of the projects along with the cost and performance metrics specific to each mode. Officials in the multimodal steering committee and the various transportation agencies can use the information from the comparison tool when aggregating projects into multimodal systems.

1 INTRODUCTION

In accord with the vision of VTrans2025 “to build a world-class multimodal transportation system,” there is the need for analytical methods to improve the communication and cooperation among the various modal transportation agencies of the Commonwealth of Virginia. The Intermodal Surface Transportation Efficiency Act (ISTEA) and the Transportation Equity Act for the 21st Century (TEA-21) 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 into a larger multimodal framework.

Figure 1 shows an excerpt from the VTrans2025 plan that describes the life cycle of transportation projects that will receive priority for federal and state funding. The Capstone team’s primary activities were the development of individual priority models and the integration of these results into a multimodal system scoring method. The lower-left portion of the figure depicts transportation project comparisons that were examined on a mode-by-mode basis. The center portion of the figure depicts transportation system comparisons that were examined on a multimodal basis. By improving prioritization methodology in these two steps of the VTrans2025 flow chart, the Capstone team can help ensure that funds of multimodal transportation agencies can be allocated in a more efficient manner.
The organization of the paper is as follows: First, a project comparison tool and the project motivations are introduced. Next, the data collection process and metrics for assessing projects are discussed. Finally, the case studies involving each mode of transportation are analyzed.

2 COMPARISON TOOL

VDOT must take into consideration a variety of factors when deciding which projects to fund. These factors include the six motivations mentioned in the Statewide Multimodal Long-Range Transportation Plan (VTrans2025). The definitions of these motivations according to the plan are as follows:

**Safe and Secure Transportation (SS):** Apply efficient and effective transportation security measures. Improve the safety of locations where modes intersect.

**System Management (SM):** Maintain an efficient and reliable transportation system balancing safety and effective operation. Promote the use of appropriate technology to maximize system effectiveness.

**Intermodalism and Mobility (IM):** Encourage intermodality to maximize the accessibility, use, and efficient connectivity of the overall transportation system. Provide effective and economical transportation choices and alternatives for people and goods across the state.

**Economic Competitiveness (EC):** Develop a transportation system that supports statewide economic development, commerce, and tourism.

**Fiscal Responsibility (FR):** Ensure balanced and effective transportation investments. Develop realistic transportation programs based on accurate cost estimates.

**Quality of Life (QL):** Enhance and protect the natural environmental quality and cultural and historic resources. Ensure the compatibility of transportation services with the stakeholders and the communities they serve.

The comparison tool lists the six motivations along the diagonal, allowing projects to be motivated by two factors (Lambert et al. 2003). The applicable projects are then placed in the intersection of the two motivating factors. The circles in the comparison tool represent projects. The area of the circle is relative to the cost of the project. The axes of each of the blocks can represent different types of data that interest decision makers. In the following case studies, the coordinate axes represent the performance metrics most suited to each mode. Projects located in the upper-right portion of the graphs have greater impacts and therefore deserve requisite attention. The comparison tool has several features that will aid decision makers in the complicated process of comparing diverse projects. Certain projects can be highlighted to distinguish one set of projects from another. Also, statistical results can be selected instead of the graphical project comparisons.

3 DATA COLLECTION AND METRICS SELECTION

For each project in each of four modal case studies, data was obtained for entry into the comparison tool. This included project cost, leveraging (percentage of funding provided by non-state sources), and data for the two comparison metrics used for the mode of that project.

To utilize the comparison tool, motivations for each project were also determined. While a primary motivation is often easily identified, sometimes the secondary motivation is less prominent and somewhat subjective. Assigning appropriate motivations to the project is an important step since the motivations aid in the comparison of funded projects.

Metrics for each of the four transportation modes were identified. These metrics were intended to encompass the six main goals of the steering committee. With data for two relevant metrics of a project, graphical comparisons for projects can be made. These graphical comparisons are made on a coordinate graph with each axis representing a metric. Such metrics are termed orthogonal metrics.

In order to make comparisons between transportation projects from different modes, a relevant common set of metrics had to be determined. A common set would include two metrics that are applicable to all transportation modes and that represent variables that are significant in making a comparison. Only with these common metrics could an explicit comparison be made across modes using the comparison tool. Projects in all modes require data for the two common metrics. Although several of the modes had metrics that were common to other modes, there was no set of metrics common across all modes. The initial goal of being able to compare transportation projects from different modes on a single coordinate graph could not be achieved.

4 CASE STUDIES

Four case studies were completed to represent four modes of transportation. The comparison tool was developed in previous effort for use with highway projects (Lambert et al. 2003). These case studies served to extend the comparison tool to other modes of transportation and demonstrate its usefulness in a multimodal setting.
4.1 Aviation Case Study

The Virginia Department of Aviation (DOAV) provided data for this case study on its aviation projects. This data included performance and cost statistics on 85 aviation projects throughout Virginia. In addition, the case study used the Geographic Information System (GIS) to gather population data for the areas surrounding Virginia’s airports.

The two performance measures used in this case study were population served within 20 miles and annual operations. The population served is an indicator of how to handle congested conditions in locations surrounding the airport, such as expanding highways and roadways leading to the airport. The population served advocates the need for creating extra safety and precautionary measures around the populated area of the congested airport, such as designing convenient exits to hospitals, building fire stations, and/or constructing emergency pathways. Annual operations include capacity and peak operating conditions of the airport. As the number of annual operations of an airport increases, the priority of its planned construction and design improvements increases as well. The annual operations metric is similar to the population served within 20 miles, in terms of planning, designing, implementing, and managing the airport system to assure performance, safety, reliability, and maintainability. Overall, the population served and the annual operations metrics have helped the DOAV assess the efficiency of the airports in Virginia.

Figure 2 shows a variety of projects scattered around different motivations. Each square is represented by the horizontal axis, which is population served within 20 miles in thousands based on a logarithmic scale, and by the vertical axis, which is annual operations in thousands based on a linear scale. The intersection of the intermodalism and mobility field and the quality of life field consists of projects that serve intermodalism and mobility and quality of life only. A larger radius implies a more costly project. Blue circles indicate approved projects selected in this intersection, based on the metrics shown in the adjacent graph (population served within a 20 mile radius in thousands vs. annual operations in thousands). For example, the smallest blue circle in the middle right of the intersection of the quality of life and intermodalism and mobility fields represents a less costly project that has the greatest impact in terms of population served.

4.2 Port Case Study

The Virginia Port Authority provided data for this case study on its port projects (Moffatt and Nichol Engineers, 2002 & Yochum, 1995). There was only project data available for three main ports within Virginia: Norfolk International Terminals, Newport News Marine Terminal, and Portsmouth Marine Terminal. Many ports do not handle passenger travel, and therefore statistics on safety were unavailable. Additionally, data on percentages of funding required by the state was not available.

There were no relevant statistics for individual port projects, so metrics for the port related to that project were used. The two metrics chosen for this case study were 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 an individual port allows for the physical size of the port to be considered in the comparison.

All of the port projects were motivated by economic competitiveness, system management, or intermodalism and mobility. Because there was data available for only three ports, the projects appeared in three specific areas in the comparison tool. In Figure 3 in the box at the intersection for intermodalism and mobility and system management, the smallest circle in the top right region represents one of the most desirable projects.
4.3 Public Transit Case Study

The Virginia Department of Rail and Public Transportation (VDRPT) provided data for this case study on its transit projects (Virginia Department of Transportation’s Six-Year Program). The 2003 Public Transportation Improvement Program section of the Six-Year Program listed over 100 projects. The listing, broken down 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. Data on these metrics were collected for over 40 of the transit systems in Virginia. These metrics were included because they were recommended by the VDRPT and data was readily available for use. Because the data was collected by transit system and not by project, this case study does not use project-specific data. It would be preferable in the future to analyze projects using project-specific data if it became available. After experimenting with the data, population served and revenue hours plus revenue miles were found to be the most useful metrics in the comparison tool. 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 overall impact a project will have on society in terms of people affected. Revenue hours plus revenue miles is calculated by adding the hours of revenue service a transit system provides and the miles of revenue service it provides. In this manner, both systems with fewer long, high-speed routes (more revenue miles) and systems with more short, low-speed routes (more revenue hours) will be represented. Therefore, this metric fairly describes the size of a transit agency in terms of service provided and is an effective performance measure in quantifying the impact of a project. Figure 4 shows the results of the case study. The study concluded that intermodalism and mobility, system management, and safe and secure transportation motivated the most projects, particularly intermodalism and mobility. Projects motivated by fiscal responsibility and system management had the greatest total cost, while projects motivated by intermodalism and mobility and system management impacted the greatest number of people. In addition, any set of projects could be directly compared through an elementary cost/benefit analysis. Conclusions from these analyses depend on what sets of projects the user is interested in analyzing.

4.4 Rail Case Study

The Virginia Department of Rail and Public Transportation (VDRPT) provided data for this case study on its rail projects. Included was a list of fiscal year 2002 funding allocations and 20-year cost needs for eight rail lines in Virginia, Rail Industrial Access Funding from fiscal year 1999 to present, and a summary of Virginia’s passenger and freight rail projects. In addition, the Virginia High Speed Rail Six-Year Plan contained data for various improvement project proposals (High Speed Six-Year Plan 2002). Further information came from on-line databases at CSX and Norfolk Southern web sites. CSX and Norfolk Southern are the two largest cargo rail companies in Virginia. From each of these sources data was extracted from 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 railroad line 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 is 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 was chosen as the second performance metric. 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 track usage of Virginia railroads.

Figure 5 shows the results of the heavy rail case study. As one can see, the majority of the projects are motivated by system management and intermodalism and mobility. This is because these metrics are frequently the two most important factors in freight transportation. Other observations include project cost. Over half of the projects are very expensive as indicated by the large size of the bubbles.

**ACKNOWLEDGEMENTS**

We would like to thank the following members of the VTrans2025 steering committee and others for their support throughout this effort: Jim Bland, Cliff Burnette, Jeff Florin, George Connor, Bill LaBaug, Alan Tobias, Ranjeet Rathore, Ken Lantz, Diane Mitchell, Marsha Fiol, Katherine Graham, Kimberly Spence, Frank Dunn, Gus Robey, Mary Lynn Tischer, Mike Knott, Chip Badger, Alan Tobias, Bill Ketron, Kevin Page, Wayne Ferguson, Mike Fontaine, and John Miller.

**REFERENCES**


Moffatt and Nichol Engineers. 2002. Virginia Port Authority 2020 Master Plan. Richmond, VA.


Page, Kevin. “Rail Access 1999.” Virginia Department of Rail and Public Transportation. Obtained via email <kbpage@drpt.state.va.us> [November 5, 2002].


Tobias, Alan. “Virginia Passenger Rail Projects.” Rail Passenger Project Manager: Virginia Department of Rail and Public Transportation. Obtained via email <ato-bias@drpt.state.va.us> [November 5, 2002].


Virginia Department of Transportation. Virginia Airports. Available online via <http://www.doav.state.va.us/airport s.htm> [accessed October 10, 2002].


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