Virginia's Long-Range Multimodal Transportation Plan

Final Report:

Economic Impact of Transportation Investments in Virginia

Prepared for:
Office of Intermodal Planning and Investment
Virginia Department of Transportation

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EXECUTIVE SUMMARY

Economic Impact of Transportation Infrastructure Improvements in Virginia

by Economic Development Research Group,
with Delcan and Cambridge Systematics,
January 2010

Overview. This document summarizes key findings on the economic impact of transportation activities in Virginia, and the economic impact of infrastructure improvements that were planned to take place in Virginia over the six year period of 2009-2014. It also describes tools and methods developed for the Commonwealth to enable state agency staff to assess the economic impact of future transportation investments spanning all modes.

Transportation in Virginia. Virginia's transportation infrastructure – including roads, rail lines, aviation facilities, marine facilities and associated freight and passenger terminals – enable a broad range of passenger and freight movements. They provide access for households and businesses, and make Virginia a cost-effective location for commerce and a broad range of economic activity. Operation of transportation facilities and services directly account for over 246,000 jobs in Virginia.

Yet that is only one small part of the role of transportation in the economy. In a very real sense, every job in Virginia depends on transportation infrastructure for some combination of: (a) commuting to work, (b) deliveries of materials and products to users, and (c) visits to business and recreation destinations. However, the future of that economic base is not guaranteed. The capacity and effectiveness of Virginia's transportation systems to handle future demand, and the quality and cost of service it provides, can potentially have a positive or negative impact on the future economic growth within the Commonwealth.

Impact of Six-Year Planned Investments. The projected spending for the six-year time period of 2009-2014 is based on the "Commonwealth Transportation Fund Allocation Summary" for those years. This includes both *capital investment* on vehicles and facilities (such as roads, runways, docks, terminals, buses and trains) and *operations* (such as road maintenance, port equipment operators, bus drivers and public agency management). Additional details on expected project and program spending was provided by the Virginia Dept. of Transportation (VDOT), Virginia Dept. of Rail and Public Transportation (DRPT), Virginia Dept. of Aviation (DOAV) and the Virginia Port Authority (VPA).

The numbers reported here were based on a profile of transportation investment that was planned for the next six years in Virginia, as of February 2009. These numbers have since been revised, and they may continue to be further revised as economic conditions and state tax revenues shift over time. For that reason, the numbers shown here should be interpreted as merely indicative of the magnitude of impacts associated with the given scale and mix of transportation investments.

Projected Transportation Capital Investment and Operations Spending

Projected Capital Investment (Total 2009 – 2014)	*Total Over Six Years (millions)**
Highways: Capital Construction (incl hwy system + earmarks)	$ 6,455 m
Public Transportation & Rail : Capital Projects	$ 2,441 m
Aviation Capital Projects: functional improvements	$ 314 m
Aviation Capital Projects: safety/conformity projects	$ 467 m
Port : Capital Construction Projects	$ 745 m
TOTAL CAPITAL INVESTMENT $	**$ 10,422 m**

Estimated Operations Spending (Total 2009-2014)	*Total Over Six Years (millions)**
Highways: Ongoing Operation & Maintenance	$10,641 m
Public Trans: Ongoing Operations Support	$ 1,066 m
Airports: Terminal Operations (wages)*	$ 7,442 m
Marine ports: Ship & Harbor Operation (wages) *	$ 1,854 m
VDOT Administration	$ 1,465 m
TOTAL OPERATIONS SPENDING $	**$22,468 m**

**see main report for further explanation of this data.*

Impact Analysis Process. The expected impact of this capital and operations spending on the Virginia economy was calculated using a multi-modal economic analysis tool known as TREDIS (Transportation Economic Development Impact System). This type of structural analysis system has been applied in numerous states across the country, but the version applied here was built upon a model of the Virginia economy, its specific flows of imports and exports, and ways in which different Virginia industries depend on transportation for workers, materials and product deliveries.

This economic analysis process was used to calculate two types of impacts on the Virginia economy. First, it calculated *short-term spending impacts*, which are the effects of money spent on capital investment and operations (during the period of 2009-2014) on the flow of income supporting business activity and jobs during those years in which the spending occurs. It also calculated *long-term productivity impacts*, which are the continuing effects of improved transportation conditions on economic productivity and competitiveness, and hence economic growth, for years after the investment was made (which in this case were calculated out to the year 2035). Both types of impact were measured in terms of additional employment, increased business output, value added and wages.

Short-Term Economic Impact of Capital & Operations Spending. The short-term spending impact included three elements: It first considered *direct effects* of capital and operations spending on money flowing to Virginia workers and to contracted suppliers, construction companies and operators. It then considered *indirect effects* generating additional orders to supplier industries (which provide parts, materials and supporting services). It also included *induced effects* on consumer spending generated by the additional (direct and indirect) wages of workers living in Virginia. Adjustment was also made for the fact that 50% of the Reagan National Airport workers and 29% of the Dulles Airport workers do not live in Virginia and hence tend to spend their incomes elsewhere.

The results, shown in the table that follows, indicate that the $33 billion of expected capital investment and operations spending over six years will support over $56 billion of business output (sales revenue) with an average of over 78,000 jobs per year (totaling 468,000 job-years). That economic growth will, in turn, return roughly $2.3 billion of additional revenue back to state and local governments over the six years.

Short-Term Spending Impact of Capital and Operations Budgets*

Category	***Total Effect on Virginia Economy, 2009-2014***		
	Total Over 6 Yrs	**Avg. Year**	**Per $ Mil Spent**
Capital Investment Spending ($ mil)*	**$ 10,422**	**$ 1,737**	**--**
Employment (Jobs)	142,082 *(job-yrs)*	23,680	14
Business Output ($ mil)*	$ 18,780	$ 3,130	1.8
Value Added (GRP)($ mil)*	$ 9,740	$ 1,623	0.9
Worker Income ($ mil)*	$ 7,518	$ 1,253	0.7
Capital + Operations Spending ($ mil)*	**$32,890**	**$5,481**	**--**
Employment (Jobs)	468,850 *(job-yrs)*	78,142	14
Business Output ($ mil)*	$56,172	$9,360	1.7
Value Added (GRP)($ mil)*	$29,302	$4884	0.9
Worker Income ($ mil)*	$20,340	$3,890	0.6

** All values are in constant year 2008 dollars. Dollar amounts in different rows cannot be added together. Specifically, worker income is a subset of value added, and value added is the portion of business output that does not go for materials and supplies.*

Long-Term Economic Impact of Transportation System Improvements. The long-term benefit of capital investment in transportation facilities is the improvement in travel conditions which lead to economic cost savings and productivity enhancement for Virginia residents and businesses. These improvements occur through five types of impacts on transportation system users:

- cost savings due to reduced user time delay & expense
- cost savings due to enhanced safety & reliability
- cost savings from enhanced inter-modal capacity & connectivity
- cost savings and scale economies from enhanced market access
- Added growth enabled by elimination of capacity constraints at gateways

Those user benefits, in turn, lead to direct, indirect & induced effects on household living costs, business operating costs, productivity and competitiveness. They enable more jobs and business activity to take place in Virginia, which also reduces the "leakage" of income and savings that might otherwise flow to businesses located outside of Virginia. The results (shown in the table below) indicate that the $10.4 billion of capital investment will enable continuing economic growth totaling $81 billion of additional business output over 25 years. That represents an average of $3.1 billion/year of additional business output, although the level will rise over time to reach $13.6 billion/year of additional output by 2035. Associated with this economic growth will be an average of over 23,000 more jobs, rising to over 101,000 more jobs by 2035.

Long-Term Economic Growth Impact of Transportation System Improvements from Planned Six-Year Program of Capital Investments

Impact Category	*Avg. Year 2010-2035*	*Year 2035 Impact*	*Sum of 2010-2035*	*Per $mil of Capital Investment*
Employment (Jobs)	23,523	101,932	611,590	58.8
Business Output ($ mil)*	$ 3,137	$13,594	$ 81,566	$ 7.8
Value Added ($ mil)*	$1,539	$ 6,668	$4 0,006	$ 3.8
Worker Income ($ mil)*	$ 1,025	$ 4,441	$ 26,645	$ 2.6

** All values are in constant year 2008 dollars. Dollar amounts in different rows cannot be added together. Specifically, worker income is a subset of value added, and value added is the portion of business output that does not go for materials and supplies.*

These long-term economic impacts of planned capital investments should be interpreted carefully. It is important to note that these impacts represent the difference between a scenario in which needed investments are made and a scenario in which those capital investments are not made. So in a very real sense, the capital investments are enabling a continued level of economic growth while the failure to invest would lead to a lower level of economic growth.

Analysis was also conducted of the mix of business activities associated with the projected job growth. It showed that fully 96% of the job impact generated by the transportation capital investments are private sector jobs.

Total Economic Impact and Return on Investment. Adding together the short-term spending impacts and the long-term improvement impacts lead to the following overall job impacts:

- Capital Investment Spending 142,100 job-yrs over 6 yrs (23,700/yr)
- Operations Spending 326,700 job-yrs over 6 yrs (54,400/yr)
- Total Six-Year Spending 468,800 job-yrs over 6 yrs (78,100/yr)
- Long-Term Impact 611,600 job-yrs over 26 yrs (23,500/yr)
- Total 1,080,400 job-yrs total

Benefit-Cost Ratio. While the focus of this study was on the calculation and measurement of impacts on the economy, the information collected as part of this analysis also made it possible to calculate measures of "benefit/cost ratio" and "economic return on investment." Both of these measures apply a discount rate to calculate the present value of cost, revenue and benefit streams that occur over periods of time.

Two different measures are shown in the table which follows. One is the *economic impact ratio*, which reflects value added (wage income and business profit income) generated per dollar of transportation investment. That calculation comes directly from the economic impact analysis results. The other measure is *the benefit/cost ratio*. It is similar to the economic impact ratio in that it also recognizes long-term cost savings and productivity gains as benefits, but it differs in that it also adds the value of non-money benefits (such as personal time and safety) while ignoring spending impacts on the economy. These differences nearly offset each other, and as a result, the two ratios end up similar – with a 4.0 to 1 benefit/cost ratio and a 3.8 to 1 ratio of value added per dollar of investment.

These findings confirm that there are significant returns associated with the current packages of planned transportation investments in Virginia. They also demonstrate how the Commonwealth of Virginia can systematically apply economic impact tools and methods to assess other projects and programs that may arise in the future.

Summary of Findings

For every $Million of Capital Investment & Operations Spending

- Short-term effect: 14 immediate jobs in VA during same year of spending
- Long-term effect of capital improvement: 59 job-years over 26-yrs (2.3 per year)

Total Impact of $33 billion spending on Six-Year Plan

- $56 billion of business sales in Virginia generating $29 billion of worker wages
- 468,800 Job-yrs over 6 yrs. (78,100/yr)
- At least $2.3 billion of state and local tax revenues
- Plus long-term (26 yrs): $82 billion of business sales; 611,590 Job-yrs (23,500/yr), of which 96% are private sector

Return on Capital Investment *(net present value)*

- Benefit-Cost Ratio of 4.0 to 1 (total benefit per investment dollar)
- Economic Return Ratio of 3.8 to 1 (gross domestic product per investment dollar)

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It was prepared by Economic Development Research Group, Inc. (EDR Group), with Delcan Corporation and Cambridge Systematics, Inc. (CS). Authors were Glen Weisbrod, Stephen Fitzroy, Adam Winston, Brian Alstadt and Lisa Petraglia of EDR Group, Donald Ludlow and Dan Goldfarb of CS, and Richard Mudge of Delcan.

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All conclusions of the study are solely those of the authoring organizations and not necessarily the positions of sponsoring and cooperating organizations.

ACRONYMS & ABBREVIATIONS

CTB	Commonwealth Transportation Board
DOAV	Department of Aviation
DRPT	Department of Rail and Public Transportation
FHWA	Federal Highway Administration
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
MPO	Metropolitan Planning Organization
TREDIS	Transportation Economic Development Impact System
VDOT	Virginia Department of Transportation
VPA	Virginia Port Authority
VRE	Virginia Railway Express
WMATA	Washington Metropolitan Area Transit Authority

1

INTRODUCTION: ISSUES & OBJECTIVES

1.1 Report Overview

This report examines the role of transportation in the Virginia economy, and the economic impact of state transportation investments planned for the future. It is organized into a series of chapters addressing different aspects of economic impact:

- Chapter 1 provides an introduction to key issues -- the motivations for examining economic impacts, and the importance of multi-modal perspectives for addressing these issues.

- Chapter 2 lays out key metrics – the definitions and metrics of economic impact, economic benefit, and performance metrics.

- Chapter 3 describes the current role of transportation in the state's economy, focusing on jobs, business sales and trade impacts.

- Chapter 4 presents findings on the economic impact of state spending on transportation capital investment and operations (planned over 2009-2014).

- Chapter 5 presents findings on the long-term economic impact of transportation improvements that are made possible by planned transportation capital investments.

- Chapter 6 discusses recommendations regarding transportation economic impact measurement and monitoring.

- Appendix A documents the statewide highway impact sketch planning model that was developed for this study, and

- Appendix B documents the statewide economic analysis model and methodology developed for this study,

1.2 Background and Motivation

The Commonwealth of Virginia possesses a long-standing and well-deserved reputation as a standard bearer for economic prosperity. From its early beginnings as a center of wealth and commerce in Colonial America, it has served as both a leader in the development of new opportunity and a bellwether of economic tides. This success results from a combination of factors, including an educated population and a business-friendly environment that includes a first-rate transportation network.

However, even as the Commonwealth celebrates its fourth consecutive year as the "Best State for Business" according to Forbes.com, the pathways that carry the lifeblood of the Virginia economy threaten its competitiveness through mounting highway congestion, continued bottlenecks at strategic intermodal locations in the network, and progressive deterioration of an aging infrastructure.

The Virginia Department of Transportation (VDOT), along with counterpart agencies for transit and rail (DRPT), aviation (DOAV) and marine ports (VPA), recognizes that substantial investment is needed to address critical transportation issues. However, while the need for additional transportation investments is a recognized issue in Virginia, it has not been easy to generate a consensus regarding how best to identify and commit new funding sources, or how best to prioritize transportation infrastructure investments underwritten by these funds.

Informed decisions regarding initiatives to enhance transportation infrastructure investment, commensurate with the underlying needs of commerce in the Commonwealth, can be achieved with better understanding of the economic value generated by the current transportation network and by the efficiency and productivity gains generated by proposed investments. Toward that end, this report describes findings of a project to develop and apply methods and measures needed to directly relate transportation investments to the overall economic vitality of the state, with the ability to do this on an ongoing basis as conditions and plans change. Economic impacts are portrayed in terms of jobs, income, business output and tax revenues.

1.3 Multi-modal Approach

There are three key considerations underlying the multi-modal perspective taken for this economic impact study:

- **Multi-Modal Interactions.** A core principle of VTrans2035, Virginia's long-range transportation planning process, is that transportation infrastructure planning should be made on a comprehensive, multi-modal basis that can optimize the complementary relationships of highway, transit, rail, air and marine modal investments. Accordingly, the economic impact study and its analysis methods address economic impacts and benefits on a multi-modal basis. This approach complements and is consistent with prior efforts of individual modal agencies to assess the economic impact of their own facilities and programs. However, it is not intended to compete with or replace those other modal-specific analysis methods and studies.

- **Focus on Economic Vitality.** One of the explicit goals of VTrans2035 is the economy – to improve Virginia's economic vitality and facilitate the coordination of transportation, and economic development planning activities. Accordingly, the economic impact analysis focuses on measuring the extent to which planned transportation investments will provide desired impacts on expanding Virginia's economic base by enhancing both passenger and freight movements. It examines these impacts in terms of jobs and income produced by various industries throughout the Commonwealth.

- **Performance Measures.** The VDOT Office of Intermodal Planning and Investment initiated efforts to improve capabilities for measurement of transportation system performance, value to taxpayers and impact on communities. Accordingly, this economic impact study supports these performance measurement efforts by applying analytic tools to assess the effect of various forms of transportation investment on the economy.

2 ECONOMIC IMPACT & PERFORMANCE INDICATORS

2.1 Objectives of Economic Indicators

Interest in economic impact and performance metrics is driven primarily by a need for informed decision-making regarding transportation funding levels, project designs and investment priorities. A variety of different metrics can be used to assess the economic benefits and impacts of transportation systems and investment in them. However, essentially all of the metrics relate to one of the three key objectives of measuring economic impacts:

- ***Funding:*** There is a public interest in understanding the economic importance of transportation facilities, in terms of supporting jobs and income throughout communities and the state. Such information can enhance understanding of the economic stakes involved in supporting the operation and financial health of transportation agencies and facilities.

- ***Planning:*** Transportation planners can optimize the design of projects and programs when equipped with information concerning current gaps and future needs for transportation investment. This depends critically on changes occurring in the economic factors that create and shift transportation needs.

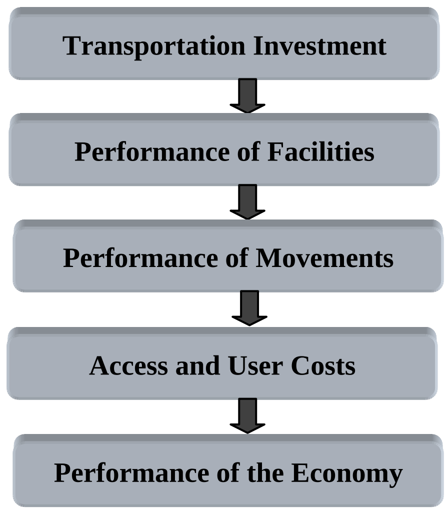
- ***Prioritizing:*** When resources are limited, decision-makers need to rank and select projects to achieve the most effective public benefit or economic "return on investment." In addition, decisions about committing funding must be balanced against a variety of strategic needs including the long-term economic vitality of communities throughout the state.

Different types of economic impact and benefit measures are needed to address each of these three objectives. This chapter discusses the range of available indicators, their uses in this report and their broader uses for funding, planning and prioritizing transportation projects.

2.2 Types of Indicators

Broad Range of Performance Measures. The concepts of "performance measures" and "impact measures" are interrelated. For instance, a change in *transportation investment* can lead to changes in the capacity and carrying (or processing) speed of transportation *facilities* (spanning highways, rail lines, airports and marine ports). And that can, in turn, lead to changes in travel times, operating expenses, safety and reliability of transportation system *movements* (spanning private and commercial carriers of passengers and cargo). And those changes can, in turn, lead to further changes in market access and costs faced by *households and businesses* (spanning labor markets, delivery markets, and intermodal connectivity). Ultimately, they affect productivity and competitiveness of the *state's economy* as shown in Exhibit 2-1.

Exhibit 2-1 Five Levels of Performance/Impact Measurement



The above example illustrates the cascading impact of investment on the performance of transport facilities, travel movements, travel costs and economic competitiveness. Because there are so many different dimensions of impact, studies of performance indicators often cover a very broad range of factors. In practice, transportation agencies tend to select those factors that they can readily measure. In Virginia, this is illustrated by the efforts of DRPT to provide a "dashboard" of indicators that tracks performance for public transit services. While that represents an important effort towards consistent, ongoing measurement, there is a remaining need to also assess the expected economic impacts of proposed projects and track the current economic impacts of existing projects.

Focus on Economic Impact Indicators. It is useful to identify six discrete forms of economic impact or economic benefit measures. They are:

1. Economic Role of Transportation: What is the role of current transportation facilities and services in supporting the Virginia economy and what are the stakes associated with failure to continue to support them?

   This impact measure involves tracking the number of jobs in the state, as well as the level of statewide products and services that are supported by operation of transportation facilities and services. Those jobs and activities would potentially be at risk if the transportation facilities and services on which they depend were to be discontinued or allowed to deteriorate. This type of measurement is already being made in reports for Virginia airports by DOAV, and reports for Virginia ports by VPA. However, this measurement has not been made on a fully multi-modal basis covering all modes of passenger and freight transportation in Virginia. *Chapter 3 addresses this form of impact measurement.*

2. Impact of Transportation Spending: How does ongoing and planned transportation spending affect the Virginia economy, and what is the income benefit from it?

   Whereas the preceding impact measure (#1) covered transportation activities and their users, this impact measure reflects the effect of ongoing spending to operate and maintain transportation activities. It encompasses not only transportation industries (direct effects), but also non-transportation businesses that are supported because of them – i.e., those supplying parts, materials and services to enable functioning of the transportation industries (indirect effects) and those that benefit from transportation-related workers re-spending their incomes on consumer goods and services (induced effects). *Chapter 4 addresses this form of impact measurement.*

3. Benefit of Transportation Investment: How does ongoing and planned spending on transportation in Virginia provide benefits for users of those facilities?

   Whereas the preceding impact measure (#2) covered the impact of spending dollars on the economy, this impact measure reflects the value of user benefits received as a result of improvements in transportation system conditions (over what would occur without those improvements). It encompasses the value of time, expense, safety, reliability and/or access improvements for users. *Chapter 5 addresses this form of impact measurement.*

4. Economic Return on Investment. How will planned future capital investments affect the future competitiveness and growth of Virginia's economy? And what is the payback from it?

   Whereas the preceding impact measure (#3) covered benefits to users, this impact measure reflects effects on growth of income (or value added) in the Virginia economy. While it shares some common factors with the preceding measure, it also has some important differences. (See box below.) Economic impact measurement is accomplished by calculating the ways in which current and planned transportation spending leads to impacts on income received, expenses incurred, and productivity of operations by households and businesses in the state. Ultimately, these factors affect economic competitiveness and growth of the state's economy. *Chapter 5 also addresses this form of impact measurement.*

Value of User Benefits vs. Impact on the Economy

While both measures encompass the dollar value of user cost savings, there are two primary differences:

- The user benefit measure *adds* recognition of the additional value of benefits that do not directly add to the flow of dollars in the area economy. (This includes travel time savings for personal trips and most environmental benefits.) The economic impact measure generally *ignores* those effects.
- The user benefit measure *ignores* impacts that add money to the local economy due to business reorganization and location shifts (This includes income generated by spending on suppliers, and business attraction effects.) The economic impact measure *adds* these effects.

5. <u>Impact of Future Scenarios for Strategic Planning.</u> How will alternative scenarios for future transportation capital investments affect the future competitiveness and growth of Virginia's economy? How can that information help to identify investment gaps that need to be funded to allow economic growth opportunities to occur?

   This impact measure applies the methods defined under #4 above, to forecast future changes in economic conditions under alternative scenarios, in order to identify the need for future transportation investments in Virginia to keep up with a changing (global) economy. It can be used to help define new initiatives in transportation policy, funding and finance that may be needed to bolster statewide economic development. It can also show the cost of under-funding transportation investment, and the investment gaps that need to be filled to meet other strategic objectives and initiatives such as the Commonwealth's goal to maintain its top-ranked status as a desirable place to do business. *Chapter 6 addresses these issues.*

6. <u>Ongoing Performance Tracking:</u> How can evaluation and selection of future projects incorporate economic impacts and benefit/cost relationships? And how can that approach apply to multimodal planning?

   These metrics can provide a means of placing individual projects in the context of an overall strategy and plan for the Commonwealth, and show how each project helps to enhance the competitiveness and cost-effectiveness of that investment using metrics that relate to the overall objectives of state-wide investment goals. They can also be used in the form of a dashboard or scorecard to track overall progress in meeting both transportation and economic goals. *Chapter 6 also addresses these issues.*

3 TRANSPORTATION ROLE IN VIRGINIA'S ECONOMY

This chapter examines the role of current transportation facilities and services in supporting the Virginia economy. It examines the number of transportation-related jobs in the state, and the inflow of income to the state that depends on transportation for shipments to, and tourism visits by, out-of-state customers.

3.1 Perspective: A System of Transportation

Economic Role

Virginia's transportation infrastructure – including roads, rail lines, aviation facilities, marine facilities and associated freight and passenger terminals – represent an integrated set of systems that enables a broad range of passenger and freight movements. These facilities, and the services that utilize them, provide access for households and businesses, and make Virginia a cost-effective location for economic activities. Their operation also directly provides jobs and the means for exporting Virginia products to outside customers.

As will be shown in this chapter, over 246,000 jobs in the Commonwealth of Virginia are directly related to the operation of transportation facilities or the provision of transportation-related services. Yet that is only one small part of the role of transportation in the economy. In a very real sense, every job in Virginia depends on transportation infrastructure for some combination of: (a) commuting to work, (b) deliveries of materials and products to users, and/or (c) visits to business and recreation destinations.

However, the future of Virginia's economic base is not guaranteed; it will depend on preservation or enhancement of Virginia's competitiveness as a place to live and locate business activities. The capacity and effectiveness of Virginia's transportation systems to handle future demand, and the quality and cost of service it provides, can affect future economic growth of the state.

Classification of Transportation-Related Activities

Virginia's transportation systems encompass public and private-sector activities related to both infrastructure and services for moving passengers or freight. The state's interests regarding this system are multi-faceted and very often, multi-modal.

Transcending all modes of transportation, we can identify six facets of economic activity that are directly associated with operation and use of Virginia's transportation systems. They are:

1. *Right-of- way Infrastructure Operations* – establishing and maintaining road pavement, bridges, railway tracks, marine channels and airport runways;
2. *Terminal Operations* – operation of sites and buildings providing intermodal transfer and gateway functions, including airports, seaports, bus stations, train stations and intermodal freight and warehouse terminals;
3. *Transportation Operations* – passenger and freight transport services including public transit, taxi services, trucking companies, courier services, railroads, airlines and marine vessel operators, as well as personal car use;
4. *Maintenance of Existing Services* – including maintenance, repair, rehabilitation and reconstruction services for right of way facilities, terminal facilities and vehicles;
5. *New Vehicle Manufacturing and Sales* – associated with acquisition and replacement of train cars, buses, taxis, cars, trucks, aircraft and ships; and
6. *New Facilities Construction* – including new construction and expansion for both right-of-way and terminal facilities.

In this chapter, we focus on categories #1 – 4, which cover ongoing operations and use of transportation facilities. We address categories #5 – 6 (manufacturing and construction activities) in later chapters that address the impact of capital investment in transportation system enhancements.

Because of the way that job statistics are classified by service and mode, we calculate the number of transportation-related Virginia jobs in each of categories #1 – 4, by transportation mode. However, it is important to note that the multi-modal nature of many transportation movements often make it difficult to accurately distinguish all passenger and freight activities by mode. For instance, nearly all cargo shipment at seaports also requires truck or railroad trips to get the freight to and from the port. So in that case, it can be difficult to cleanly distinguish whether a rail freight handling job at a seaport should be counted as a railroad job or as a seaport job. Other classification difficulties arise as nearly all aviation trips require some ground access to and from airports via car, truck, taxi or public transportation. Many intercity rail trips and some public transportation trips also involve riding in a car to/from a parking lot. And many products shipped to retail stores involve intermodal truck-rail transfers and/or warehouse transfers at distribution centers.

To provide an indication of the scale of transportation as an engine for employment, we examine Virginia's current employment levels in relevant economic sectors.

3.2 Transportation-related Jobs

The latest published statistics available at this time (2008 data) indicate that there are over 246,000 jobs in transportation-related industries. These are jobs involved in operating and maintaining transportation facilities and transportation services that use those facilities. In this section, we distinguish these jobs by their transportation functions and associated transportation modes. (Additional indirect and induced impacts are discussed in Chapter 4.)

Road-related Transportation (excluding Public Transportation)

There are nearly 179,000 highway related jobs in Virginia as of 2008. The primary group, accounting for approximately 154,000 jobs, is comprised of services that provide motor transport for people and freight, or maintain and service the vehicles that use the roads. As shown in Exhibit 3-1, jobs in trucking and package delivery account for the largest share, while taxis, vehicle repair and fueling businesses support the remainder. Bus services are not included here because they are classified under a separate category called public transportation services (discussed later). The category of private automobiles, while clearly the dominant use of highways, is not included here because its drivers and operators are typically not paid salaries for their travel.

In addition, there are nearly 25,000 additional jobs, shown in shaded gray in the table, that are primarily related to highway freight and passenger movements but which may also involve rail, air or marine transportation activities. For instance, the category of warehousing facilities typically involves truck freight transfer facilities that are an intrinsic element of trucking services, though they can also include warehouses used for railroad intermodal transfers or for airport or marine port transfers. Similarly, the category of freight transportation arrangement involves trucking services, but may also involve rail, air or marine transportation arrangements.

Exhibit 3-1 Jobs in Road-Related Transportation Services (excl. Transit)

Category	# of Jobs
Road Transportation Services	
Road Freight Transport (Trucking)	
Trucking/freight companies	45,194
In-house Company Truck Fleets	18,644
Courier and Package Delivery	19,518
	83,356
Road Passenger Transport Service	
Taxis	***4,180***
Buses (not counted here; see table 3-2)	
Vehicle Services	
Automotive repair & maintenance	22,785
Gasoline Stations	32,843
Road transport support (towing, info services)	2,703
	58,331
Highway Planning, Operations, Maintenance & Rehabilitation	
Virginia DOT Staff	***8,100***
Local and regional highway staff	*N.A.*
Total Road Transportation Services	**153,967**
Jobs Supporting Multiple Modes and Sectors	
Warehousing/Storage (truck/rail/air/marine)	20,111
Freight transport arrangement (truck/rail/air/marine)	4,744
	24,855

Source: US Dept. of Commerce, Bureau of Economic Analysis (REIS - Regional Economic Information Service) data for 2007. The sub-categories of trucking were estimated by EDR Group, based on data from County Business Patterns for 2007 and the US Transportation Satellite Accounts. In addition, jobs in road transport support and multi-modal freight arrangement were estimated by EDR Group by updating details from the 2003 Economic Census, factored up to represent control totals for all transport arrangement as shown in 2007 BEA. Data for VDOT staff jobs were reported by VDOT.

Bus and Rail Transportation (including passenger & freight)

There are nearly 33,000 railroad and bus-related jobs in Virginia, as of 2008. As shown in Exhibit 3-2, the majority of the jobs are involved with passenger transit services and transporting school children, while freight railroads account for the remainder. Over 25,000 additional Virginia jobs serve freight and passenger movements that include bus or rail activities, though they also overlap with other economic categories.

Exhibit 3-2 Jobs in Bus and Rail Transportation Services

Category	# of Jobs
Railroad and Bus Mode Services	
Freight Railroads	5,431
Passenger transit and rail services	11,169
School buses	16,020
	32,620
Jobs Supporting Multiple Modes and Sectors	
Sightseeing services (bus/ recreation)	701
Warehousing/Storage (truck/rail/air/marine)	20,111
Freight transport arrangement (truck/rail/air/marine)	4,744
	25,556

Source: US Dept. of Commerce, Bureau of Economic Analysis (REIS - Regional Economic Information Service) data for 2007. Jobs in freight arrangement were estimated by EDR Group by updating details from the 2003 Economic Census, factored up to represent control totals for all transport arrangement as shown in 2007 BEA data.

Special Case of Multi-modal Terminals

Importance for Modal Transfers. Airports, seaports and intermodal rail facilities serve as transfer terminals for passenger and/or freight movements that switch between modes. For freight movements, airports provide the point of transfer between air and truck modes. Similarly, marine ports serve freight transfers between marine ships and either railroads or trucks. Intermodal rail terminals also serve freight transfers between trucks and railroad cars (usually TOFC – "truck on flat car" or COFC – "container on flat car"). For passenger movements, airports, marine ports and train stations serve as the point of transfer between cars or transit and the respective air, sea or rail modes.

Altogether, Virginia has:
- 66 public use airports, including 9 with commercial airline service;
- 10 marine ports (including 3 operated by the Virginia Port Authority); and
- 4 locations of intermodal truck/rail terminals.

Common Elements. Because these facilities serve as points of transfer between multiple modes of transportation, they tend to have three common elements:

1) Operation. They are typically operated wholly or largely by non-highway modal organizations (i.e., aviation, marine or railroad company or agency);

2) Activity Mix. They provide business activities that span: (a) terminal operations, (b) road transportation services (via truck, car and public transportation), (c) non-road transportation services (air, marine shipping and railroad companies), and (d) supporting services for freight and passengers.

3) Contribution to Economy. They play a particularly important role in the Virginia economy because they include major international air and sea gateways that provide incoming parts for Virginia businesses, incoming visitors who spend money in Virginia, and the exporting of Virginia-made products that generate income for Virginians.

Job Measurement Issues. Jobs associated with air and marine transportation services are different from ground-based (highway, public transportation and railroad) activities because they are concentrated at major terminals that nearly always involve some element of intermodal transfer of cargo or passengers to/from other (ground transportation) modes. For that reason, jobs at these facilities can be divided into two groups:

- those that support air or marine modes (include airlines and marine transport companies, aircraft and marine vessel handling, passenger and freight loading and unloading, terminal administration, and government oversight); and
- those that support the inter-modal (ground transfer) functions of the terminals (including railroad, truck, car rental, taxi, parking and cargo warehousing that occurs at the air and marine ports).

Air Transportation

It is estimated that there are currently approximately 40,000 jobs spread among the 66 public use airports in Virginia, as shown in Exhibit 3-3. The numbers of these jobs tend to vary over time, as the state of the economy and the number of aircraft operations (takeoffs and landings) and passenger volumes rise and fall from year-to-year. The values shown here are 2008 estimates, extrapolated from a 2004 economic impact report for airports around the state, with 2006 updates for Dulles and Reagan National airports and adjustment made for changes in airport activity levels since then. (See table note for more details.) A new study of jobs at Virginia airports is expected to be completed in 2010, and that will replace these interim estimates.

The total airport jobs include around 32,000 jobs that are directly related to the operation of aviation activities in Virginia (airlines and airport operations). In addition, there are currently around 8,000 jobs at airports that serve air passengers and air freight movements, though they may also be classified as providing services for other modes and other economic sectors. For instance, *freight services* often maintain facilities at airports, though their transportation services typically involve a combination of truck and aviation as part of the pickup and delivery processes. *Passenger transportation services*, including parking, car rentals and taxis, represent separate ground transport modes although they also locate at airports to serve the ground/air transfer movements that occur there.

Exhibit 3-3 Airport Jobs

Category	# of Jobs
Aviation Related Services	
Air Carriers and Fixed Base Operators	
Reagan National and Dulles	9,311
Other Public-Use Airports*	5,334*
	14,645
Airport Operation (FBOs, security, catering, custodians)	
Reagan National and Dulles	5,526
Other Public-Use Airports	3,258
	8,784
Airport Terminal Concessions (passenger retail):	
Reagan National and Dulles	1,694
Other Public-Use Airports	468
	2,162
Airport Management (administration & government):	
Reagan National and Dulles	3,788
Other Public-Use Airports	2,542
	6,330
Airport Jobs Supporting Multiple Modes & Economic Sectors	
Air Freight Transportation Services (air cargo transfer to trucking)	
Reagan National and Dulles	1,783
Other Public-Use Airports	N.A.
	1,783
Ground Passenger Transport (parking, car rental, taxi):	
Reagan National and Dulles	4,128
Other Public-Use Airports	362
	4,490
Construction contractors (runway & terminal improvements)	
Reagan National and Dulles	2,432
Other Public-Use Airports	139
	2,571
Total Airport Jobs:	
Reagan National and Dulles	28,337
Other Public-Use Airports	12,104
	40,441

Sources: Estimates for 2008 prepared by EDR Group on the basis of earlier studies, with values adjusted to reflect changes in airport operations over the intervening years. Earlier studies were: (1) Virginia Dept. of Aviation, Virginia Airport System Economic Impact Study, Technical Report, prepared by HNTB, SH&E and EDR Group, 2004; (2) Metropolitan Washington Airports Authority (MWAA), The Local and Regional Economic Impacts of Ronald Reagan Washington National and Washington Dulles International Airports, prepared by Martin Associates, 2006; plus (3) MWAA airport employee report for Reagan National Airport, 2009.

** Estimate for total air carrier employees came from the US BEA 20007 state total for NAICS 481 (air transportation companies); the figures reported for Dulles and Reagan National were subtracted from that total to estimate the "rest of state" total. That total is higher than reported in local airport surveys conducted for the 2004 airport study.*

It is also common for there to be some construction activity occurring at airports around the state, as these facilities undergo runway and taxiway improvements, apron (tarmac) changes and terminal enhancements or refurbishment. As a result, airport employment surveys commonly find some construction and design engineering jobs also located at airports. However, these jobs are usually classified as construction industry jobs. The statistics shown in Exhibit 3-3 indicate a higher than typical level of construction jobs largely because of major construction associated with a new runway and inter-terminal train at Dulles.

Finally, it should be noted that airport economic impact reports commonly include jobs supported off of the airport site by air visitors who spend money locally on hotels, ground transportation, retail and recreation. These reports also commonly show estimates of jobs supported by indirect economic effects (e.g., orders to suppliers of materials, products and services to the airports) and induced economic effects (airport-related workers spending their money on consumer purchases in the community). While all of these additional impacts can be appropriate for a report on the economic role and economic importance of airports, they are not shown here because this section focuses solely on direct, aviation-related jobs.

Marine Transportation

There are ten marine ports in Virginia, though the three Hampton Roads area facilities of the Virginia Port Authority (VPA) account for the vast majority of the total tonnage shipped. (This does not count the "Virginia Inland Port," which actually serves as a truck/rail intermodal facility.)

It is estimated that there are currently over 10,000 jobs at VPA marine ports, as shown in Exhibit 3-4. The numbers of these jobs tend to vary over time, as the state of the economy and the volume of international trade changes from year-to-year. The values shown here are from the 2006 Virginia Port Authority report, "*Economic and Fiscal Impacts of Virginia Port Authority Operations.*" That study measured and assessed the economic impacts of the operation of four public marine terminals in Hampton Roads area on the Virginia economy.

Exhibit 3-4 Marine Port Jobs (Virginia Port Authority)

Category	# of Jobs
Marine Related Services	
Ship & harbor operations (cargo lading & unlading)	3,088
Port Management (administration & police)	150
Support Services: (freight arrangement, marine support)	1,965
	5,203
Multi-modal Support	
Truck and Rail transportation	4,131
Warehouse and Storage	972
	5,103
Total Employees Virginia Ports Authority	**10,306**

Source: Virginia Economic and Fiscal Impacts of Virginia Port Authority Operations, data for fiscal year 2006, by the Mason School, College of William and Mary, January 2008.

Total for All Modes

Adding together the jobs associated with all modes of transportation, and adjusting for double counting of the multi-modal categories (shaded in gray), we calculate that there are over 246,000 jobs in Virginia that are directly associated with the operation of transportation facilities and services.

However, it is important to note that this total, and the previously-shown breakdowns by mode, are both rough figures because there are significant differences in the way that jobs are counted for the various modes. This leads to two additional comments on interpretation of the employment numbers:

- ***Completeness of the Total Figure:*** The total job figure may not be complete, because of modal differences in the accounting. For instance, airport terminals commonly include on-site air traveler services – such as restaurants, retail stores, information booths and sometimes also lodging – and the airport employment counts reflect that fact. On the other hand, highway-serving restaurants, retail stores, information centers and lodging are not included in highway-related employment figures. If we add the corresponding highway traveler services, then the total would be even higher. However, current data sources do not allow us to estimate the magnitude of this additional category.

  The professional drivers (or pilots) of commercial buses, trains, trucks, aircraft and marine vessels are counted in the employment figures. However, those driving cars or vans on the road are not counted even if they are doing so as part of their jobs during the workday – to deliver business services or attend business meetings. Similarly, those piloting corporate aircraft for business purposes are typically classified as working in their industry rather than working as transportation workers. This study was able to estimate the portion of transportation jobs associated with "in-house" truck fleets, but there was not enough information to also do so for cars or corporate aircraft. This may also be considered a source of job under-count.

- ***Assignment of Activities to Specific Modes:*** Marine ports and airports, and some highway interchanges, can have significant clusters of warehousing and trucking activities located nearby but off of the actual property of the transportation facilities. While these additional activity clusters are clearly related to the functioning of the corresponding transportation facilities, they are typically not counted as part of the port, airport or highway employment figures. This study does capture those activities through the inclusion of warehousing and freight transportation arrangement services, though those categories cannot be directly assigned to any specific transportation mode.

3.3 Facilitating Import & Export Flows

The Virginia economy is buttressed by its ability to maintain and expand its export base – that is the ability to attract dollars flowing into the state from customers outside of its borders. Apart from foreign direct investment, the main methods for achieving this are: (1) Virginia businesses exporting products to overseas destinations or elsewhere in the US, and (2) Virginia businesses exporting tourism, which means attracting visitors who spend their money on hotels, recreation and retail within the state. In addition to expanding the export base, Virginia businesses and consumers rely on imported foreign products.

All of these types of commerce flows require the transportation network as it has evolved today – including highways, railroads, airports and marine ports. Furthermore. as the nature of those transactions change, so will the necessary components of the transportation system. We examine the direct dollars and associated jobs supported by these income flows to further emphasize the strategic value of various parts of the state's transportation system.

International Cargo Flows

Every mode of freight-carrying transportation in Virginia contributes to cargo movements generated by domestic (US) or international (foreign) trade. These transactions are increasingly crucial to supporting existing in-state jobs due to the broad geographic scale of both supply chains and consumer markets. Dulles Airport and Virginia's ports are important gateways for international trade gateways with overseas locations. Virginia's highway system and freight rail networks are important for direct trade between Virginia and both Canada and Mexico, and they are also important as inter-modal links for moving cargo to/from airports and marine ports that link Virginia businesses with foreign products or customers.

International Trade Gateways. Altogether, $31.3 billion of goods are exported annually through Virginia airports and seaports (source: Year 2008 international trade statistics provided by WISERTrade). Of that total, Virginia-made foreign-bound exports handled through those seaports are account for $8.6 billion.

Virginia Seaports. The VPA seaports alone handle $25.6 billion of exports, of which $6.6 billion are Virginia-made foreign-bound exports, supporting nearly 23,000 jobs.[1] In addition, these seaports account for $34.6 billion of imports to the US. Virginia-consumed foreign imports entering through these ports are estimated to be worth $8.5 billion and require an estimated 109,636 (direct) Virginia employees in the subsequent value-added processes on these foreign intermediate goods (source: calculated using IMPLAN data).

[1] These 2008 export value and jobs figures reflect a downturn in the economy; the value in 2006 of Virginia- made exports flowing through Virginia ports was $8.1billion supporting nearly 28,000 jobs.

Virginia Airports. The MWAA airport economic study (also done in 2006) calculated that around $11 billion of freight products are annually shipped out of Virginia's Dulles Airport (including shipments to both domestic and international destinations). Approximately $5.3 billion of those shipments are international exports, including $2.2 billion of goods produced in Virginia.

Other Air and Marine Ports. There are also Virginia-made international exports that are moving to their foreign customers via out-of-state international trade gateways. While these exports are not relying on Virginia air or marine ports, they are relying on Virginia's highways and freight rail networks to move the products out of state.

In 2008, Virginia's total international exports totaled $18.9 billion. Of that amount, the value of Virginia-made products exported to foreign customers through out-of-state seaports, airports, or truck and rail border-crossing crossings was $12.2 billion. (Source: US foreign trade statistics provided by WISERTrade, 2009.) Three-quarters of this export value had a final move off-shore by airplane or ocean-going vessel from elsewhere in the U.S. The Virginia leg of that trade outflow used in-state highway, rail or airport to reach that ultimate gateway. The remaining value of Virginia-made products exported through non-VA international trade gateways, crossed land borders by truck or rail or some combination of the two.

Visitor Tourism

The Virginia Tourism Corporation (VTC) posts annual updates of the value of domestic tourists' spending (and subsequent economic multiplier dollars) within the state. These are trips made for either leisure or business or some combination. The last published headcount of tourists to the state was for 2005 with 55 million person-trips (source: D.K Shifflet & Associates, *Travel Scope 2006)*.

The direct visitor spending coming into the state represents Virginia exports of its cultural, recreational, scenic and historic assets. This amounted to $16.4 billion in 2005 and was preliminarily estimated at $ 19.2 billion for 2008 (source: US Travel Association study on behalf of VTC, Sept. 2009). The latter was also gauged to have 210,600 Virginia jobs directly associated with it, accounting for 5.6% of the state's non-agricultural employment.

Tourism is a vital engine for many states' economies and Virginia is no exception. The transportation system is vital to sustaining tourism travel in bringing out-of-state visitors to Virginia and providing regional mobility upon arrival. VTC produced a profile of domestic (leisure & all) travel to Virginia for FY2007-2008. Based upon a sample of 4,850 travel parties, the primary mode of travel for the trip is: 80% by car, 12% by air transport, bus or passenger rail, 2% by motor coach/group tour/camper/RV and the balance via other modes. For international visitors to Virginia, the mode shares are likely to focus more on airports, though the modal breakdown is not currently available.

4 ECONOMIC IMPACT OF CAPITAL & OPERATIONS SPENDING

Virginia's networks of transportation facilities and services, described in the prior chapter, serve to enable broader economic activities associated with commuting, business product/service deliveries, recreation and personal travel. Yet they can continue to effectively serve those functions only if there are: (a) continuing streams of money spent to operate and maintain the facilities and services, and (b) continued capital investment to rehabilitate, enhance and reconfigure facilities as needed to meet evolving future demands.

We evaluate the economic impacts of this spending in a two-step process: first we examine the statewide economic impacts of projected transportation spending flows, and then we examine the change in productivity and economic growth facilitated by capital investment to improve transportation facilities in the state. This chapter addresses the first of these two steps, by examining the statewide economic impacts of projected transportation spending flows. (The other step is covered in Chapter 5.)

4.1 Types of Transportation Spending Flows

Overview. The economic impact of transportation spending is calculated here for a specific transportation spending scenario. It represents the effect of spending that is provided by state agencies, flows through state agencies, or occurs at publicly-owned terminal facilities. It includes both capital investment on vehicles and facilities (such as roads, airport runways, port docks, multi-modal terminals, buses and trains) and operations spending (for activities such as ongoing road maintenance, port equipment operators, bus drivers and public agency management).

This type of scenario was adopted to show how state and related public funding of transportation facilities has impacts on the broader economy. As such, it does not show the full impact associated with additional capital or operations spending that is enabled by transportation usage fares, local terminal facility fees, local community subsidies or private freight operator investments. However, the methodology presented and applied for this report could also be applied, if desired, to calculate those additional impacts. (That additional task would also require further data to become available documenting the additional revenue sources and how they are spent).

Coverage of Spending Impacts. The capital investment spending figures shown in this chapter include essentially all publicly-funded projects plus those privately funded projects that involved public participation. The figures for roads and public transportation are based on the Six Year Improvement Program, which covers essentially all projects funded by state, local or federal funds. This includes state and interstate highways, as well investment in urban systems and secondary roads. For public transportation, it covers nearly all capital (vehicle, terminal and right-of-way) projects. For railroads, the public funding focused on road/rail crossings and public/private partnerships. However, major private railroad line improvements made in conjunction with public/private partnerships were also counted. For airports and marine ports, the capital investment figures cover nearly all major capacity and safety projects, though they do not necessarily cover private equipment investments that may be made by air or marine service operators, or locally-funded elements of terminal building improvements.

The operations spending figures shown in this chapter differ by mode. Nearly all highways and public transportation services are publicly owned and operated. The spending figures for these modes include all transfers of state funds and pass-through of federal funds. They also do not cover spending of local transit operations that come from fare box revenue and local community subsidies. For private railroads, there is no state support for cost of operations, so no public spending impact is calculated.

The operations spending for airport and marine port facilities are of a different nature. These are multi-modal terminals that are typically owned by public agencies, though large parts of their operations are conducted by private airlines, marine shipping lines, railroads and trucking companies, as well as vendors who provide other sales and services to travelers and shippers. Accordingly, public elements of these port/terminal operations cannot be isolated in the same way as government funding of highway, train and bus service operations and maintenance. Instead, the study examines the impact of worker wages that are directly associated with port/terminal operations.

Sources of Information. The initial base of information was a profile of transportation spending over the six-year time period of 2009-2014, drawn from the Commonwealth Transportation Board (CTB) document, *Commonwealth Transportation Fund Allocation Summary* (February 2009). More detailed breakdowns of planned spending for operations and capital improvements came from the following sources:

- Spending for highway capital and operations was based on the Virginia Dept. of Transportation (VDOT) *Six Year Improvement Plan*;
- Spending for transit capital and operations was based on the Virginia Dept. of Rail and Public Transportation (DRPT) *Six Year Projection for Rail and Public Transportation Improvement Program;*
- Spending for railroad capital was based on the DRPT allocation for public/ private partnership and information on planned private freight rail line enhancements;

- Spending for aviation capital investments was based on the Virginia Dept. of Aviation (DOAV) *State Airport System Plan;*
- Spending for port capital investments was based on the Virginia Port Authority (VPA) *2040 Master Plan* (including only projects for the 2009-2014 period).
- Spending for aviation and port operations was estimated by calculating the portion of airport and marine port worker wages associated with transportation terminal operations, based on economic impact reports issued by DOAV, VPA and the Metropolitan Washington Airports Authority (MWAA).

Variation in Scenario Figures. The analysis reported here is based on a profile of transportation spending planned for the period of 2009-2104, as of the February 2009 CTB document. The planned spending has been revised since that date in updated CTB documents, in response to state budget constraints during a period of economic downturn. In fact, the actual level of transportation spending that will occur during the 2009-2014 period will continue to be subject to modifications over the next five years as economic conditions and state tax revenues shift over time. For that reason, the numbers shown here should be interpreted as merely indicative of the general magnitude of impacts associated with the given scale and mix of transportation investments.

4.2 Spending Scenario

Allocation of Funds. Table 4-1 shows projected public facility spending on transportation capital investment and operations spending for public facilities and services in Virginia over the six year period. The spending totals $32.9 billion, which includes $10.4 billion of capital spending and $22.5 billion of operations spending.

The capital spending is dominated by highway and public transportation projects. The operations spending is also lead by ongoing highway maintenance and operations, though airports and marine ports follow in their level of operations spending. This latter result reflects the fact that airport and marine ports operate as intermodal (ground/air and ground/sea) transfer facilities in which there are many private operators working on site part of the terminal operations.

Comparison Analysis. The economic impact analysis provided in this chapter compares the effect of the planned scenario, in which state support for transportation facilities and services occur as shown in Exhibit 4-1, against an alternative in which there is a freeze on further public investment and the additional spending does not occur. While the latter situation is unlikely to occur at this time, this comparison makes it possible to show the ways in which state funding for transportation generates jobs and income within the state.

Exhibit 4-1 Projected Transportation Capital Investment and Operations Spending

Projected Capital Investment (Total 2009 – 2014)	*Total Over Six Years (millions)*
Highways: Capital Construction (incl hwy system + earmarks)	$ 6,455 m *(A)*
Public Transportation & Rail : Capital Projects	$ 2,441 m *(B), (C)*
Aviation Capital Projects: functional improvements	$ 314 m *(D),(F)*
Aviation Capital Projects: safety/conformity projects	$ 467 m *(D),(F)*
Port : Capital Construction Projects	$ 745 m *(E),(F)*
TOTAL CAPITAL INVESTMENT $	**$ 10,422 m**

Estimated Operations Spending (Total 2009-2014)	*Total Over Six Years (millions)*
Highways: Ongoing Operation & Maintenance	$10,641 m *(A)*
Public Trans: Ongoing Operations Support	$ 1,066 m *(B), (C)*
Airports: Terminal Operations (wages)*	$ 7,442 m *(D),(F)*
Marine ports: Ship & Harbor Operation (wages) *	$ 1,854 m *(E),(F)*
VDOT Administration	$ 1,465 m
TOTAL OPERATIONS SPENDING $	**$22,468 m**

(A) Highway spending includes federal, state and locally funded projects

(B) Public transportation capital and operations spending includes state funds and pass-through of federal (FTA) funds; any further spending of local community and transit fare box revenues are not included here.

(C) Rail capital spending includes only funds for road/rail crossings and public/private partnerships. Other private investment is not included here. There is no operating support for railroads.

(D) Aviation capital spending includes state funds and pass-through of federal (FAA) funds; any spending of local community funds and airport fees are not included here.

(E) Port capital spending includes state investment for capacity expansion; any additional private operator spending is not included.

Operations spending shown here for airports and marine port facilities represent payroll associated with terminal and harbor operations only (79% of total wages at Dulles and Reagan National airports, 95% of wages at other airports and 56% of wages at Virginia ports). The payroll and operations of ground transportation operators, freight forwarders and values for visitor spending are not included here though they are discussed in economic impact studies of the Virginia Port Authority, Virginia Dept. of Aviation and Metropolitan Washington Airports Authority. (Those reports show total business revenues of approximately $2 billion/year at Hampton Roads marine ports facilities, $6.5 billion/year at Dulles and Reagan National Airports, and over $610 million/year at other airports in Virginia.)

4.3 Analysis of Spending Patterns

Methodology. The capital and operations spending leads to broader impacts on the Virginia economy in several ways.

- First, there are *direct effects* of capital and operations spending on money flowing to Virginia workers and to contracted suppliers, construction companies and operators. The shares flowing to these different parties may differ, depending on the specific project profile and associated mix of spending elements (to be shown later);

- Second, there are *indirect effects* generating additional orders to supplier industries (which provide parts, materials and supporting services). The types of suppliers and the extent to which they are located in Virginia will also depend on the specific profile and mix of spending.

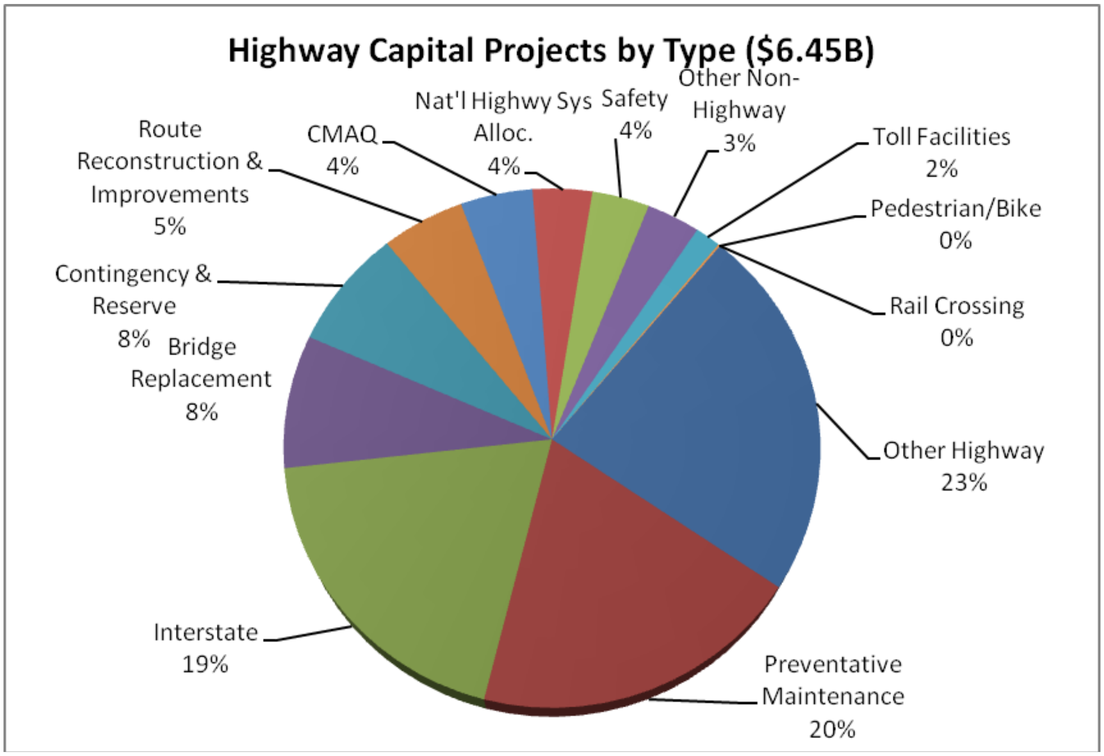
- Third, there are *induced effects* on consumer spending generated by the additional (direct and indirect) wages of workers living in Virginia. As the workers spend their wages on food, clothing, shelter and recreation, they support additional jobs in the economy. However, adjustment is also made for where the workers live, particularly the fact that 50% of the Reagan National Airport workers and 29% of the Dulles Airport workers do not live in Virginia and hence tend to spend most of their incomes elsewhere.

There are additional impacts on economic productivity and competitiveness enabled because the transportation spending affects transportation costs and conditions; however, that effect is examined separately in Chapter 5.

To assess all of the above-cited economic effects (in both this chapter and the next chapter), a multi-modal economic analysis tool known as TREDIS (Transportation Economic Development Impact System) was used to calculate overall impacts on the Virginia economy. This type of structural analysis system has been applied in numerous states across the country, but the version applied here was built upon a model of the Virginia economy, its specific flows of imports and exports, and ways in which different Virginia industries depend on transportation for workers, materials and product deliveries. It utilizes a version of the IMPLAN multi-regional input-output economic model, combined with a time series forecasting process and detailed calculations of transportation project profiles. Further information is provided in Appendix B.

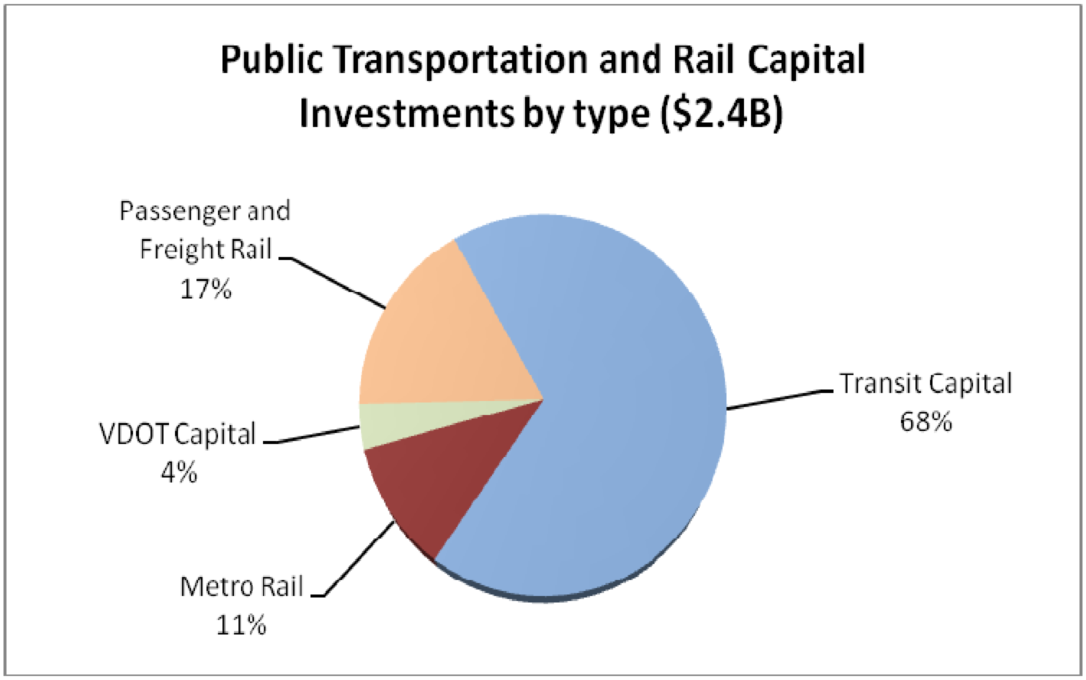
Highway Capital Spending Profile. The mix of capital spending for highways is shown in Exhibit 4-2. It was based on a list of projects provided by VDOT for the *Six Year Improvement Plan*. The chart shows that most of the spending is for highways and bridges (including Interstate Highway System, National Highway System and State highways). There is also spending for highway reconstruction, rehabilitation and preventive maintenance programs, as well as the federal CMAQ ("Congestion Mitigation and Air Quality") program that helps fund ridesharing, transit information centers and trip reduction programs. There is also small funding for pedestrian and bicycle paths.

Exhibit 4-2



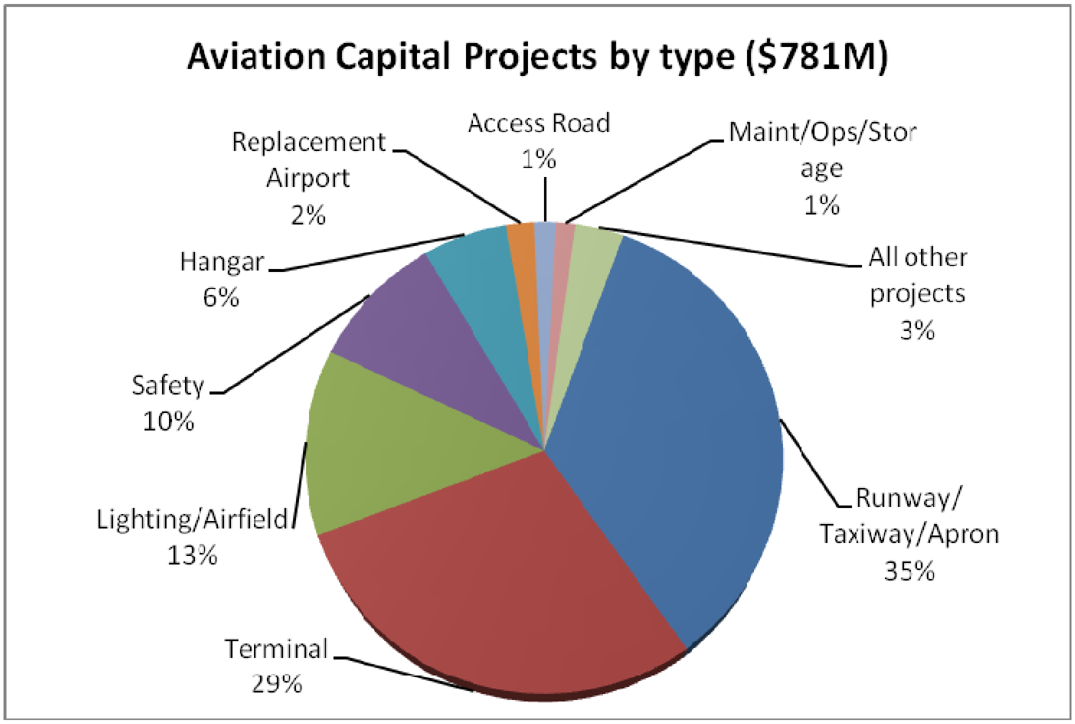
Public Transportation and Rail Capital Spending Profile. The mix of public spending on capital investment for public transportation and rail projects is shown in Exhibit 4-3. It was based largely on the 2009 profile of DRPT funding for local public transportation, and the DRPT *Six Year Projection for Rail and Public Transportation Improvement Program.* It shows that most of the capital investment spending is expected to go for transit capital projects, which mostly include purchase of new buses and bus stop facilities. The "VDOT capital" category refers to safety improvements at road/rail crossings. Other spending is contributing financial support for extension of MetroRail service in Virginia, and for expansion of freight rail facilities (that have private funding but with also some contributing state funds).

Exhibit 4-3



Airport Capital Spending Profile. The mix of capital spending for airports is shown in Exhibit 4-4. It was based on a list of 80 proposed airport construction projects contained in the DOAV *Airport Capital Improvement Plan* (ACIP) for FY2010-2015. The major categories are (1) paving projects – runways, taxiways and aprons, (2) terminal expansion and enhancements, (3) lighting improvements, (4) safety (redesign and reconstruction) and (5) hangars.

Exhibit 4-4



Marine Port Capital Spending Profile. The mix of capital spending for marine port facilities is shown in Exhibits 4-5a and 4-5b. The capital spending planned by VPA was drawn from the VPA *2040 Master Plan,* using only the parts of the master plan expected to be completed during the 2009-2014 period. Most of the funding (an estimated $605 million) is allocated to the new port facility at Craney Island, shown in Exhibit 4-5a. This includes largely preliminary work including dike and road construction, plus landfill and environmental mitigation. The remaining funding (an estimated $140 million) is allocated to renovation and terminal improvements at the Norfolk, Portsmouth and Newport News facilities.

Exhibit 4-5a

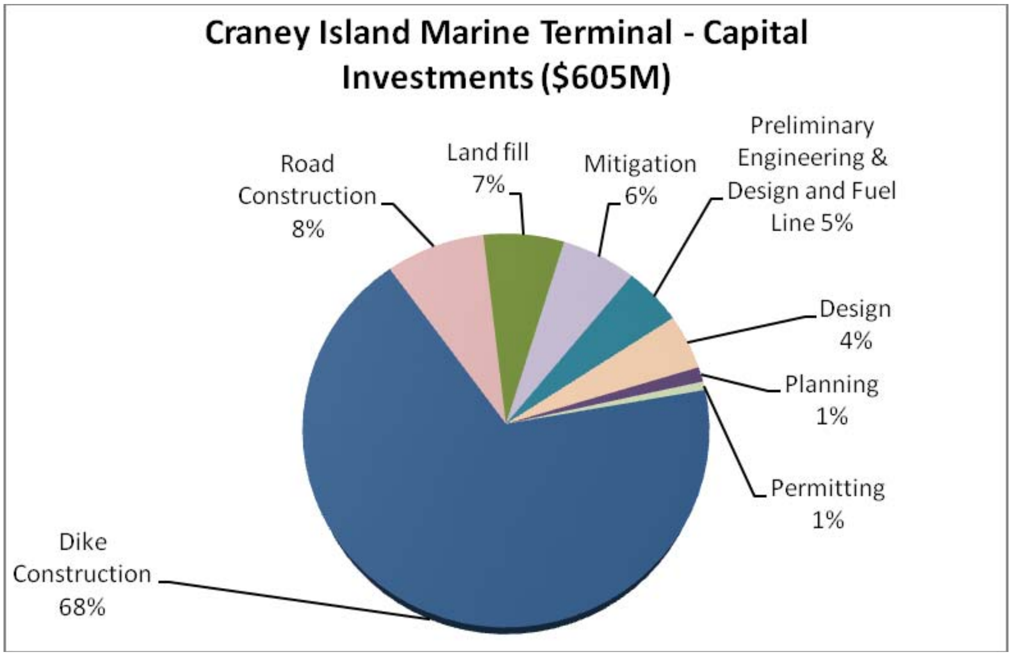
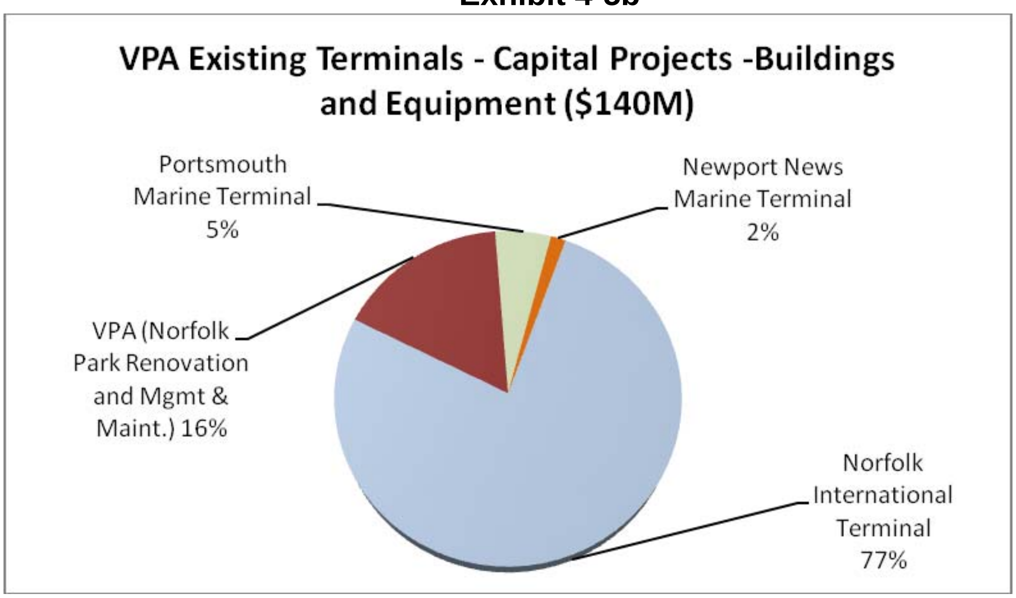


Exhibit 4-5b



4.4 Findings: Short-term Economic Impact of Transportation Spending

The profiles of transportation spending (that were shown in Exhibit 4-1) and further details of capital spending (shown in Exhibits 4-2 through 4-5) were input to the TREDIS- IMPLAN economic model of Virginia. The findings, shown below, represent a partial impact analysis because they only represent the short-term impacts of spending. (Additional economic impacts associated with changes in transportation conditions were also examined using the TREDIS economic model, and they are discussed in the next chapter.)

The results, shown in Exhibit 4-6, indicate that the $32.9 billion of expected capital investment and operations spending in Virginia, spread over a period of six years, will support over $56 billion of business output (sales revenue) with an average of over 78,000 jobs per year (totaling 468,000 job-years).

Exhibit 4-6 Short-term Economic Impact of Capital and Operations Budgets*

Category	*Total Effect on Virginia Economy, 2009-2014*		
	6-Yr. Total	**Avg. Year**	**Per $ Mil Spent**
Capital Investment Spending ($ mil)	**$ 10,422**	**$ 1,737**	--
Employment (Jobs)	142,082 *jy*	23,680	14
Business Output ($ mil)*	$ 18,780	$ 3,130	1.8
Value Added (GRP)($ mil)*	$ 9,740	$ 1,623	0.9
Worker Income ($ mil)*	$ 7,518	$ 1,253	0.7
Capital +Operations Spending ($ mil)	**$32,890**	**$ 5,481**	--
Employment (Jobs)	468,850 *JY*	78,142	14
Business Output ($ mil)*	$56,172	$9,360	1.7
Value Added (GRP)($ mil)*	$29,302	$4884	0.9
Worker Income ($ mil)*	$20,340	$3,890	0.6

* *All values are in constant year 2008 dollars. Dollar amounts in different rows cannot be added together. Specifically, worker income is a subset of value added, and value added is the portion of business output that does not go for materials and supplies.*

JY denotes "job-years". For instance, 100 jobs maintained for 4 years would represent 400 job-years.

The added household income and net business revenues will, in turn, also generate some revenue flowing back to state and local governments over the six years. A tax model of Virginia, contained in the TREDIS-IMPLAN model, calculates that the return to state and local governments will be roughly $2.3 billion of additional tax revenues. (See Exhibit 4-7.)

Exhibit 4-7 Short-term Economic Impact of Capital and Operations Budgets

Revenue Category	*State /Local Revenue*
Household + Business Income	$ 410
Sales Taxes	$ 695
Property Tax	$ 481
Social Insurance Payments	$ 20
Other Taxes & Fees	$ 696
TOTAL	$2,302

The short-term economic impacts of spending (shown here) can be combined with the long-term economic impacts of transportation improvements that are enabled by that spending (covered next). The sum of these impacts represent total economic impacts of transportation funding in Virginia (presented later, in Section 5.4).

5 LONG-TERM IMPACT OF CAPITAL INVESTMENT

Whereas the prior chapter examined *short-term spending impacts* on the Virginia economy , this chapter examines *long-term productivity impacts* of improved transportation conditions, which reduce costs, expand markets and increase economic competitiveness, ultimately expanding economic growth for years after the investments are made. (In this analysis, the long-term economic impacts of spending during the 2009-2014 period were calculated out to the year 2035.)

5.1 Travel Benefits Affecting the Economy

The long-term benefit of capital investment in transportation facilities is the improvement in travel conditions which lead to economic cost savings and productivity enhancement for Virginia residents and businesses. These improvements occur through five types of impacts on transportation system users:

(1) cost savings due to reduced time delay & expense;
(2) cost savings due to enhanced reliability;
(3) cost savings from enhanced intermodal connectivity;
(4) cost savings & scale economies from enhanced market access;
(5) added growth enabled by elimination of capacity constraints at gateways.

Those user benefits (accruing to travelers, shippers & consignees) lead to direct, indirect & induced effects on household living costs, business operating costs, productivity and competitiveness. They enable more jobs and business activity to take place in Virginia, which also reduces the "leakage" of income and savings that might otherwise flow to businesses located outside of Virginia.

However, the nature of the "improvements" must be measured in terms of the difference between two scenarios – one in which the planned or proposed spending takes place over 2009-2014 and another scenario in which no such spending takes place. Given the current condition of many transportation facilities in Virginia, a reduction in maintenance and rehabilitation may lead to degradation of travel conditions. And given the growth rate of demand for highway, transit, air and marine port facilities in Virginia, a failure to meet that demand with additional capacity or alternative travel options may raise congestion, increase travel delays and/or add capacity constraints for some travel. Thus, many of the "improvements" associated with planned transportation capital and operations spending actually improve transportation conditions and the economy by avoiding further degradation of those conditions under the "no spending" scenario.

5.2 Calculating Transportation Benefits

The calculation of transportation benefits and their economic consequences was conducted by analyzing the impacts of the transportation spending scenarios on transportation facility capacity, use and conditions. The latter ranged from projected traffic and congestion on highway facilities, to growth of freight passing through port facilities. The project team applied available performance measures and analysis tools to assess how passenger and freight volumes, speeds, travel distances and service reliability will differ among the scenarios, and those results were related to the five transportation economic impact factors previously itemized in Section 5.1. The process for accomplishing this differed by transportation mode, due largely to differences in the nature of projects but also due to differences in the availability of applicable information. The results were then input to the TREDIS economic impact model for Virginia.

The rest of this section describes further details about the methods used to calculate direct economic benefits of the planned projects. Users not interested in these details may skip to the results in section 5.3.

Calculation of Highway Benefits. VDOT provided a list of planned highway projects for the six-year plan. Staff of Cambridge Systematics then developed and applied a spreadsheet-based "Sketch Planning Tool" to estimate how planned projects would improve travel characteristics in the state. That tool is further described in Appendix A.

Benefits Calculated for Highway Projects	
User Time & Expense	X
Reliability	X
Intermodal Connectivity	X
Market Access	X

The analysis team selected a sample of projects across the state, with particular emphasis on 55 projects in 9 key corridors across the state. These key corridors identified in the VTrans2035 documents, and are listed below:

- I-64 (4 projects)
- I-66 (3 projects)
- I-81 (8 projects)
- I-95 (12 projects)
- US-13 (1 project)
- US-17 (2 projects)
- US-460 (7 projects)
- US-58 (14 projects)
- Hampton Roads (4 projects)

For each project, the sketch planning tool was used to estimate the expected impact on vehicle volumes, travel times and speeds, VMT (vehicle-miles of travel), VHT (vehicle-hours of travel) and congestion resulting from the 6-yr plan vs. the "no investment" scenario. Impacts were also distinguished by mode (car or truck).

Special attention was then given to freight movement since it is a major factor affecting business output and income flow to the state. This included two concerns:

(a) the extent of inter-modal freight connectivity and (b) the extension of freight corridors to connect major activity centers. Both concerns were a major element of the VTrans2035 planning process, and the identified freight connectivity improvements included:

- Improving the *US 460 highway corridor* to enhance freight movements with both the Port of Virginia and the "Heartland Corridor" of NS Railroad;
- Improving the *I-66 highway corridor* to enhance passenger and freight access to Dulles Airport and freight access to Virginia Inland Port (intermodal rail);
- Improving the *I-64 highway corridor* to enhance freight access to both CSX rail lines and the Hampton Roads port facilities;
- Improving the *US 17 highway corridor* to provide an alternative and reliever route between the Hampton Roads port facilities and I-95;
- Improving the *US 13 highway corridor* to improve the link between Hampton Roads and the eastern shore for freight (Bay Coast Railroad with ferry barge);
- Improving the *I-95 highway corridor* to support the "National Gateway" freight corridor of CSX Railroad, and connectivity for Amtrak lines; and
- Improving the *I-81 highway corridor* to support development of the "Southern Crescent" freight corridor of NS Railroad.

For each highway segment that was studied, the project team also constructed a "Freight Congestion Index" (FCI) as the ratio of capacity available to capacity actually utilized by Virginia trucks. The FCI value was averaged over a 24-hour period, and over all highway segments in a given multimodal corridor. Higher FCI scores indicate greater utilization and congestion; lower scores indicate the opposite.

Benefits Calculated for Transit & Rail Projects	
User Time & Expense	X
Reliability	X

Calculation of Transit Benefits. Virginia DRPT provided a list of projects included in the six-year plan. Staff of Delcan then estimated the direct travel-related impacts that would be expected of each project (when completed) in terms of transit riders attracted per day. These mode shift estimates were annualized and put into the transportation impact module of TREDIS to estimate time, operating cost, and emission-related cost savings. Mode-switchers were assumed to be drawn from congested travel conditions (average 35 mph with 25% congestion), and net average bus transit movement in urban areas was assumed to average 25 mph. Future studies may enable more precise estimates of transit project benefit to be used with this same general methodology.

Benefits Calculated for Airport Projects	
Delay Time & Expense	X

Calculation of Aviation Benefits. Virginia DOAV provided a list of Airport Capital Improvement Plan (ACIP FY2010-2015) projects. The original project list contained 605 different expenditure items in the categories construction, debt service, demolition, design, construction, equipment purchase, land acquisition and plan/study. Staff of EDR Group then reduced this list to 80 by filtering out all expenditure categories except “construction” and “design & construction”. Projects were then grouped into three categories: (1) those that reduced access, taxiing, or in-air delay, (2) those that enabled new air service and (3) those that achieved required safety improvement. Transportation benefit values were calculated only for those projects in categories #1 and #2 They included:

- expansion (airfield, apron, taxiway, lighting, runway extension),
- new facilities (access road, airfield, runway, apron, taxiway, instrument landing system, lighting, airfield, maintenance, /storage, parking, terminal),
- relocation (apron, access road, off-airport roadway), and
- upgrade (lighting).

Typically, benefit-cost studies are conducted for airport projects receiving FAA financial support over $5 million. However, most of the projects on these lists were either too early in the planning process or too small to have such studies done. However, DOAV was able to provide data on general aviation operations, percent transient, and passengers per operation for each of the applicable airports in which projects were planned. Accordingly, the projects were assigned typical values for the corresponding type of improvement, consistent with a review of FAA benefit cost studies reported in Airport Cooperative Research Program, Synthesis Report 13 (*Effective Practices for Preparing Airport Improvement Program Benefit-Cost Analysis*, by EDR Group, 2009).

The resulting value of benefits varied, depending on the airport and nature of the improvement project. For delay-reducing projects, it averaged $10-12 per transient general aviation enplanement, reflecting both time and diversion-related cost savings. The average for capacity-enhancing projects was $25 per transient general aviation enplanement, reflecting savings associated with use of larger and heavier aircraft and in some cases, also savings in ground access time due to the availability of airports closer to the trip origin or destination. Future studies may enable more precise estimates of airport project benefit to be used with this same general methodology.

Benefits Calculated for Marine Port Projects	
Capacity Constraints	X

Calculation of Port Project Benefits. In the case of Virginia ports, the major funding for port improvement is for a new facility at Craney Island to expand Virginia’s international container shipping capacity. Thus the focus of the economic benefit analysis was on the value of the added capacity. VPA provided the list of projects included in its long-term improvement plan as well as data on port capacity and port utilization trends. Staff of EDR Group then calculated the difference in container flows through Virginia ports that would occur with and without the capacity addition, and the extent of any deficit or gap between growing long-term demand and the available supply of port capacity.

The starting point of the port analysis was the database of foreign trade statistics provided by WISERTrade, showing containerized imports and exports, by commodity, for all Virginia Ports in 2008. As they currently stand, Virginia ports have a capacity ceiling of 3,230,000 TEUs per year (source: VPA).

To estimate benefits, demand in terms of TEU flows was forecast to grow at a long-term average of 3.5%/year to the year 2035. At this growth rate, port traffic would just barely exceed current port capacity in 2021, with a growing capacity deficit thereafter. The impact of inaction (failure to add the planned capacity expansion) was calculated as the consequence of this capacity deficit. For any commodity tonnage trying but unable to get through Virginia ports under the no build scenario from 2021 to 2035, it was calculated that 87% would ship through non-Virginia Ports, and 13% would end up relocating the source of production to somewhere other than Virginia. The "lost production" was quantified at $2,000 per ton (slightly less than the average $/ton reported by USDOT "Freight Analysis Framework" for the state of Virginia). Diverted trips were assumed to carry an additional cost of $25 per ton-trip to route to a non-Virginia port.

Of the total benefits, nearly 35% were estimated to accrue to Virginia businesses, in accordance with freight data indicating that over one-third of the shipments moving through Virginia ports had their origins or destinations in-state. While the various assumptions involved in calculating port impacts appear to be in a reasonable range, future studies may enable more precise estimates of port project benefit using this same general methodology.

Calculation and Interpretation of Overall Benefit. The benefit estimation process discussed in the preceding pages shows that there were differing forms of benefit calculation performed for different types of transportation projects, depending on the nature of the transportation modes involved. These differences are summarized in Exhibit 5-1. While all of the various benefit categories can in theory be applicable for any of the modes, this study employed a "sketch planning" process that calculated benefits only for the dominant classes of benefit applicable to the list of planned projects.

Exhibit 5-1 Key Benefit Calculation Categories, by Mode

Category of Benefit	Highway	Transit	Rail	Airport	Sea Port
User Time, Delay & Expense	X	X	X	X	
Reliability	X	X			
Intermodal Connectivity	X		X		
Market Access (labor & delivery)	X				
Capacity Constraints (gateways)					X

Because of the differences in benefit calculation performed for different classes of projects, it became clear during the course of this calculation process that it would be inaccurate and misleading to compare project benefits and costs among different modes. It also became apparent that the benefits of many of the projects listed for any one mode were dependent on investments also being made for other modes.

For instance, the port expansion benefits were actually dependent not only on port capacity expansion, but also on planned railroad line capacity enhancements to deliver the additional demand. Similarly, the benefit calculation for airport enhancements assumed continued air travel growth that in some cases required planned highway improvements (for airport access) to be made. The highway freight demand and congestion calculations also assumed freight growth generated by movements to and from various airports, marine ports and intermodal rail facilities. And finally, the value of transit improvements were dependent on highway speed assumptions that in some cases would be affected by whether or not planned highway improvements were to take place. Thus, many of the projects should be viewed as complementary to other projects, and enabling their benefits to occur.

If this perspective is taken, then the planned projects may be best viewed as together comprising an integrated, multi-modal package of transportation system improvements serving Virginia. And in that case, the various classes of projects can be seen as bringing different aspects of benefit that can be added together to generate the expected economic benefit of the full package.

5.3 Long-term Economic Impact of Transportation Improvements

Use of TREDIS. The calculation of long-term economic impact from multi-modal transportation improvements was analyzed using a package called TREDIS (Transportation Economic Development Impact System) for the Virginia economy. This economic impact modeling system is designed specifically for multi-modal transportation scenarios. The system is comprised of a set of modules. One module translates changes in travel times, costs, reliability and safety into household income and business productivity changes. A second module translates changes in labor and delivery market access and intermodal connectivity into business productivity and growth changes. A third module applies a time series, multi-regional economic model to calculate longer term impacts on growth of jobs, income and business activity in Virginia. Impacts on tax revenue are also estimated. A fourth module calculates benefit/cost ratios from various perspectives. Further information about the system is provided in Appendix B.

While this analysis system has been applied in numerous states across the country, the version applied here was built upon a model of the Virginia economy, its specific flows of imports and exports, and ways in which different Virginia industries depend on transportation for workers, materials and product deliveries. .

Impacts on the Economy. The results, shown in Exhibit 5-2, indicate that the $10.4 billion of capital investment will enable continuing economic growth totaling $81 billion of additional business output over 25 years. That represents an average of

$3.1 billion/year of additional business output, although the level will rise over time to reach $13.6 billion/year of additional output by 2035. Associated with this economic growth will be an average of over 23,000 more jobs, rising to over 101,000 more jobs by 2035.

Exhibit 5-2 Long-Term Economic Growth Impact of Transportation System Improvements from Planned Six-Year Program of Capital Investments

Impact Category	*Avg. Year 2010-2035*	*Year 2035 Impact*	*Sum of 2010-2035*	*Per $mil of Capital Investment*
Employment (Jobs)	23,523	101,932	611,590	58.8
Business Output ($ mil)	$ 3,137	$13,594	$ 81,566	$ 7.8
Value Added ($ mil)	$1,539	$ 6,668	$40,006	$ 3.8
Worker Income ($ mil)	$ 1,025	$ 4,441	$ 26,645	$ 2.6

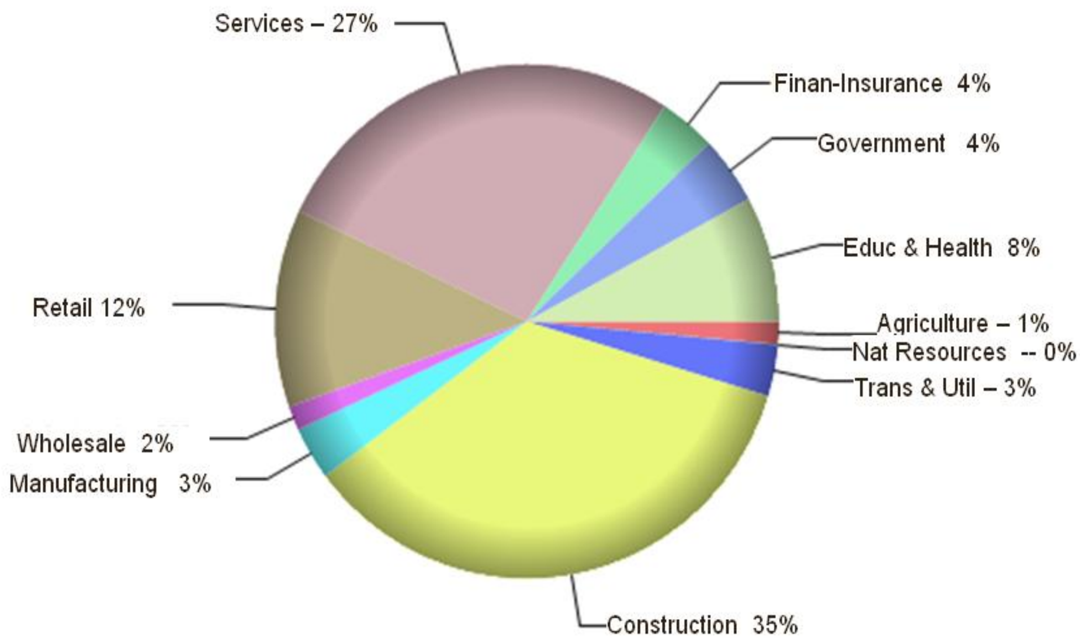
** All values are in constant year 2008 dollars. Dollar amounts in different rows cannot be added together. Specifically, worker income is a subset of value added, and value added is the portion of business output that does not go for materials and supplies.*

These long-term economic impacts of planned capital investments should be interpreted carefully. It is important to note that these impacts represent the difference between a scenario in which needed investments are made and a scenario in which those capital investments are not made. So in a very real sense, the capital investments are enabling a continued level of economic growth while the failure to invest would lead to a lower level of economic growth.

It is also notable that the magnitude of long-term economic impacts enabled by capital investment dwarf the short-term spending impacts of capital investment that were previously shown in Chapter 4.

In addition, the mix of Virginia’s economic sectors that are aided by the capital investment are notable. As shown in Exhibit 5-3, fully 96% of the job impact generated by capital investment are private sector jobs.

Exhibit 5-3 Mix of Job Impacts from Capital Investment



5.4 Total Economic Impact & Return on Investment

Total Economic Impact. The short-term spending impacts discussed in Chapter 4 (which occur over the period of 2009-2014) and the long-term improvement impacts presented in Section 5.3 (which occur over the period of 2010-2035) may be added together to provide the total job impacts shown in Exhibit 5-4.

Exhibit 5-4 Total Economic Impact
(Sum of Short-Term Spending and Long-Term Transportation Improvement Effects)

• Capital Investment Spending	142,100 job-yrs over 6 yrs	(23,700/yr)
• Operations Spending	326,700 job-yrs over 6 yrs	(54,400/yr)
• Total Six-Year Spending	468,800 job-yrs over 6 yrs	(78,100/yr)
• Long-Term Impact	611,600 job-yrs over 26 yrs	(23,500/yr)
• Total	1,080,400 job-yrs total	

Benefit-Cost Ratio. While the focus of this study was on the calculation and measurement of impacts on the economy, the information collected as part of this analysis also made it possible to calculate measures of "benefit/cost ratio" and "economic return on investment." Both of these measures apply a discount rate to calculate the present value of cost, revenue and benefit streams that occur over periods of time. The advantage of this process is that it corrects for the fact that most of the costs are incurred in the first six years, while the benefits occur in later years. The process of discounting adjusts for the time value of money over-and-above the effect of inflation. (In a general sense, it can be viewed as adjusting for the real interest cost of borrowing money that is above the inflation rate, or the value of what the money might otherwise be earning if loaned out or invested in some other way.)

Two different measures are shown in Exhibit 5-5.

- The *economic impact ratio* reflects value added (wage income and business profit income) generated per dollar of transportation investment. That calculation comes directly from the economic impact analysis results.

- The *benefit/cost ratio* is similar to the economic impact ratio in that it also recognizes long-term cost savings and productivity gains as benefits, but it differs in that it also adds the value of non-money benefits (such as personal time and safety) while ignoring spending impacts on the economy.

In this particular case, the differences between these two measures nearly offset each other, and as a result, the two ratios end up similar – with a 4.0 to 1 benefit/cost ratio and a 3.8 to 1 ratio of value added per dollar of investment.

Exhibit 5-5 Return on Investment*

Benefit/Cost Findings	***Value ($ millions)***
Present Value of Cost Stream (2009-2014)	$ 9,167
Present Value of Benefit Stream (2010-2035)	$ 36,645
Net Present Value (=Benefits - Costs)	$ 27,478
B/C Ratio (=Benefits / Costs)	4.0
Economic Impact Findings	**Value ($ millions)**
$ Value Added per $1 million of capital investment	3.8

** Using a 4% real discount rate; all values expressed in constant 2008 dollars, with capital investment defined to exclude $467 million of regulatory-required airport safety improvements that were not intended to affect economic productivity.*

These findings confirm that there are significant returns associated with the current packages of planned transportation investments in Virginia. They also demonstrate how the Commonwealth of Virginia can systematically apply economic impact tools and methods to assess other projects and programs that may arise in the future.

6 RECOMMENDATIONS FOR MEASUREMENT & MONITORING

Transportation planning and decision-making processes in Virginia can benefit from the adoption and implementation of measurement systems for project prioritization, and impact monitoring. However, for such systems to be work, there needs to be: (1) clearly-defined needs that they are designed to address, and (2) clearly-defined mechanisms to ensure that they will effectively meet those needs. This chapter outlines potential directions for progress towards those goals.

6.1 Measurement & Monitoring Needs

There are three very different measurement concepts that are likely to be applicable for VDOT and its intermodal partners (DRPT, DOAV and VPA):

1. *Measuring the economic role of transportation facilities and services*. There is value in periodic updating of statistics showing the economic role of Virginia's transportation facilities and systems, as that can aid public discussion of the importance of continuing investment in them. The key measures are employment and value of trade. To date, economic impact studies of this type have been conducted primarily for airport and marine port facilities in Virginia, though there is no reason why the same basic approach cannot also be conducted for other modes and presented in a consistent manner.

   The basic transportation employment and international trade statistics laid out in Chapter 3 be updated every 3-5 years using readily-available data sources, with relatively low cost involved. The updated numbers can be useful to show the ongoing importance of transportation services for the economy of Virginia. In addition, a comparison across time can also be useful to identify any major changes in Virginia's transportation activity levels, such as major gains or losses in particular segments of the freight rail industry, trucking and supply chain sector, or international shipping and trade sector of the economy. Those changes may also have economic development implications for state business attraction and infrastructure investment strategies.

2. *Measuring the overall return on investment from a program or package of projects*. There is value in showing how investment in an integrated, multi-modal plan such as the short-term "six year improvement plan" will pay off for the state and its residents. The analysis presented in Chapters 4 and 5 of this study represents a first attempt to systematically conduct this form of

measurement on a fully multi-modal basis. The results are expressed in terms of income and value added (or GDP), and various ratios of "return on investment."

While significant effort was required to conduct this study, it has laid out model processes, along with a "sketch planning" highway analysis tool and application of a multi-modal economic impact modeling system for Virginia. The processes and tools that have now been applied will allow for future studies of this sort to be done much more quickly and with less resources. These tools and methods may also be applied for either single modes or for combinations of all modes, as desired. In either case, it is recommended that this type of scenario analysis be considered when major funding decisions have to be made about transportation programs and policies.

3. The *economic impact of a specific project.* VDOT has had a highway project prioritization process that scores proposed projects based on a series of criteria and weights, which include some factors that can be related to economic development (passenger and goods movement flows, tractor-trailer truck levels and local unemployment rate). To date, though, VDOT has not had the ability to calculate impacts that relate directly to business productivity or its implications for economic growth (such as jobs and income).

   While this study did not address project evaluation or rating systems, the economic impact methodology and tools that were developed here can in fact be applied for assessment of competing projects or alternatives. Some state transportation departments are already in the process of implementing economic impact assessment into their project scoring systems. Examples such as Wisconsin DOT and Kansas DOT offer divergent examples of the ways that this can be done with or without statewide transportation forecasting models.

   Another notable aspect of the process laid out in this report is that it directly identifies a series of *travel impacts* as causal factors affecting *economic impact* results. This combination of impact measures makes it possible to portray the impact of alternative projects not just in terms of economic impact calculations, but also in terms of the causal transportation factors that drive those economic results. These "driver" factors, shown in Chapter 5, are travel times, service frequency, travel costs, congestion levels, reliability, intermodal connectivity, market access and capacity constraints. They are particularly important when they affect routes or facilities that serve the key industrial centers, distribution/ warehouse facilities, intermodal terminals, or centers of convention, tourism and banking that bring money into the state economy.

6. 2 Performance Metrics

The methodology provided for this study also identifies key metrics that VDOT may use in the future for ongoing monitoring of the performance of the state's transportation system as viewed from the perspective of business growth and economic development.

An important consideration, from the economic development perspective, is that average speeds, volumes, and other travel efficiency measures are of limited use unless they can also distinguish those metrics for routes of major significance for Virginia's business productivity and competitiveness. The sensitivity of economic growth to transportation conditions is most important when the following criteria can be distinguished:

- Market Access – the extent to which proposed route changes affect the size of labor markets or truck delivery markets;
- Intermodal Connectivity – the extent to which affected vehicles serve ground transport enabling air, sea or rail gateway facilities to function efficiently.
- Location – the extent to which affected routes serve industrial, warehouse or other business centers (where reliability is important).
- Purpose for External Trips– the extent to which affected routes carry freight moving into and out of Virginia (as opposed to internal deliveries and pass-through traffic).

6.3 Consideration of Alternative Scenarios

The economic impact modeling process that is laid out in this report was used to show the expected short-term and long-term impacts of a planned six year transportation spending program. However, this same methodology can be applied by VDOT and other Virginia transportation agencies to assess the impact of alternative scenarios concerning investment risk. Such risk can relate to uncontrollable factors such as the economic downturn, fuel prices, or international trade. Two examples are provided here to illustrate the range of issues that can be considered.

- ***Consideration #1: Questions about VDOT investments strategies in the face of current global commodity and financial market instability.*** There are several disruptive near-term conditions in global markets that may persist. For instance, the potential for persistence of historically transient fuel and materials price spikes may lead decision-makers to closely question assumptions upon which most economic impact assessments rely. Fundamental changes in available funding or funding sources initiated by reform of federal funding programs could re-shape the investment strategies and financial resources available to VDOT for implementing even a six-year plan. Introducing these issues into the main study could pose a serious distraction or diversion of attention from the important message about the economic impacts of infrastructure investments. However, the potential for such scenarios may be of future interest to VDOT.

- ***Consideration #2: The Black Swan Effect.*** The vulnerability and robustness of proposed investment plans can have unforeseen risks in the face of "black swan" scenarios such as those characterized by events that have a relatively low probability of occurrence, but a high relative impact should they occur. Examples such as major shifts in trade patterns, unanticipated fluctuations in the movements of key commodities essential to the economic well-being of the Commonwealth's key industries, or unanticipated, rapid changes in fundamental supply and demand for one or more significant parts of the Commonwealth's base of economic activity could produce a major shift in available short-term funding or re-prioritization of investments.

6.4 Analysis of Sub-State Areas

While the economic impact analysis methods developed in this study are designed for statewide economic impact analysis, such methods could potentially be extended to sub-state analysis (separating VDOT districts, metropolitan areas, or individual counties) if desired in the future.

The motivation for conducting more detailed sub-state impact analysis is that key constituencies may wish to know in more detail how transportation investments will affect their part of the Commonwealth. Moreover, it is possible that important economic impacts of transportation investments may have more significance at a sub-state or regional level than at a broad state level. In particular, they may contribute to the economic benefit of particular regions by providing connectivity and access to markets, opportunities for growth, and support of existing businesses and economic development initiatives and opportunities. Finally, issues that are important at a state-wide level, or issues that are important in one region may be less relevant or of more intense interest for particular regions. For all of these reasons, there can sometimes be additional value in also assessing transportation investment impacts for specific regions of the state.

A

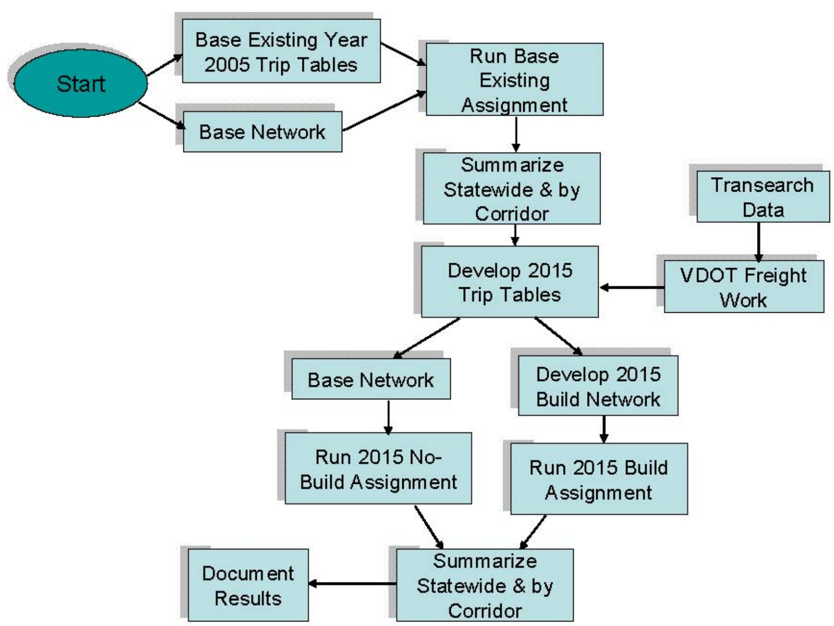
APPENDIX A: SKETCH PLANNING TOOL

As part of the VDOT Economic Impact Study, Cambridge Systematics (CS) developed a sketch planning tool that allows for analysis of vehicle travel within the Commonwealth of Virginia. This sketch planning tool was developed using the existing framework of the Virginia Statewide Model (VSM) to analyze the change in travel between a 2009 base year and two potential scenarios for 2014: a "no build" and a "build" scenario.

A.1 Methodology

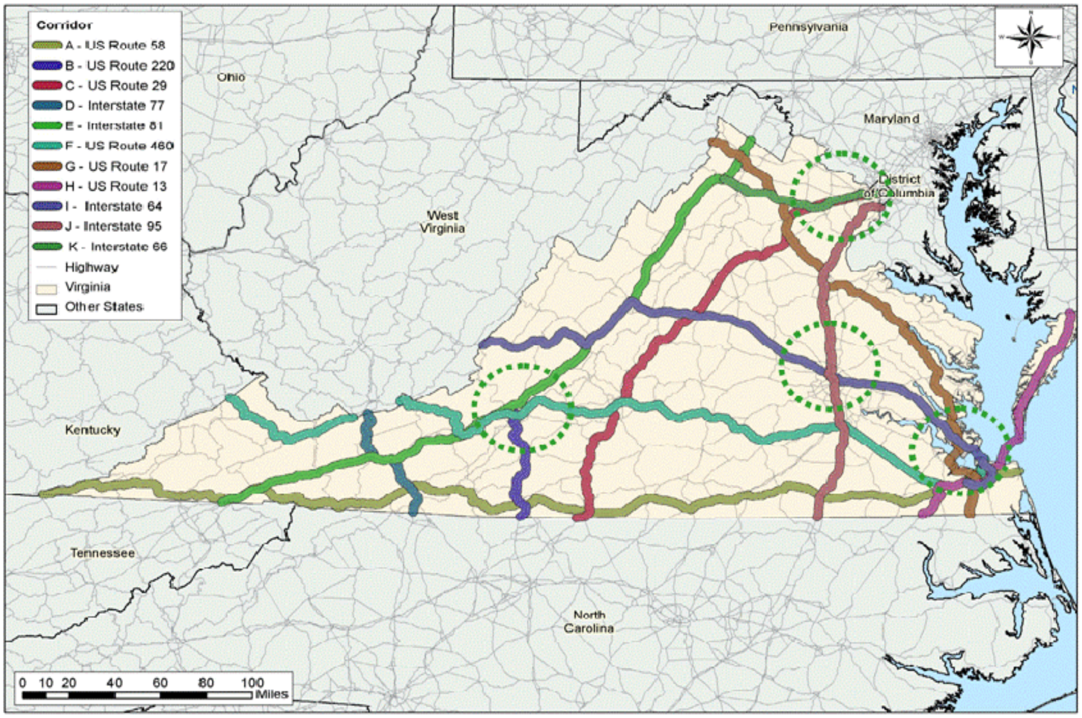
The flow chart in Exhibit A-1 illustrates the process of developing and using this sketch planning tool. The first activity was to develop a base year set of inputs and evaluate the sketch planning tool based on previously collected count data. By studying historic rates of traffic growth along the eleven study corridors, future forecasts can be checked for reasonableness. In total, three different scenarios were analyzed for a variety of metrics that allow for comparison between the scenarios.

Exhibit A-1. Overview of Sketch Planning Tool Development and Application



The sketch planning tool focuses on eleven major freight and passenger corridors that traverse the Commonwealth as illustrated in Exhibit A-2, including U.S. Route 58, U.S. Route 220, U.S. Route 29, I77, I81, U.S. Route 460, U.S. Route 17, U.S. Route 13, I64, I95, and I66.

Exhibit A-2 Map of Highway Corridors



Networks. Two networks were used in this analysis: a baseline network and a build network. The baseline network includes an approximation all of the facilities in existence as of 2009. The build network includes a range of projects designed primarily to increase capacity along the eleven study routes. The final build network includes the addition of 55 projects that are planned in the six year statewide transportation plan. A select number of projects being constructed with private funds (such as the HOT lanes on I95) were also included in this build network. Exhibit A-2 lists projects that were included in the build scenario network.

Exhibit A-2. Build Network Project List

Corridor	Project Description
I-64	Widening 4 To 6 Lanes Widening 6 To 8 Lanes Add High Occupancy Toll (HOT) Lanes
I-81	Widen From 4 To 8 Lanes Addition Of Truck Climbing Lanes
I-95	Widen To Add Additional Lanes HOT (High Occupancy Toll) Lanes Add HOV (High Occupancy Vehicle) Lanes
U.S.-13	Rural – 4 Lane With Median
U.S.-17 U.S.-17	Widen To 4 Lanes Widen From 4 To 6 Lanes
U.S.-460	Connector Coalfields Expressway Widen To 3 Lanes With Curb & Sidewalk
U.S.-58	Parallel Lane Corridor Development – 4 Lanes Bypass-New Location Martin Luther King Freeway Ext.
Hampton Roads	Construct Maersk Terminal Interchange In Portsmouth Pinner's Point New Marine Terminal Intermodal Connector

The corridors are all of different lengths; the longest (U.S. 58) is over 925 miles long while the shortest (I77) is only 111 miles long. Exhibit A-3 shows the lengths of each corridor and the total lane miles on each corridor for both the no build and build networks. Of the study corridors, the build scenario projects caused the greatest increase in lane-miles on I95, with a 13 percent increase.

Exhibit A-3. Length and Lane-Miles by Corridor

		Lane-Miles		
	Length	**No Build**	**Build**	**Change**
US 58	928	3,029	3,262	8%
US 220	338	1,066	1,108	4%
US 29	498	1,953	1,990	2%
I-77	111	242	242	0%
I-81	644	1,313	1,393	6%
US 460	835	3,189	3,248	2%
US 17	482	1,778	1,883	6%
US 13	244	1,023	1,064	4%
I-64	538	1,175	1,237	5%
I-95	340	968	1,097	13%
I-66	141	343	364	6%
Total	5,099	16,080	16,888	5%

Trip Tables. Truck and car trip tables were developed from parts of the Virginia Statewide Model (VSM) as well as Global Insight TranSearch data purchased by VDOT. From this data trip tables for the years 2009 and 2014 were derived for this sketch planning activity. The VSM has the capability of calculating car trip tables for any intermediate year between 2005 and 2030. VSM was used to develop the car trip table for 2014; model correction factors were then developed to adjust the VSM output based on available count data. The model bias correction factors were applied by corridor.

Using a variety of sources, truck tables were also developed for the VSM study for 2009 and 2030. Global Insight TranSearch freight data was combined with data about local trips to create comprehensive truck trip tables for the two years of interest. A truck table for 2014 was estimated by interpolating between 2009 and 2030; calculations of travel statistics (such as VMT -- vehicle miles traveled) were further factored based on a model bias correction factor developed from traffic counts. Table a-4 shows a 16 percent increase in overall truck trips and a 7.5 percent increase in car trips in Virginia between 2009 Baseline and 2014 Build scenarios.

Exhibit A-4. Statewide Trip Table Comparison

	2009 Baseline	2014 No-Build	2014 Build
Car Trips	5,369,718	5,729,489	5,773,120
Total Truck Trips	210,137	233,883	244,564
Internal Truck Trips	30.7%	31.6%	30.0%
External (through) Truck Trips	30.0%	29.3%	32.2%
External to Internal Truck Trips	20.3%	20.3%	19.6%
Internal to External Truck Trips	19.0%	18.8%	18.2%

Exhibit A-5 shows the origins and destinations of trips entering and exiting on each of the eleven study corridors. As an example, this table indicates that of all the trips that enter or exit the state on U.S. 220 in the 2009 baseline scenario, 38 percent originate in Virginia and are destined for locations outside of Virginia, 41 percent originate outside of Virginia and are bound for locations within the state, and only three percent have both origin and destination outside of Virginia.

Exhibit A-5. Percent Internal/External Trips Entering Each Corridor

	Internal to External			External to Internal			External to External		
	2009	**No Build**	**Build**	**2009**	**No Build**	**Build**	**2009**	**No Build**	**Build**
Trucks									
US 58	46%	47%	49%	51%	50%	49%	3%	2%	2%
US 220	30%	31%	29%	38%	37%	37%	32%	32%	34%
US 29	55%	54%	35%	37%	37%	54%	8%	9%	11%
I-77	7%	7%	9%	11%	12%	11%	82%	81%	80%
I-81	11%	12%	17%	16%	17%	16%	73%	72%	67%
US 460	59%	58%	25%	34%	35%	17%	6%	7%	58%
US 17	17%	19%	19%	32%	34%	33%	52%	46%	48%
US 13	45%	46%	46%	50%	50%	50%	5%	5%	4%
I-64	39%	39%	23%	56%	57%	51%	5%	4%	25%
I-95	10%	11%	11%	28%	29%	31%	63%	60%	58%
I-66	21%	21%	36%	57%	59%	42%	23%	21%	22%
Total	18%	18%	19%	26%	26%	28%	57%	56%	53%
Cars									
US 58	48%	48%	49%	48%	48%	49%	3%	3%	3%
US 220	42%	38%	37%	42%	39%	39%	16%	24%	23%
US 29	19%	17%	20%	75%	78%	77%	6%	5%	3%
I-77	24%	20%	18%	26%	22%	19%	49%	58%	63%
I-81	38%	37%	47%	38%	38%	41%	24%	25%	12%
US 460	40%	36%	38%	40%	36%	38%	20%	28%	24%
US 17	32%	33%	33%	32%	33%	33%	37%	34%	34%
US 13	48%	47%	47%	49%	49%	49%	3%	4%	3%
I-64	46%	45%	41%	46%	45%	46%	8%	9%	13%
I-95	36%	37%	36%	48%	47%	48%	16%	16%	16%
I-66	51%	53%	56%	47%	45%	40%	2%	2%	3%
Total	39%	39%	41%	48%	47%	45%	14%	14%	15%
All Vehicles									
US 58	48%	48%	49%	48%	49%	49%	3%	3%	2%
US 220	38%	34%	33%	41%	38%	38%	21%	28%	28%
US 29	20%	19%	20%	74%	76%	76%	6%	5%	3%
I-77	19%	15%	14%	22%	18%	16%	59%	68%	70%
I-81	26%	25%	33%	28%	27%	30%	46%	48%	37%
US 460	49%	48%	35%	37%	35%	33%	14%	16%	31%
US 17	28%	29%	29%	32%	34%	33%	41%	37%	38%
US 13	47%	47%	47%	49%	49%	50%	4%	4%	4%
I-64	44%	43%	34%	49%	49%	48%	7%	8%	18%
I-95	31%	31%	31%	44%	43%	44%	25%	25%	25%
I-66	51%	52%	56%	47%	45%	40%	2%	2%	4%
Total	35%	34%	36%	43%	43%	41%	22%	24%	23%

Exhibit A-6 shows the number of estimated pass-thru trips for each corridor by mode; that is, the number of trips that use the whole length of a corridor to complete a trip with both origin and destination outside of Virginia. An example would be a vehicle traveling between Maryland and North Carolina using the I¬95 corridor; this type of movement is only possible on six of the eleven study corridors.

Exhibit A-6. Thru Trips by Mode and Corridor

	Trucks			Cars			Total		
	Baseline	**No Build**	**Build**	**Baseline**	**No Build**	**Build**	**Baseline**	**No Build**	**Build**
U.S. 220	<100	<100	<100	<100	<100	<100	<100	<100	<100
U.S. 29	<100	<100	<100	<100	<100	<100	<100	<100	<100
I-77	3,906	4,493	4,294	7,099	6,867	6,940	11,005	11,005	11,360
I-81	9,976	11,130	7,887	2,078	2,034	1,649	12,054	12,054	13,164
U.S. 13	340	406	401	408	439	429	748	748	844
I-95	960	993	956	1,642	1,641	1,474	2,602	2,602	2,634

A.2 Results

Three scenarios were tested for this sketch planning activity: 2009 baseline, 2014 no-build, and 2014 build. A range of metrics were used to analyze the relative changes between these three scenarios which are discussed in this section.

VMT and VHT. The first metrics that were calculated include vehicle miles traveled (VMT) and vehicle hours traveled (VHT); Exhibit A-7 highlights differences between the three scenarios in these two key metrics by mode. The results indicate a substantial growth in travel (as measured by both VMT and VHT) between 2009 and 2014.

Overall, the improvements included in the build network result in a lower total VMT on the corridors when compared with the no¬build scenario.

Vehicle Trips. The total number of vehicles provides an indication of the number of trips occurring on each corridor and throughout the state. Exhibit A-8 shows the number of vehicles on each corridor and a statewide total for each of the three tested scenarios.

Congestion Measures. Congestion is currently a major issue in some areas of the Commonwealth and is expected to increase by 2014. Each corridor has different levels of congestion along its length, and the projects in the build scenario are designed to alleviate some of the worst congestion areas. For each of the eleven corridors, the percentage of total VMT occurring on the corridor sections with the highest congestion levels in 2009 is shown in Exhibit A-9. As shown in the table, in the majority of corridors, a higher percentage of travel (as measured by VMT) will occur on these corridor segments under the build scenario than the no-build scenario.

Exhibit A-7. VMT and VHT by Scenario

	2009 Baseline		2014 No Build Scenario				2014 Build Scenario			
	VMT	**VHT**	**VMT**	**Diff**	**VHT**	**Diff**	**VMT**	**Diff**	**VHT**	**Diff**
TRUCKS										
US 58	867,539	15,292	943,352	9%	15,954	4%	673,860	-22%	12,147	-21%
US 220	472,101	8,068	544,448	15%	8,913	10%	493,652	5%	8,825	9%
US 29	771,738	13,243	942,214	22%	15,636	18%	756,867	-2%	13,600	3%
I-77	446,628	6,467	513,688	15%	7,197	11%	491,039	10%	7,342	14%
I-81	4,059,016	59,591	4,528,706	12%	64,286	8%	3,208,972	-21%	47,881	-20%
US 460	1,134,376	20,094	1,138,187	0%	19,196	-4%	987,144	-13%	17,922	-11%
US 17	524,695	9,370	750,800	43%	12,791	37%	683,045	30%	12,465	33%
US 13	282,600	5,274	337,092	19%	5,614	6%	333,583	18%	6,045	15%
I-64	905,661	13,699	1,000,985	11%	14,679	7%	1,175,118	30%	18,051	32%
I-95	1,854,706	28,992	1,917,206	3%	27,994	-3%	1,846,781	0%	28,558	-1%
I-66	298,350	4,553	313,498	5%	4,699	3%	310,406	4%	5,013	10%
Total	11,617,409	184,643	12,930,176	11.3%	196,959	6.7%	10,960,467	-5.7%	177,848	-4%
CARS										
US 58	11,514,899	204,994	11,658,460	1%	207,193	1%	10,812,637	-6%	203,914	-1%
US 220	4,713,649	80,048	4,223,098	-10%	72,034	-10%	4,082,414	-13%	75,366	-6%
US 29	7,116,411	125,490	10,574,780	49%	186,841	49%	9,119,382	28%	174,998	39%
I-77	690,097	9,980	667,564	-3%	9,697	-3%	674,580	-2%	10,445	5%
I-81	4,510,281	66,195	4,414,949	-2%	64,990	-2%	3,579,470	-21%	55,391	-16%
US 460	10,580,775	189,764	9,764,014	-8%	176,125	-7%	9,450,444	-11%	180,344	-5%
US 17	9,455,864	179,770	12,657,609	34%	230,169	28%	11,241,371	19%	219,361	22%
US 13	975,360	18,551	1,048,994	8%	18,759	1%	1,025,580	5%	19,323	4%
I-64	4,759,598	74,194	4,748,310	0%	74,423	0%	4,911,511	3%	80,768	9%
I-95	6,451,498	99,415	5,707,738	-12%	88,047	-11%	5,791,571	-10%	95,515	-4%
I-66	5,436,117	87,291	5,154,877	-5%	83,162	-5%	5,639,013	4%	98,852	13%
Total	66,204,549	1,135,690	70,620,392	6.7%	1,211,441	6.7%	66,327,972	0.2%	,214,277	6.9%
ALL VEHICLES										
US 58	12,382,439	220,286	12,601,811	2%	223,147	1%	11,486,497	-7%	216,061	-2%
US 220	5,185,750	88,116	4,767,546	-8%	80,947	-8%	4,576,066	-12%	84,190	-4%
US 29	7,888,149	138,733	11,516,994	46%	202,477	46%	9,876,249	25%	188,598	36%
I-77	1,136,725	16,447	1,181,251	4%	16,893	3%	1,165,619	3%	17,788	8%
I-81	8,569,296	125,786	8,943,655	4%	129,276	3%	6,788,441	-21%	103,273	-18%
US 460	11,715,151	209,858	10,902,201	-7%	195,321	-7%	10,437,588	-11%	198,265	-6%
US 17	9,980,558	189,140	13,408,410	34%	242,960	28%	11,924,416	19%	231,826	23%
US 13	1,257,960	23,825	1,386,086	10%	24,373	2%	1,359,163	8%	25,367	6%
I-64	5,665,259	87,892	5,749,295	1%	89,102	1%	6,086,629	7%	98,819	12%
I-95	8,306,204	128,407	7,624,944	-8%	116,042	-10%	7,638,352	-8%	124,072	-3%
I-66	5,734,467	91,844	5,468,375	-5%	87,862	-4%	5,949,419	4%	103,865	13%
Total	77,821,958	1,320,333	83,550,568	7.4%	1,408,399	6.7%	77,288,439	-0.7%	,392,125	5%

Exhibit A-8. Total Vehicles Traveling by Corridor (VMT/Lane-Miles)

	Total			Car			Truck		
	2009 Baseline	2014 No Build	2014 Build	2009 Baseline	2014 No Build	2014 Build	2009 Baseline	2014 No Build	2014 Build
US 58	4,088	4,160	3,521	3,801	3,849	3,315	286	311	207
US 220	4,866	4,473	4,129	4,423	3,962	3,684	443	511	445
US 29	4,040	5,898	4,962	3,644	5,415	4,582	395	483	380
I-77	4,705	4,889	4,867	2,856	2,763	2,817	1,849	2,126	2,050
I-81	6,527	6,812	4,875	3,435	3,363	2,571	3,092	3,449	2,304
US 460	3,673	3,418	3,214	3,318	3,061	2,910	356	357	304
US 17	5,612	7,540	6,334	5,317	7,117	5,972	295	422	363
US 13	1,229	1,355	1,278	953	1,025	964	276	329	314
I-64	4,820	4,891	4,920	4,049	4,040	3,970	771	852	950
I-95	8,580	7,876	6,960	6,664	5,896	5,278	1,916	1,980	1,683
I-66	16,699	15,924	16,331	15,830	15,011	15,479	869	913	852
Total	4,840	5,196	4,577	4,117	4,392	3,928	722	804	649

Exhibit A-9. Percent of VMT Occurring on Most Congested Portions of Corridors

Corridor	2009 Baseline	2014 No-Build Scenario	2014 Build Scenario
US 58	14.82%	17.26%	37.14%
US 220	39.27%	56.55%	88.35%
US 29	9.78%	12.73%	18.37%
I-77	46.92%	66.94%	82.51%
I-81	32.53%	48.70%	25.53%
US 460	17.32%	40.12%	73.58%
US 17	18.70%	27.50%	31.66%
US 13	27.20%	31.20%	65.15%
I-64	5.96%	14.86%	15.07%
I-95	31.10%	57.47%	55.05%
I-66	5.70%	31.43%	37.00%

A.4 Freight Congestion Index

For each highway segment that was studied, the project team constructed a "Freight Congestion Index" (FCI) as the ratio of capacity available to capacity actually utilized by Virginia trucks.

FCI = [capacity available for VA trucks] / [capacity utilized by VA trucks]

The FCI value was averaged over a 24-hour period, and over all highway segments in a given multimodal corridor. Higher FCI scores indicate greater utilization and congestion; lower scores indicate the opposite. The FCI is similar to highway level of service, but cannot be used to evaluate the overall performance of a highway link because it excludes autos. It is therefore best used as a relative measure, to evaluate the effectiveness of improvements, rather than as an absolute measure of the "goodness" of performance.

An FCI of 1.00 represents the average condition for the No Build scenario over each of Virginia's eleven designated multimodal corridors. The FCI was calculated using the Virginia Statewide Model output and corresponding highway network. The model output for the truck flows was based on the assignment of the Transearch data purchased by the Virginia Department of Transportation.

For each corridor the truck volumes by link were summed and then divided by the total number of lane miles for each corridor. The process was done in CUBE and the data processed in a worksheet pivot table. This was a simple measure of available capacity to truck demand. It was averaged for the no-build case across all designated corridors. The purpose of averaging was to show where improvements occurred while portraying a scaling factor representative of the impact for the improvement on truck flows.

B

APPENDIX B: ECONOMIC IMPACT TOOL (TREDIS)

As part of the VDOT Economic Impact Study, Economic Development Research Group provided an analysis process and tool that allows VDOT to conduct quantitative comparison of the economic impacts of alternative transportation programs and projects.

B.1 System Overview

The economic impact model provided to VDOT is TREDIS – the "Transportation Economic Development Impact System." The system is designed to provide both economic development impact evaluation and benefit-cost analysis for transportation investments and policies. It is applicable for all modes -- highway, bus rail, aviation and marine projects, as well as multi-modal projects. It is also applicable for both freight and passenger transportation projects, and accounts for rural accessibility as well as urban congestion factors. The system also distinguishes generative and distributive effects of transportation on regional economic growth. This is done using economic geography tools that integrate GIS with an economic development assessment process that accounts for threshold effects associated with changes in service areas, market access and travel times.

As a web-based system, TREDIS also provides the capability to be simultaneously used by multiple staff members, evaluating multiple projects, with study areas and time periods that can be redefined by users as needed.

While the TREDIS framework has been used in 35 states, the version provided to VDOT is tailored to reflect the composition of the Virginia economy and the state's freight shipping patterns. It is also designed to use results of the Sketch Planning Model (discussed in Appendix A) as an input for highway projects. The data sources used for other modes are discussed in Section 5.2 of the main report.

TREDIS is comprised of modules that work together to determine the full economic impact of transportation projects. They are listed below and illustrated in Exhibit B-1.

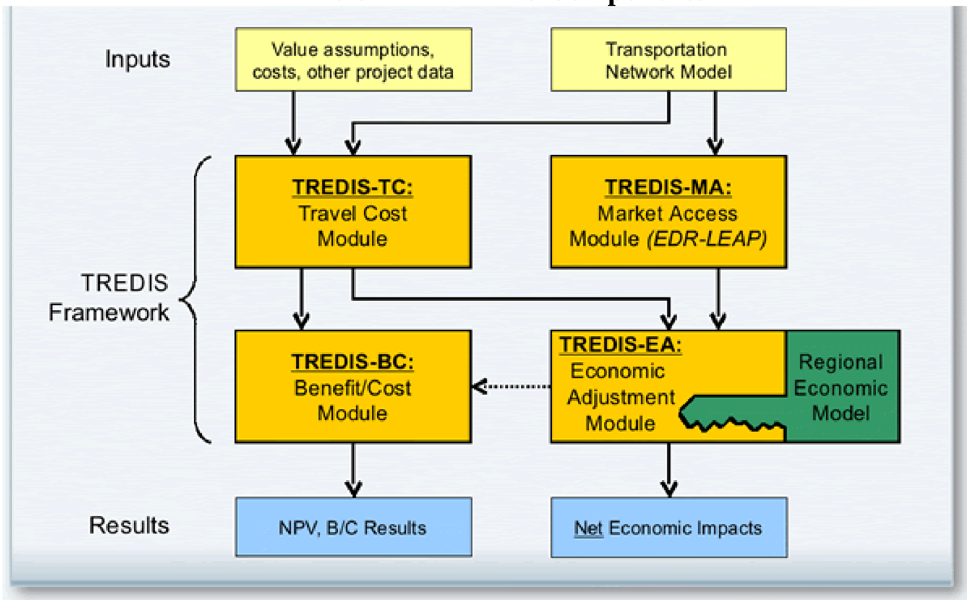
- **Travel Cost Module (TC).** The first module translates changes in traffic volumes, travel times and accidents into direct cost savings that accrue to households and businesses.

- **Market Access Module (MA).** The second module translates changes in regional accessibility and intermodal connectivity into effects on productivity and business relocation.

- **Economic Adjustment Module (EA).** The third module incorporates a dynamic time series economic impact model to estimate total impacts on growth of the state economy over time.

- **Benefit-Cost Module (BC).** The fourth module of TREDIS calculates the net present value of project benefits and costs from the differing perspectives of federal, state and local agencies.

Exhibit B-1 TREDIS Components



The TREDIS modeling framework is designed as a seamless tool to analyze the economic impact of transportation projects "from scratch." However, it can also be "broken apart" so that each of the four modules may be used individually, in any combination with one another, or in conjunction with a user's in-house substitute. For example, a user may already have estimated the direct effects of a transportation policy, and is only interested in the market access effects and secondary impacts. In this case, the Travel Cost Response and Benefit/Cost Accounting modules may be circumvented.

B.2 Capabilities for VDOT

The TREDIS analysis framework, as implemented for Virginia, provides the capability to assess both: (1) return on transportation capital investment in Virginia (by mode or overall), and (2) economic impacts and benefits of individual projects, for project prioritization and selection (by mode or overall). It also provides the capability for VDOT staff to make the following additional applications and distinctions:

1. *Projects and Programs* – ability to evaluate the economic impacts of individual projects, groups of projects or entire programs, under alternative future scenarios;

2. *All Modes* - ability to assess economic impacts for highway, bus, rail, airport and marine port projects, as well as multi-modal modal projects and inter-modal terminals;

3. *Freight and Passenger Impacts* – ability to distinguish freight impacts from passenger impacts; so it can reflect differences in freight and passenger mix among airport, marine port, rail, road and bus-oriented projects and programs.

4. *Rural and Urban Impacts* – ability to assess market access, congestion, and connectivity impacts (by mode); so it can be used for rural, urban and corridor studies.

5. *Peak and Off-Peak Effects* – ability to account for seasonal or time-of-day differences in service levels and congestion; so it can give benefit to projects that address special commuting and tourism needs.

6. *Transportation Efficiency and User Benefits* – ability to distinguish travel efficiency and user savings effects, so that transportation benefits can be compared to broader economic impacts.

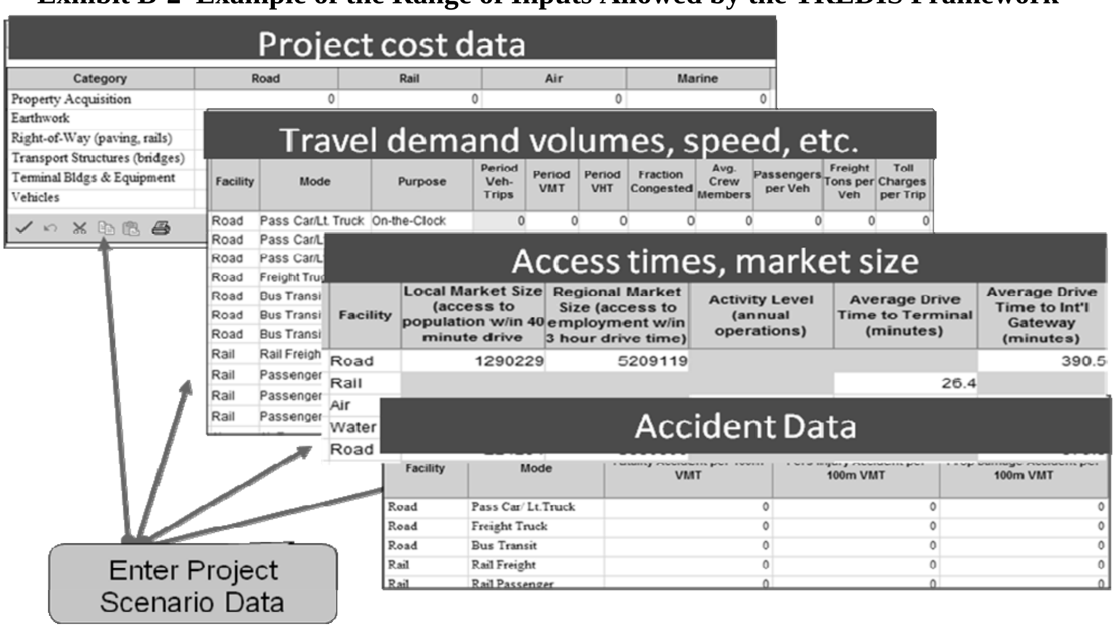
7. *Economic Impact Analysis* – - ability to distinguish economic development growth impacts related to access and productivity changes, and keep them separate from other societal impacts for use in economic and environmental impact statements.

8. *Benefit/Cost Analysis* – ability to provide benefit/cost analysis with alternative definitions of benefit and study area, so results can be tailored to decision-making needs

B.3 Input and Output Forms

Information on project costs, travel patterns, traffic conditions, market access and intermodal connectivity can be input through a series of input forms, or they can be input directly from spreadsheets or from travel demand models, The range of inputs is shown in Exhibit B-2.

Exhibit B-2 Example of the Range of Inputs Allowed by the TREDIS Framework



From those inputs, TREDIS then calculates changes in travel patterns, transportation costs, safety and environmental costs for every mode in Virginia. This is illustrated in the report form shown as Exhibit B-3.

Exhibit B-3 Example of a Report on Transportation System Changes

DIRECT IMPACT BY MODE (TARGET YEAR)
Period/Region Combination Inputs

Base Scenario: Base Scenario
Region: Unnamed Region / Period: Annual

Transportation Measure	Pass Car	Truck Freight	Bus Transit	Rail Freight	Rail Transit	Air Trans	Water Trans
Gross VMT	0	0	0	0	0	0	0
Gross VHT	0	0	0	0	0	0	0
Gross VHT w/reliability adj	0	0	0	0	0	0	0
Passenger Trips	0	0	0	0	0	0	0
Passenger Miles	0	0	0	0	0	0	0
Freight Ton - Trips	0	0	0	0	0	0	0
Freight Ton - Miles	0	0	0	0	0	0	0
Fatalities	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Injuries	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Property Damage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Local Gross VMT	0	0	0	0	0	0	0
Local Gross VHT w/reliability adj.	0	0	0	0	0	0	0
Total Value of Travel Costs:							
Passenger Cost - Total	$0	$0	$0	$0	$0	$0	$0
Crew Cost - Total	$0	$0	$0	$0	$0	$0	$0
Freight Cost - Total	$0	$0	$0	$0	$0	$0	$0
Veh Oper Cost - Total	$0	$0	$0	$0	$0	$0	$0
Toll Cost - Net Total	$0	$0	$0	$0	$0	$0	$0
Safety Cost - Total	$0	$0	$0	$0	$0	$0	$0
Environmental Cost - Total	$0	$0	$0	$0	$0	$0	$0
Sum of Total Travel Costs	$0	$0	$0	$0	$0	$0	$0

From those changes in transportation patterns and costs, the system then adjusts for intermodal interchange, mode shifting, and in-state vs. pass-through travel, and allocates impacts among industries. Using a statewide economic model, impacts are shown for both the short- and long-term in terms of employment, earnings, output and GDP by industry within Virginia. They are shown in a report form (Exhibit B-4) in terms of year-by-year forecast streams, which form the basis for both impact projection and discounted net present value calculations. Another table (not shown) shows the details of impacts by industry, for any given year.

Exhibit B-4. Example of a Report on Basic Economic Impact Measures Over Time

Summary of Overall Economic Impact - By Year
Region Name: Yamhill
Base Scenario: BASE
Project Scenario: ALT

Year	Business Output ($ mil.)	Value Added ($ mil.)	Jobs	Wage Income ($ mil.)
2007	5.535	2.715	55	2.109
2008	5.535	2.715	55	2.109
2009	5.535	2.715	55	2.109
2010	5.535	2.715	55	2.109
2011	129.640	66.697	1439	45.549
2012	187.574	96.503	2083	65.904
2013	235.037	120.922	2610	82.580
2014	277.666	142.854	3083	97.558
2015	317.611	163.405	3526	111.593
2016	354.794	182.535	3939	124.657
2017	390.173	200.737	4332	137.087
2018	425.073	218.693	4719	149.349
2019	459.767	236.542	5105	161.539
2020	494.459	254.390	5490	173.728
2021	505.881	260.267	5617	177.741
2022	517.567	266.279	5746	181.847
2023	529.522	272.430	5879	186.048

The results are then portrayed in terms of a wide range of alternative perspectives, showing statewide benefits in terms of traveler benefit, full user benefit, total societal benefit and impact on the statewide economy. This is illustrated in Exhibit B-5.

Exhibit B-5. 6 Example of Benefit-Cost Results Using Alternative Benefit Definitions

BENEFIT/COST ANALYSIS - NATIONAL PERSPECTIVE

(I) Present Value of Study Area's Benefit Stream ($m 2006 Const dollars)

Mode	(A) Traveler Benefits					(B) Shipper Logistics Cost	(C) Other Benefits		(D) Regional Val. Added Growth
	Vehicle Costs	Time Costs	Non - $ Value of Time	Safety Cost	Induced Adjustment		Social/ Environ.	Business Productivity	
Pass Car/Lt.Truck	-11.2	1373.4	1306.7	-5.3	479.6	0.0	-1.1	0.0	-
Truck Freight	-6.8	953.7	0.0	-0.3	486.7	1160.8	-1.7	0.0	-
Bus Transit	0.0	139.2	139.0	0.0	0.0	0.0	0.0	0.0	-
Rail Freight	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
Rail Transit	0.0	173.7	147.3	0.0	0.0	0.0	0.0	0.0	-
Air Transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
WaterTransport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
Total for all modes	**-18.0**	**2640.0**	**1593.0**	**-5.6**	**966.3**	**1160.8**	**-2.8**	**0.0**	**1723.5**

(II) Net Present Values and Benefit/Cost Ratios from Study Area's Perspective

Category	Definition	Present Value of Benefits	Present Value of Costs	Net Present Value (Benefits - Costs)	Benefit/Cost Ratio
Traveler Benefit	A	5176	802	4374	6.45
Full User Benefit	A+B	6337	802	5534	7.90
Total Societal Benefit	A+B+C	6334	802	5532	7.90
Economic Development Impact	D	1724	802	921	2.15