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Executive Summary

This report describes the potential to divert truck-hauled freight from I-81 to rail. To estimate these diversion potentials, the Intermodal Transportation and Inventory Cost Model (ITIC) was used. This model was developed by the Federal Highway Administration's (FHWA) Office of Policy Studies and the Federal Railroad Administration (FRA). The model is continually refined by a steering group of rail and truck experts under the FHWA. Most of the data required for the model (except for rail variable costs, highway and rail distances between origins and destinations, and drayage distances) are readily attainable. The ITIC model was used by the United States Department of Transportation and others to estimate diversions for various truck size and weight, rail and intermodal scenarios. In this study, the model was run using commodity flows from the Transearch™ database, and rail cost data from the Surface Transportation Board (STB). Assumptions used in the models come from extensive consultation with the FHWA, STB, the Virginia Department of Rail and Public Transportation (DRPT), Norfolk Southern Railroad and others.

ES-1 I-81 Freight Forecast (2035)

Forecasts of 2035 truck movements in the I-81 study area were developed within the Truck Trip Analyzer (TTA) model by applying a variety of economic growth rates to existing traffic counts. The premise of the methodology is the existence of a link between economic output and freight movements. The TTA model follows protocol established by several other freight models, including FHWA's Freight Analysis Framework (FAF) tool, to forecast commodity flows by using economic output projections as indicators of future changes in freight shipments. The rationale is that increases in industrial output create increases in freight demand because producers need to move their goods to the consumers. Increases in freight demand translate into increases in freight movements as haulers respond to market pressures.

Table ES-1 provides travel forecasts at the VDOT permanent count station locations located along I-81 for the 2035 horizon. Traffic volumes are provided for combination trucks or heavy trucks. The growth of total trucks at individual count stations varies from 135 to 152 percent by 2035. These translate to directional compounded average annual growth rates of

approximately 2.8 percent per year through 2035. These growth rates are within the range of growth anticipated by other analyses, including the compounded average annual growth rate for I-81 truck traffic of 2.96 percent predicted for the 1998 to 2020 period by the Freight Analysis Framework model and a compounded average annual growth rate for I-81 freight flows of 2.45 percent predicted for the 2005 to 2020 period by the Virginia Statewide Model.

Table ES-1 Summary of I-81 Truck Volume and Growth Forecast

VDOT I-81 Count Station Identifiers I-81 Segment (South to North)	Existing Average Annual Daily Heavy Truck Volume	2035 Average Annual Daily Heavy Truck Volume	Average Annual Growth Rate
Route 140 to South City Line of Abingdon	9,180	22,310	2.8 %
Route 11 to North City Line of Wytheville	13,450	33,970	2.9 %
Route 177 to Route 8 (near Radford)	11,240	27,120	2.8 %
Route 581 to Route 115 (Roanoke)	11,990	30,210	2.9 %
Route 11 to Route 11-614 (Buchanan)	11,970	28,130	2.7 %
Route 606 to Augusta County Line	13,480	32,750	2.8 %
Route 11 to Route 659 (Harrisonburg)	12,870	30,330	2.7 %
Route 50 to South City Line of Winchester	11,850	28,220	2.7 %

ES-2 Diversion Potential and Rail Capacity

Future truck traffic on I-81, and the resultant infrastructure needs, will be determined in part by the portion of forecasted freight traffic that might divert to rail. This is important if the potential diversion levels are substantial enough to affect the lane requirements of the roadway in 2035. Three studies funded by DRPT (*SJR-55 The Potential for Shifting Virginia's Highways to Railroads; HJR-704 The Virginia Intermodal Feasibility Study;* and *The Northeast-Southeast-Midwest Corridor Marketing Study*) have found potential for rail diversion, and have increased interest in this issue.

For the *I-81 Corridor Improvement Study*, it was assumed that diversions to rail may occur due to two primary factors: 1) the deterioration in truck service due to increased congestion on I-81; and 2) the availability of improved rail service speeds, reliability and cost reductions that result from four initial improvement concepts and improved intermodal service. The rail improvements considered in this study examined rail improvements only within the borders of Virginia. It was also assumed that the railroads would make the necessary improvements in the future to maintain capacity for expansion of their existing rail service both within and outside the borders of Virginia.

Previous DRPT studies examined the potential for rail diversion in the medium and long-term (2020) for both corridor-wide and Virginia only investments. Given the current study parameters to evaluate in-state rail improvements, the assumptions made by these previous

studies regarding public capital spending outside the state, and the regional multi-state results were not considered applicable. The DRPT Virginia-based investment scenario is consistent with this study's assumptions as it limits public spending to Virginia, while assuming railroads will make additional capital improvements outside the state. The DRPT report states that this scenario represents a case where:

> "The Commonwealth takes independent action to invest in rail inside its borders, while its railroad partners act both outside and within the state."[1]

As a result, the Virginia-based investment scenario and levels of diversion are relevant to the *I-81 Corridor Improvement Study*, and the results of the DRPT analysis for the high case are summarized in Table ES-2.

Table ES-2 DRPT Estimates of the Diversion Impact of Virginia Based Investments (High Case)[2]

Period	Annual Loads Diverted	AADTT One-Way Loads Diverted (1)	Percent of VA I-81 Forecast AADTT Diverted
Medium Term	501,000	686	10.4
Long Term (2020)	501,000	686	5.2

(1) AADTT – Average Annual Daily Truck Traffic

In the medium-term, the DRPT study estimates that 501,000 loads will be diverted, which represents an average of about 700 trucks per day in each direction. This level of diversions would be unlikely to impact the lane requirements on I-81. Moreover, there are no additional long-term diversions produced by the Virginia-based program. The DRPT report states that:

> "The reason for this is that all the capital is expended for medium-term improvements, and the Norfolk Southern system thereafter has reached capacity. More traffic cannot be absorbed without improvements in other states. Consequently, while freight traffic on the highway will continue to grow along with the economy, rail traffic cannot grow, and by the long term the effect of rail diversions will have diminished as a percent of I-81 truck volume."[3]

The DRPT analysis assumes that the rail capacity required to service the diverted trips would remain fixed regardless of market forces. The assumption used in the analysis was that part of the agreement to secure public funds for capital investment would be a commitment by Norfolk Southern and that the new intermodal service would be maintained regardless of the

1 *The Northeast-Southeast-Midwest Corridor Marketing Study*, Reebie Assoc., Virginia Department of Rail and Public Transportation, December 2003, 34.
2 Ibid, 16.
3 Ibid, 47.

growth in captive or base load traffic. To maintain this agreement, especially until 2035, Norfolk Southern would have to invest in additional capital improvements or limit increases in the types of captive traffic that provide higher rates of return than the intermodal service.

Based on the findings of the previous studies and using information obtained from Norfolk Southern, DRPT, and Reebie Associates, this report concludes that there may not be sufficient rail capacity on the Norflok Southern Piedmont rail line to service future base load rail traffic. While the scope of this study is primarily based on the future needs of I-81, some assumption of rail capacity was necessary to determine whether and at what point freight diversion to rail would not be possible. It is a distinct possibility that future diversions of truck freight on I-81 to rail mode could be restricted unless additional public investments are made to the rail infrastructure both inside and outside the Commonwealth of Virginia.

While rail improvements outside of Virginia are beyond the scope of this study, such improvements, if made, could accrue additional benefits beyond those identified in this analysis by further removing chokepoints and improving rail speeds and service reliability.

ES-3 Rail Concepts Analysis

The *I-81 Corridor Improvement Study* considered four "Build" rail improvement concepts listed in Table ES-3 and described below. It is assumed that the railroad would continue to make their normal capital improvements inside and outside Virginia.

Table ES-3 Initial "Build" Rail Improvement Concepts ($, Millions)

Rail Concept #	Rail Infrastructure (source)	Rail Rolling Stock (source)	Total
#1 Star Solutions	$111 (Source: Star Solutions proposal, page E-1, dated Sept. 5, 2003)	$0 (Same source - did not include rolling stock costs)	$111
#2 Piedmont Line	$267 (Source: Reebie report, Appendix 7 Attachment E table showing $39.1 Column A + $227.5 Column B = $267)	$229 (same source)	$496
#3 NSRR Pilot Intermodal	$280 (Source: NSRR spreadsheet titled "Pilot Project Capital Improvements 8-20-04" from Steve Eisenach, NS.)	$229 (same source – assumed as this is building on concept #2)	$509
#4 Steel Interstate	$3,200 (Source: Rail Solution, public data and by phone with D. Foster.)	$300 (same source)	$3,500 ($3.5 billion)

Initial Rail Improvement Concepts

During the initial concept development process for the *I-81 Corridor Improvement Study*, the No-Build and four rail improvement concepts were modeled using the ITIC model. In each concept, certain assumptions about truck and rail modes were modified.

No-Build Concept

In the No-Build scenario, average speeds for truck were reduced by seven miles per hour and the estimate of truck level of service deterioration was developed. Transit time reliability for truck was reduced by five percent while transit time reliability for rail service was unchanged. Load/unload times were also unchanged from the calibration estimate. These estimates are based on the I-81 average speed reduction associated with the 2035 No-Buid traffic volumes presented in the *Transportation Technical Report*.

Rail Concept 1— Star Solutions' Proposal

Rail Concept 1 modeled the phase one level of rail improvements from Manassas to Front Royal, VA, as recommended in the *Star Solutions Phase Three Detailed Proposal – Improvements to I-81 Corridor* which calls for infrastructure investments of $111 million dollars (but no rolling stock costs). Based on discussions with Norfolk Southern Railroad, it was estimated that the infrastructure improvements would provide 10 percent improvements to rail speeds, two percent improvements to transit time reliability, and no improvements to load/unload times at intermodal terminals. In this scenario, shippers were not charged a unit cost to recover a portion of the investment in rail.

Rail Concept 2 — Piedmont Line Improvements

The Rail Concept 2 expands upon the improvements described in Concept 1, and modeled rail improvements as recommended in the Virginia Department of Rail and Public Transportation's *Northeast-Southeast-Midwest Corridor Marketing Study*[4]. The concept includes capital improvements to the NS Piedmont Line from Danville to Manassas, Virginia, and extensive improvements west to Front Royal and then to the West Virginia line. One key feature is that it employs the Canadian Pacific (CP) Expressway technology which is an improvement to existing trailer-on-flatcar (TOFC) intermodal service. For this study it was estimated (based on extensive coordination with NSRR) that the infrastructure improvements would provide 25 percent improvements to rail speeds, five percent improvements to transit time reliability, and an improvement of 75 percent to load/unload times at intermodal terminals. For this concept, shippers would be charged a unit cost of 14 cents over 20 years to recover the rolling stock investment in rail.

Rail Concept 3 — Norfolk Southern RR Pilot Intermodal Program

Rail Concept 3 is a modified version of Rail Concept 2, and is the concept most favored by NSRR. It includes additional costs for infrastructure improvements (and uses the same rolling stock costs from Rail Concept 2). Again based on discussions with Norfolk Southern

4 Ibid, Appendix 7, Attachment E

Railroad, it is estimated that the infrastructure improvements for this concept would provide the maximum improvement in rail speeds to 33 miles per hours (estimate provided by Norfolk Southern Railroad), 7.5 percent improvements to transit time reliability, and an improvement of 75 percent load/unload times at intermodal terminals. It was concluded that shippers would also be charged a unit cost of 14 cents over 20 years to recover the rolling stock investment in rail.

Rail Concept 4 — Steel Interstate

Rail Solution is a rail advocacy group that proposes a major upgrade of the NS rail line in the Shenandoah Valley that would closely parallel the I-81 corridor. Where the previous concepts focused on the NS Piedmont line, Rail Concept 4 proposes to turn the NS Shenandoah Line into the "steel interstate" which they describe as "a modern, dual-track, high speed rail line, grade separated from all road crossings, capable of carrying intermodal and passenger trains at average speeds of 60-80 mph along Norfolk Southern's line between Harrisburg, PA, and Knoxville TN, and possibly beyond to Memphis and New Orleans".

Improvements under this concept were estimated to be the most expensive, and would allow 40 mph rail speeds, 10 percent improvement to transit time reliability, and an improvement of 75 percent load/unload times at several new intermodal terminals. Shippers would be charged a unit cost of 12 cents over 20 years to recover the capital investment. As with the previous concepts, these assumptions are assumed based on the type of investment required for an undertaking of this magnitude and discussions with Norfolk Southern Railroad.

ES-4 Freight to Rail Diversion Analysis Results

The results of the analysis are provided in Table ES-4 using the Uniform Rail Costing System (URCS) Plan 1.0 estimates for rail line haul variable costs. Variable costs are defined by the Federal Highway Administration's Office of Policy as costs incurred before a "contribution to their capital infrastructure and profit." The model was calibrated after rail line haul costs were raised by 35 percent above the variable cost. It was estimated that a low of 147,100 truck trips would be diverted for both directions with Rail Concept 1, to a high of 1,224,500 truck trips with Rail Concept 4 diverted annually in 2035.

Table ES-4 Mode Diversion Analysis Results Using URCS Plan 1.0 Estimates of Norfolk Southern Rail Variable Cost/Intermodal Transportation Costs

	No Build	Rail Concept 1 Star Solutions	Rail Concept 2 Piedmont Line	Rail Concept 3 NSRR Pilot Intermodal	Rail Concept 4 Steel Interstate
Truck Assumptions					
Speed (mph)	43	43	43	43	43
Transit Time Reliability[1]	0.42	0.42	0.42	0.42	0.42
Toll	$0.00	$0.00	$0.00	$0.00	$0.00
Rail Assumptions					
Speed (mph)	22.5	24.8	28.1	33.0	40.0
Transit Time Reliability[1]	0.45	0.44	0.43	0.42	0.38
Investment Recovery[2] (per hundredweight)	$0.00	$0.00	$0.14	$0.14	$0.02
Load/Unload Time (hours)	0.57	0.57	0.15	0.15	0.15
Truck Trailer Equipment Lease Rate	$20/day	$20/day	$20/day	$20/day	$20/day
Drayage Charge (base)	$340.00	$340.00	$340.00	$340.00	$340.00
Drayage Distance (miles)	80	80	80	80	80
Drayage Charge/Mile	$2.00	$2.00	$2.00	$2.00	$2.00
Infrastructure Investment (Mil)	$0.0	$111.0	$267.0	$280.0	$3,200.0
Rolling Stock Investment (Mil)	$0.0	$0.0	$229.0	$229.0	$300.00
URCS Estimate Method	Plan 1.0+35%	Plan 1.0+35%	Plan 1.0+15%	Plan 1.0+15%	Plan 1.0+15%
2035 >500 Mile Total Truck Trips (000)	7,363.8	7,363.8	7,363.8	7,363.8	7,363.80
2035 Diverted Truck Trips (000)	107.2	147.1	606.4	744.8	1,224.5
Percent Diversion of >500-Mile Trips	1.5%	2.0%	8.2%	10.1%	16.60%
2035 Total Truck Trips (000)[3]	21,031.2	21,031.2	21,031.2	21,031.2	21,031.2
2035 Diverted Truck Trips (000)	107.2	147.1	606.4	744.8	1,224.5
Percent Diversion of All Trips	0.5%	0.7%	2.9%	3.5%	5.8%

1 Reliability is a factor equal to standard deviation of transit time divided by mean transit time. A lower value improves reliability.
2 Investment recovery is a fee expressed in dollars per hundredweight.
3 Represents an estimate based on the 2035 No-Build Truck Trip Estimates.

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1 Introduction

The Federal Highway Administration (FHWA) and the Virginia Department of Transportation (VDOT) have prepared a Tier 1 Draft Environmental Impact Statement (EIS) for the *I-81 Corridor Improvement Study* in Virginia. The Tier 1 Draft EIS, prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), evaluates the potential effects associated with conceptual-level improvements along the entire 325-mile Interstate 81 corridor in Virginia.

An Appendix to the Tier 1 Draft EIS, this *Freight Forecast and Diversion Technical Report* provides detailed information on the freight analysis conducted for the *I-81 Corridor Improvement Study*. The primary tasks for the freight forecast and diversion analysis were to:

1. Develop a more complete understanding and profile of freight movements in the I-81corridor;
2. Review and analyze the anticipated growth in freight movements in the study corridor including forecasting the freight travel demand for the year 2035;
3. Examine the potential freight diversion that might occur given I-81 or rail improvements in Virginia, and
4. Examine the potential freight diversion that might occur as a result of tolls on I-81.

This report outlines the methodologies used to complete these tasks and the results of the various analyses.

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2

Economic Background and Context[5]

This chapter describes the history and context of goods movement in the I-81 study area. Interstate 81 is an important link serving the eastern United States. Native Americans and settlers utilized the corridor as a migratory and trade route. It continues to serve a vital function today as the less-congested "back route" to the population centers and industrial centers of the Northeast. Virginia's I-81 corridor has attracted and retained an industrial base that is disproportionately large for an area that is mostly rural. I-81 communities in West Virginia, Maryland, and Pennsylvania have also attracted new factories and distribution centers. Economic development officials in the Shenandoah Valley and these states confer regularly to identify and discuss trends.

2.1 Location of I-81

Interstate 81 is a major north-south freeway in the eastern United States. I-81 generally links the Northeast with the non-Atlantic South. It extends more than 800 miles from its northern terminus at the Canadian border in upstate New York to its southern endpoint near Dandridge, Tennessee (about 25 miles east of Knoxville). I-81 does not enter major metropolitan areas; it instead serves smaller cities such as Roanoke, Virginia; Hagerstown, Maryland; Harrisburg and Scranton, Pennsylvania; and Binghamton and Syracuse, New York. It is the freight-service "back road" to the Northeastern megalopolis, unburdened by the metro area traffic that often slows truck movements on I-95.

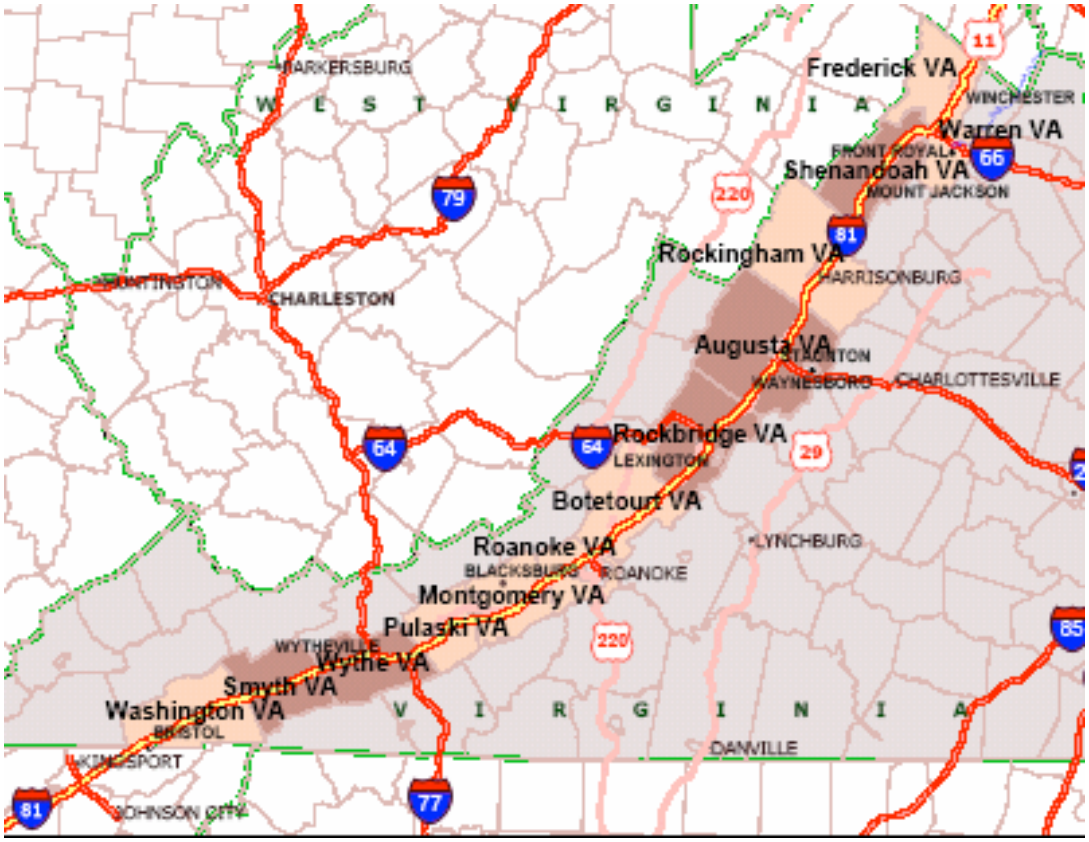
This study focuses on the I-81 corridor in Virginia. Interstate 81 enters Virginia near Bristol at the Kingsport-Johnson City area of northeastern Tennessee and travels northeast, parallel to the Blue Ridge mountains, and exits Virginia's Shenandoah Valley north of Winchester. The map provided in Figure 2-1 shows the location of I-81 in Virginia.

5 Adapted from *Economic Development History of Selected Interstates*, Jack Faucett Associates, 2004.

2.2 I-81 Study Area History

The I-81 study area has been an important transportation route for centuries. Native Americans used a trail known as the Indian Warriors Path or Shenandoah Hunting Path.[6] It evolved into the Great (Philadelphia) Wagon Road by the mid-1700s and facilitated settlement of North Carolina, Kentucky, and Tennessee. The Great Wagon Road split into two branches near Big Lick (now Roanoke). One branch left the valley and went due south; the other continued west towards the Cumberland Gap and became known as the Wilderness Road, the main pioneer route across the southern Appalachian Mountains. In the mid-1800s, the main highways included the Valley Turnpike, a toll road between Winchester and Staunton, and the Southwestern Turnpike between Botetourt County and the Tennessee state line via Wytheville, Marion, and Abingdon. The Valley and Southwestern turnpikes were among the first Virginia roads to be surfaced with pavement.

Figure 2-1 I-81 Study Area in Virginia



6 See Virginia Department of Transportation, *A History of Roads in* Virginia, 2002.

In 1918, the Valley Turnpike was included in Virginia's first state highway system. As late as 1926, it was the Commonwealth's only hard-surfaced road of considerable distance; U.S. 1, then the main route between Washington, D.C. and North Carolina via Richmond, was not fully paved until 1927.[7] U.S. 11 was designated through the length of the Great Valley in this era. I-81 was constructed parallel to U.S. 11 from the late 1950s to mid 1980s. Although most of the long-distance traffic in the study area has moved to the interstate, U.S. 11 still serves as the "Main Street" for dozens of corridor communities.

2.3 Interstate System Connectivity

I-81 provides many important interstate connections through Virginia. At the southern end of the corridor, I-81 provides access to Bristol via I-381. Just to the north, I-81 and I-77 share an eight-mile section of six-lane freeway in Wythe County. The northern section of I-77 passes through Charleston, West Virginia en route to Cleveland. The southern section of I-77 heads toward Charlotte, North Carolina and Columbia, South Carolina.

In the Roanoke area, I-581 connects with I-81, providing access to downtown Roanoke. I-581 continues U.S. 220, a four-lane divided highway that is a major truck route between North Carolina and I-81. East of Roanoke, U.S. 460 serves as a major east-west route across Virginia, linking Lynchburg, Petersburg, and the Norfolk area.

Interstate 64 overlaps with I-81 for 30 miles between Lexington and Staunton. The western section of I-64 begins near Lexington and ends in St. Louis, Missouri. The I-64 section east of I-81 connects Staunton with Charlottesville, Richmond, and the Norfolk area.

Near the northern end of Virginia's I-81 corridor, I-66 heads eastward to the Washington, D.C. area. To the west of I-66, Corridor H of the Appalachian Regional Development Highway System is under construction in West Virginia. When the project is complete, a four-lane divided highway will exist between Elkins and Wardensville, West Virginia, near the Virginia-West Virginia state line. It will be signed as U.S. 48. Virginia has no plans to continue the four-lane roadway to I-81 but has added U.S. 48 signs to the two-lane Virginia 55.

Finally, at the northern end of the corridor, Winchester sits at the crossroads of several highways: I-81, east-west U.S. 50 and Virginia 7, and north-south U.S. 17 and U.S. 522. I-81 enters West Virginia a few miles north of Winchester.

7 *Ibid.*

2.4 Rail Service

The I-81 corridor has a long history as a railroad route.[8] In the 1850s, the Virginia & Tennessee Railroad was constructed between Bristol and Salem, where it headed eastward instead of continuing up the Great Valley. Partially due to fears that Great Valley commerce would be channeled to Baltimore or Alexandria instead of to Richmond or Norfolk, rails were not laid in the Shenandoah Valley south of Winchester until after the Civil War. The Shenandoah Valley Railroad was built between Hagerstown, Maryland and Big Lick (now Roanoke) in the 1870s and 1880s. Roanoke grew into one of Virginia's major cities while it was a hub of the Norfolk & Western Railway (now the Norfolk Southern Railroad).

Major railroad lines pass through the I-81 corridor, but the ones with the greatest traffic are east-west rather than north-south. The Norfolk Southern Shenandoah Valley route parallels I-81 throughout the state. Many of the east-west lines connect the coalfields of West Virginia with export terminals in the Norfolk/Hampton Roads area. A second line, the Norfolk Southern Piedmont Line, runs parallel to I-81 to the east of the Appalachian Mountain Range, connecting to I-81 in Front Royal. This line connects Atlanta, Georgia with Harrisburg, Pennsylvania. Cross-connections between the Norfolk Southern lines are provided in two locations within Virginia—between Roanoke and Lynchburg in the south, and between Front Royal and Manassas in the north.

2.5 Businesses and Industries Along the I-81 Study Area

I-81 traverses portions of thirteen counties in Virginia and numerous cities and town including Bristol, Roanoke, Harrisonburg, and Winchester. According to the latest U.S. Office of Management and Budget designations, these counties and cities are in six metropolitan statistical areas (MetSAs) and one micropolitan area.[9] The metropolitan statistical areas are shaded in Figure 2-1. A description of businesses and industries in communities along the I-81 study area is provided below.

2.5.1 Bristol Area

The City of Bristol and Washington County are at the southern end of Virginia's section of I-81. Bristol (population 17,367) straddles the Tennessee-Virginia state line. Dairy is the

8 *The I-81 Transportation Technical Report* includes a detailed narrative of rail service in the corridor.

9 The U.S. Office of Management and Budget defines metropolitan and micropolitan statistical areas based on Census Bureau data. Each metropolitan statistical area (MetSA) must have at least one urbanized area of 50,000 or more inhabitants. Each micropolitan statistical area (MicSA) must have at least one urban cluster of at least 10,000 but less than 50,000 population. The county (or counties) in which at least 50 percent of the population resides within urban areas of 10,000 or more population, or that contain at least 5,000 people residing within a single urban area of 10,000 or more population, is identified as a "central county" (counties). Additional "outlying counties" are included in the MetSA or MicSA if they meet specified requirements of commuting to or from the central counties.

highest-grossing agricultural industry, but tobacco is also important; the county ranked 76th in the nation in 2002 for value of tobacco sold. Washington County is also a major egg producer. Washington County and Bristol together produced $651 million in Value Added by Manufacture (VAM) in 1997; local factories produce compressors, plastic products, and snack foods, among other items.

2.5.2 Smyth and Wythe Counties

Manufacturers in Smyth and Wythe counties produce plastics, refrigerated trailers, motor vehicle parts, aircraft parts, bricks, and wooden furniture. Saltville in Smyth County was once a significant town in the plaster and chemical industries. Situated at a crossroads of major highways, Wythe County has long been a stopping point for travelers between Florida and the Midwest via I-77 (formerly U.S. 52) and U.S. 21, and between the Northeast and the Southeast via I-81 (formerly U.S. 11). The 1997 Census of Retail Trade found that retail sales at Wythe County gasoline stations totaled $144.4 million; only Fairfax, Henrico, Chesterfield, and Prince William Counties and Virginia Beach, all metropolitan jurisdictions, registered higher figures in Virginia. Per capita gasoline sales were $5321 in Wythe County versus $828 in Virginia. The 1997 Census of Accommodation and Foodservices concluded that the Wythe County accommodation industry generated $16.2 million in annual sales, the highest amongst Virginia's non-metropolitan jurisdictions with the exception of Rockingham County, which has since been classified as part of the Harrisonburg MetSA. In 1997, the accommodation industry (NAICS Code 721) generated per capita revenue of $597 in Wythe County compared to $311 statewide.

The Wythe County Progress Park occupies nearly two square miles at the junction of I-81 and I-77N. Along with its crossroads location, it markets a proposed inland port intermodal facility with a direct rail link to the Hampton Roads ports.

2.5.3 New River Valley Area

Pulaski and Montgomery Counties and the City of Radford (population 15,859) are in the New River Valley. Virginia Polytechnic Institute (Virginia Tech) and State University, a major research center, is the largest employer and a catalyst for new businesses. Enrollment has grown substantially since I-81 was completed, from 10,000 in 1967-68 to over 25,000 in 2002. Radford University is the valley's other major school. Factories in the New River Valley region produce automobile parts, furniture, and explosives. Heavy-duty trucks have been assembled at the 293-acre Volvo Trucks North America-New River Valley Assembly Plant in Pulaski County since 1974; a Mack Truck assembly line was added in 2003, transferred from Winnsboro, South Carolina. Shawsville, a town on U.S. 11/U.S. 460 in Montgomery County, is an example of a small community that lost has some business since I-81 opened fully in 1971.

2.5.4 Roanoke Area

Roanoke (population 94,911) is the largest city in the I-81 study area and the most populous metropolitan area between Greensboro, North Carolina, and Charleston, West Virginia.

Roanoke is almost equidistant between New York City and Atlanta, and is a retail, media, and employment center for western Virginia. Roanoke developed into a major city while it was a hub of the Norfolk & Western Railway (Norfolk Southern), which remains a major employer.

The Roanoke area includes Botetourt County, Roanoke County, and the independent Cities of Roanoke and Salem. These jurisdictions produced $2.17 billion in Value Added Manufacturing (VAM) in 1997. Roanoke produces steel and cosmetics and has a large auto parts distribution center. It has lost jobs in the textile manufacturing and finance/insurance/real estate industries. A printing plant, metal fabricator, and hardware manufacturer operate in Roanoke County. Factories in Salem (population 24,747) make tires, industrial controls, and meat products. Automobile parts, bricks, and cement are produced in Botetourt County.

The Roanoke area has disproportionately high retail sales for its population. I-81 allows shoppers from a hundred-mile radius to patronize local malls and other retail outlets in Roanoke. As a result, Roanoke city's per capita retail sales is twice the statewide figure (1997 per capita data: $19,000 in Roanoke city versus $9,200 statewide).

2.5.5 Rockbridge County/Buena Vista and Lexington

Value added by manufacture for Rockbridge County was the smallest of the thirteen I-81 counties in Virginia in 1997. The largest manufacturing employer is Burlington Industries-Lee Carpets Division, which makes nylon carpeting in Glasgow. Buena Vista (population 6,349) is to the east of I-81; Lexington (population 6,867) is to the west. VAM data are unavailable for both communities. Washington & Lee University and Virginia Military Institute are the largest higher education institutions in this area.

2.5.6 Augusta County/Staunton and Waynesboro

Although Augusta County, Staunton, and Waynesboro constitute a non-metropolitan area, they collectively produced more than $1.1 billion in value added by manufacture in 1997. Augusta County produces snack cakes, shaving blades, disposable hospital supplies, vinyl siding, and copper fittings. One of the nine Hershey's Foods plants in the mainland U.S. is located in Stuarts Draft; it makes mostly peanut-based products. Staunton is located on I-81; it has no major factories. Best Buy opened a 701,000 sf distribution center there in 1994. In 1997, Target Stores opened an $80 million, 1.6 million sf warehouse in Stuarts Draft. Waynesboro is located on I-64 about seven miles east of I-81; its factories produce organic fibers and plastics material and resins.

The Shenandoah Valley is widest in Augusta County, consequently it ranked second among Virginia counties in 2002 for total value of agricultural products sold. It ranked sixth in the U.S. for number of turkeys (in 1997 it accounted for 2.1 percent of national turkey production) and first

in Virginia for cattle and calves; dairy is an important industry. Tourism is important in this area and there are many attractions for visitors. Staunton was the hometown of President Woodrow Wilson. Waynesboro is a gateway to Skyline Drive and the Blue Ridge Parkway.

2.5.7 Rockingham County/Harrisonburg

Rockingham County has long been associated with poultry. In 2002, the county ranked second in the U.S. for number of turkeys and sixth for number of broilers and other meat-type chickens (it produced 4.5 percent of turkeys sold in the U.S. in 1997). Rockingham County's value of livestock, poultry, and their products ranked 17th in the nation in 2002. Rockingham also has a significant dairy industry; it ranked 44th in the country for milk and other dairy products from cows. Its orchards are also productive; in 1997 Rockingham ranked 70th in the country for apple production and 74th for peach production.

The 1997 Census of Manufactures found that the value added by manufacture in Rockingham County was $2.02 billion, the highest in the I-81 study area. The only Virginia jurisdictions with higher VAM's were the cities of Richmond and Norfolk. Major factories include a poultry processors, a pharmaceutical plant, two book printers, a motor vehicle parts manufacturer, a plastic bottle maker, a large furniture maker, and a producer of aluminum and plastic tubing. The Cargill Turkey Products (formerly Rocco) plant in Dayton is said to be the country's largest turkey-processing plant. In 2004, Pilgrim's Pride announced that it would close its Hinton processing plant. The Coors Brewing Company has packaged beer in Elkton since 1987; it is brewed elsewhere and shipped to Elkton for bottling. By 2007, the company will open a brewery there, its third in the U.S.

Marshalls operates an apparel distribution center in Bridgewater. Wal-Mart intends to open a distribution center in Mount Crawford (Exit 240) in the near future.[10]

Harrisonburg (population 40,468) is an independent city carved from territory inside of Rockingham County. Its largest employer is James Madison University, a public university. Its enrollment has nearly quadrupled since I-81 was completed in Virginia, from 4,000 in 1970 to 15,000 in the early 2000s.

2.5.8 Northern Shenandoah Valley

Shenandoah, Warren, and Frederick Counties and City of Winchester (population 23,585) are in the northern Shenandoah Valley. This region is fast becoming integrated with the Washington, D.C. area. Facilities in these jurisdictions produced $1.48 billion in VAM in 1997; more than half was in Winchester. Major factories include poultry and other food processors, motor vehicle part producers, a lamp plant, a plastic dumpster manufacturer, a commercial printer, a copper tubing maker, and furniture and cabinet makers. Most large facilities were

10 Jack Lyne, "Wal-Mart Picks NW Virginia for 1,000-Worker Mid-Atlantic Distribution Center," *Site Selection*, April 7, 2003

constructed after I-81 opened locally in the late 1960s. In the past decade, Kohl's and Home Depot have located distribution centers near Winchester to serve their stores in the Northeast U.S. market.

Agriculture is still a major industry. Shenandoah County ranked 57th in the country for turkey production in 2002. Frederick County ranked 12th in the nation for acreage in apples in 2002; in 1997 it ranked 46th in the U.S. for peach production and 81st in the nation for land in orchards.

Warren County is part of the Washington, D.C. MetSA (only 1.3 miles of I-81 are in Warren County). I-66 is an important link to the community. The Virginia Inland Port opened in Front Royal in 1989. Family Dollar built a retail merchandise distribution center in Front Royal in 1998; Sysco opened a food product distribution facility there in 2004. AmeriCold Logistics recently constructed a refrigerated warehouse in Strasburg, Shenandoah County.

Page County, east of Shenandoah County, received more out-of-state municipal solid waste (MSW) in Virginia in 2002 than any other county. Other Virginia counties that accept large quantities of interstate MSW are located outside of the Ridge & Valley region.[11]

2.6 Socioeconomic Trends in the I-81 Study Area

2.6.1 Population

Table 2-1 and Figure 2-2 show the population of the I-81 study area in selected years from 1969 to 2002. The highest population growth has generally been in the northern part of the corridor, in Frederick and Warren Counties and in the City of Winchester. Much of this is due to the westward expansion of the Washington, D.C. metropolitan area. These jurisdictions have grown faster than Virginia as a whole and the U.S. In contrast, the populations of the counties at the southern end of the corridor and the City of Roanoke have grown slower than the state and nation. The net effect is a corridor growth rate that exceeds the U.S. rate in most years, but is slightly below the Virginia rate.

The I-81 study area has not grown as rapidly as the rest of Virginia since I-81 was completed. Whereas one out of every seven Virginians lived in the corridor in 1971, the corridor accounted for just one-eighth of the Commonwealth's population in 2002. Nevertheless, most of the non-metropolitan counties in the I-81 study area have grown faster than the Virginia non-metropolitan average. Population growth in Shenandoah County has exceeded both the nationwide metro and non-metro rates, again, largely due to expansion of the western Washington, D.C. suburbs.

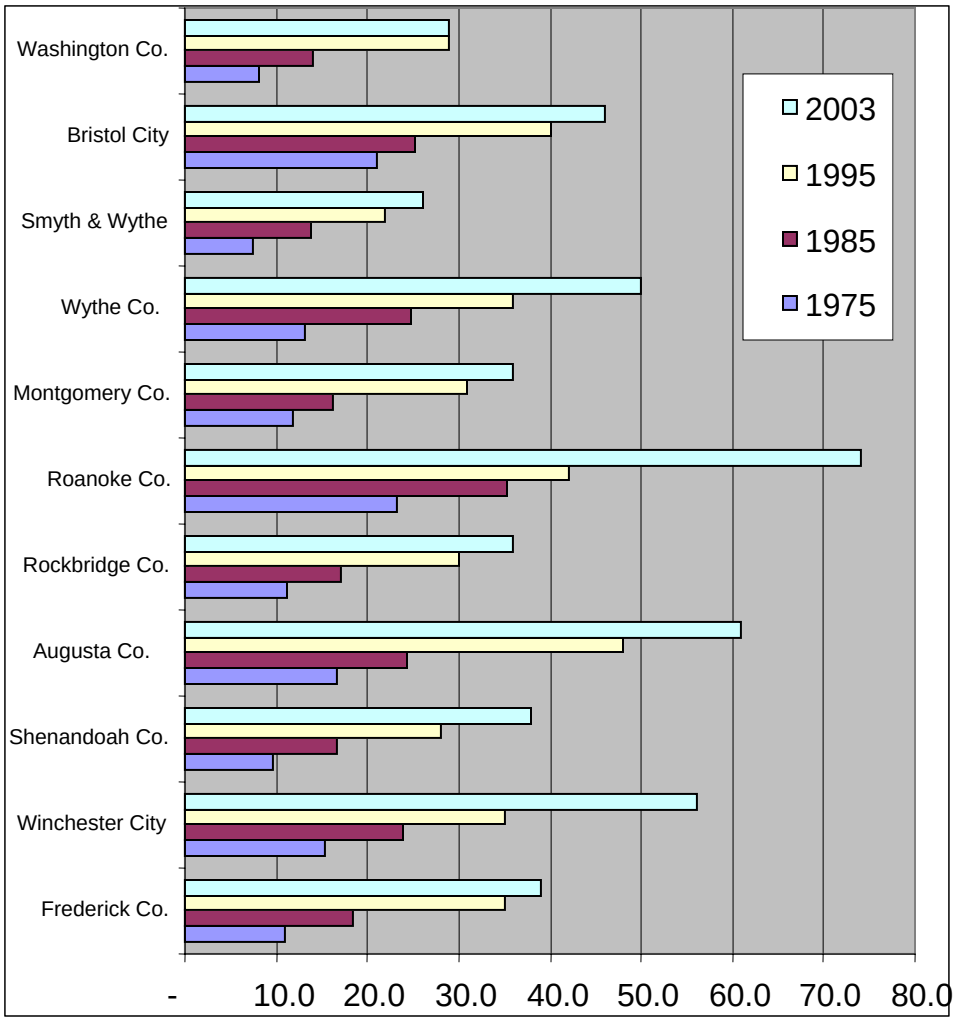
11 Wendy Pagonis, "Page County Is King Of Out-Of-State Trash," *Daily News-Record* (Harrisonburg, Virginia), October 25, 2003.

Table 2-1 I-81 Study Area Population: 1969 – 2002

Counties and Independent Cities	1969	1971	1981	2002	Compounded Average Annual Growth Rate 1969-71	1971-81	1981-02
Washington and Bristol	55,916	57,707	65,368	68,368	1.6%	1.3%	0.2%
Smyth*	31,509	32,323	33,423	32,825	1.3%	0.3%	-0.1%
Wythe*	22,306	22,931	25,596	27,795	1.4%	1.1%	0.4%
Pulaski	29,608	30,567	35,335	35,016	1.6%	1.5%	0.0%
Montgomery and Radford	57,716	60,597	78,771	100,508	2.5%	2.7%	1.2%
Roanoke County and Salem	87,352	93,205	97,430	111,024	3.3%	0.4%	0.6%
Roanoke City	93,000	93,666	100,991	93,441	0.4%	0.8%	-0.4%
Botetourt	18,205	18,547	23,428	31,126	0.9%	2.4%	1.4%
Rockbridge, Buena Vista and Lexington*	30,709	30,597	31,583	34,119	-0.2%	0.3%	0.4%
Augusta, Staunton and Waynesboro*	85,124	87,707	91,309	110,729	1.5%	0.4%	0.9%
Rockingham and Harrisonburg	62,017	65,099	78,483	110,117	2.5%	1.9%	1.6%
Shenandoah*	22,906	23,762	27,944	36,400	1.9%	1.6%	1.3%
Warren	15,304	16,249	21,442	33,072	3.0%	2.8%	2.1%
Frederick and Winchester	43,312	45,890	55,076	87,250	2.9%	1.8%	2.2%
VA I-81 Study area	654,984	678,847	766,179	911,790	1.8%	1.2%	0.8%
Virginia	4,614,000	4,752,846	5,444,094	7,287,829	1.5%	1.4%	1.4%
United States	201,298,000	206,817,509	229,465,744	287,973,924	1.4%	1.0%	1.1%
Non-Metro Virginia	903,353	921,173	1,003,852	1,078,028	1.0%	0.9%	0.3%
Non-Metro U.S.	38,926,788	39,776,189	44,303,823	49,182,854	1.1%	1.1%	0.5%

* Indicates counties and independent cities that are classified as non-metropolitan by the U.S. Office of Management and Budget in 2004.
Source: Bureau of Economic Analysis (U.S. Department of Commerce).

Figure 2-2 I-81 Study Area Population: 1969 – 2002



2.6.2 Employment

As seen in Table2-2, total full-time and part-time employment in the I-81 study area grew at rates similar to Virginia and the U.S. between 1969 and 1981. Employment plunged in many study area counties between 1969 and 1971, especially in manufacturing in the southern part of the study area (the Olin chemical plant, a major employer, closed in Smyth County around 1970). Since 1981, employment has grown at a faster pace in all non-metro study area counties than in non-metro Virginia as a whole. Over a quarter million jobs have been created in the study area since 1971.

Table 2-2 I-81 Study Area Full-time and Part-time Employment: 1969 – 2000

Counties and Independent Cities	1969	1971	1981	2000	Compounded Average Annual Growth 1969-71	1971-81	1981-2000
Washington and Bristol	23,913	24,550	31,574	42,968	1.3%	2.5%	1.6%
Smyth*	14,605	13,526	15,135	19,210	-3.8%	1.1%	1.3%
Wythe*	9,136	9,116	11,309	14,551	-0.1%	2.2%	1.3%
Pulaski	11,646	11,596	15,132	19,508	-0.2%	2.7%	1.3%
Montgomery and Radford	31,220	28,753	37,297	55,432	-4.0%	2.6%	2.1%
Roanoke County and Salem	33,702	34,985	44,810	74,107	1.9%	2.5%	2.7%
Roanoke City	62,934	64,804	73,947	88,227	1.5%	1.3%	0.9%
Botetourt	4,795	4,881	6,416	12,567	0.9%	2.8%	3.6%
Rockbridge, Buena Vista and Lexington*	12,924	12,265	13,236	18,570	-2.6%	0.8%	1.8%
Rockingham and Harrisonburg	30,328	32,660	40,729	69,744	3.8%	2.2%	2.9%
Augusta, Staunton and Waynesboro*	41,707	40,415	47,156	61,957	-1.6%	1.6%	1.4%
Shenandoah*	10,768	11,019	13,092	19,743	1.2%	1.7%	2.2%
Warren	7,010	7,346	8,797	13,860	2.4%	1.8%	2.4%
Frederick and Winchester	22,692	24,100	30,403	57,905	3.1%	2.4%	3.4%
VA I-81 Study area	317,380	320,016	389,033	568,349	0.4%	2.0%	2.0%
Virginia	2,147,852	2,196,371	2,820,157	4,407,324	1.1%	2.5%	2.4%
United States	91,057,200	91,586,400	115,304,000	166,758,800	0.3%	2.3%	2.0%
Non-Metro Virginia	377,357	379,397	442,598	529,347	0.3%	1.6%	0.9%
Non-Metro U.S.	15,994,931	16,170,795	19,502,994	25,495,489	0.5%	1.9%	1.4%

* Indicates counties and independent cities that are classified as non-metropolitan by the U.S. Office of Management and Budget in 2004.
Source: Bureau of Economic Analysis

2.6.3 I-81 Study Area Personal Income

Real per capita personal income in the I-81 study area is shown in Table 2-3. On average, per capita income expanded by 2.31 percent annually in the study area between 1971 and 1981, slightly less than the nationwide growth rate of 2.33 percent and much less than the statewide rate of 3.0 percent and non-metro statewide rate of 3.4 percent. From 1981 to 2002, per capita income increased more rapidly in the study area than nationwide, but slightly slower than in Virginia as a whole. During those years, per capita income increased at a greater average rate than non-metro Virginia and non-metro U.S. in all non-metro study area counties except Wythe. Some of this growth in personal income is likely due to the increased mobility of labor in the study area.

Table 2-3 I-81 Study Area Real Per Capital Personal Income: 1969 – 2002

Counties and Independent Cities	1969	1971	1981	2002	Compounded Average Annual Growth Rate 1969-71	1971-81	1981-02
Washington and Bristol	$10,402	$10,924	$14,986	$23,536	2.5%	3.2%	2.2%
Smyth*	$9,907	$9,792	$13,262	$20,127	-0.6%	3.1%	2.0%
Wythe*	$10,010	$10,137	$14,561	$20,029	0.6%	3.7%	1.5%
Pulaski	$11,990	$11,098	$13,665	$3,454	-3.8%	2.1%	2.6%
Montgomery and Radford	$11,055	$10,764	$13,447	$19,716	-1.3%	2.3%	1.8%
Roanoke County and Salem	$14,437	$14,307	$19,321	$31,820	-0.4%	3.0%	2.4%
Roanoke City	$14,750	$15,479	$17,890	$26,137	2.4%	1.5%	1.8%
Botetourt	$11,487	$12,244	$16,675	$30,438	3.2%	3.1%	2.9%
Rockbridge, Buena Vista and Lexington*	$10,529	$10,666	$13,524	$22,608	0.7%	2.4%	2.5%
Augusta, Staunton and Waynesboro*	$13,039	$12,933	$16,585	$24,829	-0.4%	2.5%	1.9%
Rockingham and Harrisonburg	$12,045	$12,668	$14,594	$22,499	2.6%	1.4%	2.1%
Shenandoah*	$11,253	$12,157	$15,941	$23,802	3.9%	2.7%	1.9%
Warren	$13,083	$13,695	$17,040	$25,816	2.3%	2.2%	2.0%
Frederick and Winchester	$12,599	$13,267	$15,621	$28,099	2.6%	1.6%	2.8%
VA I-81 Study area	$12,422	$12,649	$15,891	$24,920	0.9%	2.3%	2.2%
Virginia	$14,072	$14,837	$19,900	$31,706	2.7%	3.0%	2.2%
United States	$15,189	$15,747	$19,827	$29,881	1.8%	2.3%	2.0%
Non-Metro Virginia	$ 10,287	$10,880	$15,205	$21,924	2.8%	3.4%	1.8%
Non-Metro U.S.	$11,566	$12,204	$15,654	$22,587	2.7%	2.5%	1.8%

* Indicates counties and independent cities that are classified as non-metropolitan by the U.S. Office of Management and Budget in 2004.
Source: Bureau of Economic Analysis (adjusted with National Implicit Price Deflators for Personal Consumption Expenditures)

2.6.4 Industry Mix

Table 2-4 shows non-farm and farm employment by industry in the I-81 study area (sum of the thirteen I-81 counties and cities therein) in selected years from 1969 to 2000. The growth rate for total non-farm employment increased in the decade after the highway's completion. Since I-81 was completed, employment has expanded in all industry sectors for which aggregate level data are available, except on farms. Between 1971 and 2000, services employment nearly tripled and retail employment doubled.

Manufacturing employment also grew. The I-81 study area employs nearly one-quarter of the Commonwealth's manufacturing workers, with just one-eighth of Virginia's population. The 1997 Census of Manufactures demonstrates that the I-81 study area is a major manufacturing region. Value added by manufacture (VAM) in the study area's thirteen counties and seven

independent cities (data for Buena Vista, Lexington, and Staunton were unavailable) totaled $9.6 billion, more than the $8.0 billion in the Washington, D.C. metropolitan area and $7.9 billion in the Norfolk metro area. The I-81 study area accounted for at least 22 percent of Virginia's VAM that year.

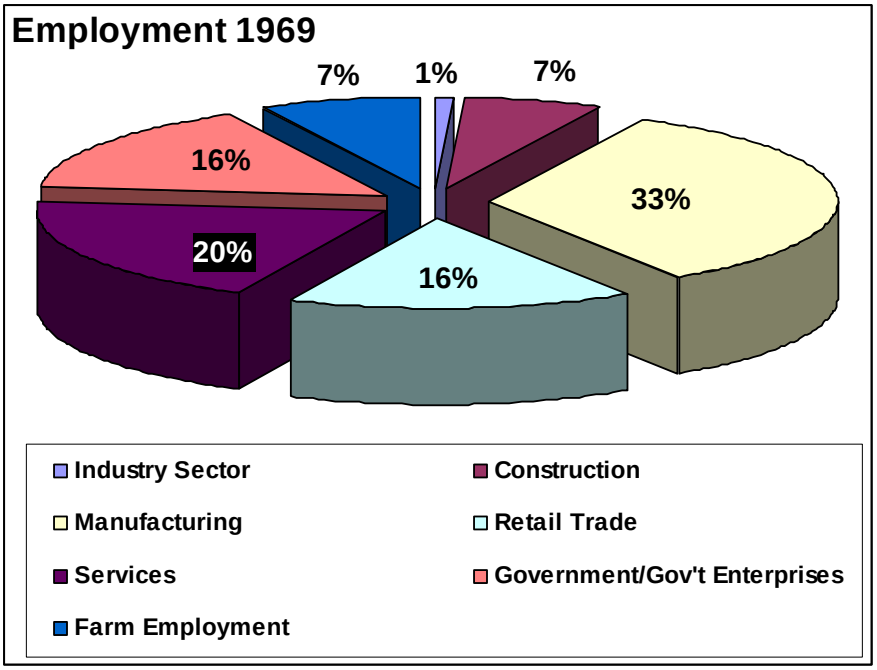
Table 2-4 Non-farm and Farm Employment by Industry in the I-81 Study Area: 1969-2000

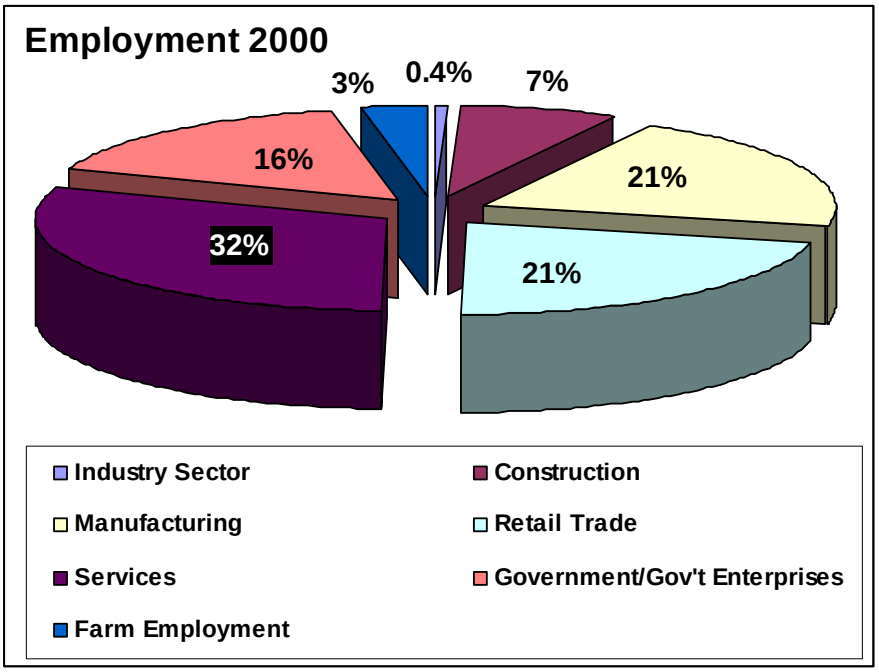
					Compounded Average Annual Growth		
Industry Sector	1969	1971	1981	2000	1969-71	1971-81	1981-00
Agricultural Services/Forestry/Fishing					-1.8%	2.0%	NA
Mining	NA	NA	NA	NA	NA	NA	NA
Construction	17,362	17,403	20,508	34,787	0.1%	1.7%	2.8%
Manufacturing	87,972	82,723	90,828	97,759	-3.0%	0.9%	0.4%
Transportation/Public Utilities	NA	NA	NA	NA	NA	NA	NA
Wholesale Trade	NA	NA	NA	NA	NA	NA	NA
Retail Trade	42,432	43,763	56,891	100,542	1.6%	2.7%	3.0%
Finance/Insurance/Real Estate	NA	NA	NA	NA	NA	NA	NA
Services	52,311	55,236	73,061	143,003	2.8%	2.8%	3.6%
Government/Government Enterprises	41,415	43,142	55,338	75,384	2.1%	2.5%	1.6%
Total Non-farm Employment	288,622	291,308	359,349	539,260	0.5%	2.1%	2.2%
Farm Employment	19,622	19,592	18,375	14,538	-0.1%	-0.6%	-1.2%
Farm As % of Total Farm and Non-farm Employment	6.4%	6.3%	4.9%	2.6%	-0.5%	-2.6%	-3.2%

Source: Bureau of Economic Analysis

Figure 2-3 illustrates changes in the make-up of corridor employment over the past 30 years.

Figure 2-3 Non-farm and Farm Employment by Industry in the I-81 Study Area: 1969 and 2000





Farm employment in the study area has declined since 1969 when it accounted for 19 percent of total farm and non-farm employment in Botetourt County, 15 percent in Shenandoah County, and 14 percent in Rockingham County; by 2002, these figures had declined to five, six and four percent, respectively.

Table 2-5 compares the corridor, state, and national industry mix derived from total non-farm employment in selected years. Manufacturing accounts for a much greater share of employment in the I-81 study area than in Virginia or the U.S. as a whole. The manufacturing strength pre-dates completion of I-81 in 1971; although manufacturing's share of total employment in the study area declined from 1969 to 2000, the sector accounted for 18.1 percent of employment in 2000, nearly twice the statewide share. Manufacturing employment expanded more rapidly in the study area (average annual increase of 0.58 percent) than statewide (0.30 percent) between 1971 and 2000. Manufacturing has been a more robust industry in the study area than in other locales; whereas manufacturing employment peaked nationwide in 1979 and statewide in 1987, it reached its apex in the study area in 1999.

The share of total non-farm employment in the services sector increased in the study area between 1969 and 2000, but the gain was not as big as in Virginia or the nation as a whole. Government's share of employment in the study area matched the national share in 2000. Virginia's share of employment due to government is unusually high due to federal agency employment in the Washington, D.C. area and military employment, especially in the D.C. suburbs and the Norfolk area.

Table 2-5 I-81 Study Area Industry Sectors as Percent of Total Non-Farm Employment: 1969-2000

	1969			1981			2000		
Industry Sector	I-81	Virginia	U.S.	I-81	Virginia	U.S.	I-81	Virginia	U.S.
Agricultural Services/Forestry/Fishing	0.6%	0.5%	0.6%	0.6%	0.7%	0.8%	NA	1.1%	1.3%
Mining	NA	0.7%	0.8%	NA	0.9%	1.3%	NA	0.3%	0.5%
Construction	6.0%	5.7%	5.1%	5.7%	5.5%	5.0%	6.5%	6.4%	5.8%
Manufacturing	30.5%	18.3%	23.6%	25.3%	15.4%	18.5%	18.1%	9.2%	11.7%
Transportation/Public Utilities	NA	5.0%	5.5%	NA	4.8%	5.1%	NA	4.9%	5.0%
Wholesale Trade	NA	3.2%	4.7%	NA	4.1%	5.2%	NA	3.7%	4.6%
Retail Trade	14.7%	13.8%	15.4%	15.8%	15.0%	16.2%	18.6%	16.3%	16.6%
Finance/Insurance/Real Estate	NA	5.8%	6.8%	NA	7.4%	7.9%	NA	7.2%	8.1%
Services	18.1%	17.3%	19.2%	20.3%	21.5%	23.1%	26.5%	32.3%	32.4%
Government/Government Enterprises	14.3%	29.6%	18.2%	15.4%	24.7%	16.7%	14.0%	18.6%	14.0%
Total Non-farm Employment	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Bureau of Economic Analysis

Retail trade has increased its share of study area employment over the past 30 years. In 1969, retail's share of total non-farm employment in the study area exceeded the Virginia figure, but lagged the nation. By 2000, the study area had surpassed the national share.

2.7 Economic Development Trends

2.7.1 Decline of Traditional Industries

Industries that were once economic mainstays in the I-81 study area have declined in recent years. Most of the textile and apparel plants within a 60-mile radius of Roanoke have closed. Augusta Mills has closed its sheets and pillow cases factory in Elkton, Rockingham County. In 2002, VF Jeanswear announced closure of its Wrangler jeans plant in Woodstock, Shenandoah County and sewing support center in Luray, Page County. Pilgrim's Pride is selling or closing its turkey processing plant in Hinton (Rockingham County). The apple industry centered on Winchester is in decline due to foreign competition and to residential development.[12]

2.7.2 Distribution Centers

Distribution is increasingly becoming an important industry in the I-81 study area, especially in the Shenandoah and Roanoke valleys. Virginia is the northernmost "right to work" state, with lower labor costs and management-friendly employment laws in comparison with nearby states in the Northeast and Midwest. The combination of central location and employer-favored labor conditions is thought to have spurred development of distribution centers in the northern portion of the I-81 study area since the early 1990s.[13]

The Virginia Port Authority operates an "inland port" in Fort Royal on I-66 near its junction with I-81. Containers are imported at marine terminals in the Hampton Roads area and transported via the Norfolk Southern Railroad to the Virginia Inland Port, from which they are trucked to distribution centers such as those in the I-81/Shenandoah Valley and to destinations in Pennsylvania and in the Ohio River Valley.

Table 2-6 lists the distribution centers operated by major retail chains in the Shenandoah Valley. All are located near I-81 with the exception of the facility in Front Royal, which is sited near I-66. The Target distribution center is said to be the second-largest building in Virginia after the Pentagon. The Volvo/Mack truck assembly plant in Pulaski County is of similar size. Although most commerce with these operations is carried by truck, some distribution centers also ship and receive by rail.

12 Greg Edwards, "Uprooting Virginia's Apple Industry: Foreign Competition, Weather Causing Some Apple Growers to Get Out," *The Patriot-News* (Harrisburg, Pennsylvania), June 1, 2004.
13 Telephone interview with Ken Jones, Winchester-Frederick County Economic Development Commission, August 11, 2004.

Table 2-6 Distribution Centers Operated by Major Retailers in the Shenandoah Valley

Community	Retailer	Square Feet	Opened
Winchester	Home Depot	768,000	2004
Winchester	Kohl's	420,000	1997
Front Royal	Family Dollar	907,000	1998
Staunton	Best Buy	701,000	1994
Mt. Jackson	Wal-Mart	1,200,000	2005
Bridgewater	Marshalls	672,000	NA
Stuarts Draft	Target	1,600,000	1997

The nation's largest food-service marketing and distribution companies have also sited facilities in the Shenandoah Valley. Sysco recently opened its 854,000 sf Baugh Northeast Co-op Redistribution Center in Front Royal near I-66; it is the company's prototype mega-warehouse for supply of subsidiaries. The Front Royal center will serve fourteen Sysco operating companies in the Northeast (including the Harrisonburg/Mount Crawford facility). AmeriCold Logistics operates a 245,000 sf (7.5 million cubic feet) distribution facility for refrigerated foodstuffs in Strasburg. U.S. Foodservice operates a distribution center in Roanoke.

The Roanoke Valley is the site of smaller distribution centers, especially for catalog sales and other direct-to-customer retail operations. Hanover Direct (775,000 sf) and Orvis, Inc. (300,000 sf) operate order fulfillment centers at the Roanoke Centre for Industry and Technology. The Home Shopping Network (HSN) fulfillment center in Roanoke sends tens of thousands of packages per day. HSN closed its Salem, Virginia center in 2004, claiming lack of space for expansion. Most of the Salem operation was transferred to a 1 million sf center in Piney Flats, Tennessee. Large plots of flat land are scarcer in the Roanoke area than in the Shenandoah Valley; consequently, Roanoke economic development officials prefer value-added industrial operations over large distribution facilities for national retailers because factories generally provide better jobs and higher tax revenues.

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2.7.3 Motor Vehicle Parts

Automobile manufacturing was centered in the Midwest and Northeast from the early 20th century until the 1980s. Since the early 1980s, numerous motor vehicle assembly plants have been constructed in the Southeast, and an increasing number of automobile component manufacturers have opened facilities along Virginia's portion of I-81.

Motor vehicle parts are manufactured at factories throughout the I-81 study area. Yokohama makes tires in Salem. BBA Friction Materials produces brake linings in Pulaski County. Eagle-Picher Industries manufactures automotive gaskets in Montgomery County. In Botetourt County, Dynax America makes clutch plates and Koyo Steering Systems produces steering and suspension parts. Lear Operations makes components in Shenandoah County and in the Winchester area. Also in the Winchester area, PolyOne produces vinyl panels and Federal Mogul makes parts and accessories. Tenneco Automotive manufactures parts in Harrisonburg. Advance Auto Parts, the nation's second-largest retailer of replacement components, is based in Roanoke, where it operates a 442,000 sf distribution center.

Volvo/Mack builds heavy-duty trucks at its 1.6 million sf plant in Pulaski County, the only motor vehicle assembly facility along Virginia's section of I-81.

2.7.4 Colleges and Universities

Numerous institutions of higher education are in relatively close proximity to I-81 in Virginia including Virginia Tech, James Madison University, University of Virginia-Wise, Virginia Military Institute, Washington & Lee University, Shenandoah University, Radford, Roanoke College, Mary Baldwin College, Emory & Henry, and Sweetbriar. Their presence has affected economic development in two major ways. First, enrollment has rapidly expanded at some schools, causing an economic multiplier effect in the retail and services sectors in their communities. Second, universities have served as catalysts for new businesses. For example, Blacksburg Industrial Park and Virginia Tech Corporate Research Center in Blacksburg are home to many businesses related to Virginia Tech. The Carilion Biomedical Institute in Roanoke is a spin-off of the local Carilion Health System, Virginia Tech, and the University of Virginia.

2.7.5 Tourism

The I-81 corridor, rich in scenic and cultural resources, is also a major tourism corridor. The American Automobile Association (AAA) voted I-81 as one of the top ten most scenic interstates in the U.S. An estimated $1.7 billion dollars is expended annually in the study area by visitors. These visitors are attracted by recreational opportunities in the Shenandoah and Blue Ridge Mountains, the rich civil war history, and the numerous attractions along I-81.

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3
Methods

The primary goals for the freight forecast and diversion analysis of the *I-81 Corridor Improvement Study* were to: 1) develop a more complete understanding and profile of freight movements in the corridor; 2) review and analyze the anticipated growth in freight movements in the study area including forecasting the freight travel demand for the year 2035; and 3) examine the potential freight diversion that might occur given various rail improvements and/or the impact of tolls. This analysis was completed during the improvement concept development process completed for the *I-81 Corridor Improvement Study*.

This chapter discusses the methodology used to estimate truck trips in the I-81 study area for the forecast year 2035, and estimate truck trip diversions if rail improvements were made or tolls were added on Interstate 81 in Virginia. Several tasks were completed as part of the freight study including:

- Review previous studies on intermodal planning developed for the corridor or the Commonwealth including SJR-55, HJR-701, and the *Northeast-Southeast-Midwest Corridor Paralleling I-81 & I-95 Marketing Study*, and *The Impact of Tolls on Freight Movement for I-81 in Virginia* reports. These studies provided base year forecasts, and useful information for the mode diversion and toll impact modeling efforts.
- Identify existing data sources and mode choice models, modifying and using the Intermodal Transportation and Inventory Cost (ITIC) mode shift model to develop truck trip diversion estimates for the four rail improvement concepts.
- Refine the ITIC model to develop truck diversion estimates to gauge the impacts of tolls in the study area.
- Complete a truck driver intercept survey in the study area to analyze truck movement characteristics in the I-81 study area.
- Complete a shipper/receiver survey in the study area.

The following sections describe these efforts in greater detail.

3.1 Surveys

Two surveys were conducted to collect data about freight transportation in the I-81 study area of Virginia. Both surveys contained questions about truck usage within and through Virginia's 325-mile stretch of I-81.

The I-81 Freight Shipper/Carrier Survey was designed for truck traffic that originates or terminates in cities and counties within the I-81 study area. It was distributed electronically, by hand, and through the mail. A website was created on which visitors could answer the survey (see http://www.jfawest.com/I-81/Survey.html). The American Trucking Association installed a link to the survey on their website and the Virginia Trucking Association sent an e-mail to its membership urging that they respond. The survey was also mailed to 167 manufacturers and distribution centers in the thirteen counties. Finally, surveys were distributed to the attendees of the Roanoke Valley-Alleghany Regional Commission's "Freight Forum" in June 2004. This chapter explains the goals and methodology of the I-81 Freight Shipper/Carrier Survey and presents the results.

The second survey, I-81 Truck Intercept Survey, was designed to capture "through traffic"—trucks that utilize I-81 for interstate trips with neither origin nor destination in the study area. It was conducted at nine truck stops along a 200-mile stretch of I-81 in Virginia in June 2004.

3.1.1 I-81 Freight Shipper/Carrier Survey

A copy of the actual Freight Shipper/Carrier Survey is attached as Appendix A. The first section collected background information about the respondent and the respondent's company and facility. The most important queries concerned the nature of operation at the facility and the types of materials, products, and/or equipment shipped and received.

The second section asked questions about facility or carrier company activity, range of trucks (local versus long-distance; and inside Virginia versus outside Virginia), top three states of origin and destination, and peak periods of activity during the day and year. A key question asked what percentage of trucks moving through their facility use I-81. Another important question inquired about the percentage of freight that moves by rail through the respondent's facility.

The final portion of the survey consisted of open-ended questions about rail usage, recommendations for I-81 improvements, and identification of specific traffic problems related to I-81.

Survey Recipients

Three groups were the primary targets of the survey: (1) major employers in the I-81 study area, (2) motor carriers in Virginia who use I-81, and (3) freight transportation stakeholders in the Roanoke area.

Major employers in the I-81 study area were targeted because they presumably are the most dependent upon the highway. Motor carriers in Virginia were targeted because they use I-81. Finally, the Project Team especially targeted the freight transportation community in the Roanoke area because it is the largest metropolitan area on Virginia's 325-mile stretch of I-81.

Major Employers

A mailing list of 167 major employers in the I-81 study area was compiled. It included most manufacturing, distribution, and motor carrier facilities that employ 100 or more workers at a single site. The list was developed with data from the Virginia Economic Development Partnership, interviews with local economic development officials, telephone directories in the I-81 study area, electronic archives of Virginia newspapers, Securities & Exchange Commission 10-K report filings, press releases and facility locators on corporate websites, and an informal windshield survey.

Universities and hospitals were removed from the major employer list because they are not traditional entities involved in goods transportation. The Project Team excluded major employers in Virginia jurisdictions outside of the I-81 study area and out-of-state entities due to concern about the validity of the sample size.

The mailings to the 167 facilities included self-addressed stamped-envelopes (SASE's) and invited recipients to complete the web version of the survey in lieu of mailing back their responses. In the end, thirty-three of the 167 forms (20 percent) were returned by mail. It is believed that an additional portion of these responded , while an unknown number responded via the website (this exact number can not be determined since motor carriers and Roanoke Area stakeholders also responded via the website).

Motor Carriers

The Virginia Trucking Association distributed the survey to its membership. Most received an e-mail with a link to the web survey. VTA members without e-mail addresses were mailed a survey form. The VTA passed the information about the survey to the American Trucking Associations, the national trade organization for the trucking industry. In July and August 2004, the main page of the ATA website included a link to the survey. Appendix B includes a copy of the ATA webpage inviting participation in the web survey.

VTA and ATA members submitted their responses by mail, fax, and the web site. The ATA link resulted in responses from out-of-state motor carriers at a greater-than-anticipated level.

Administering the Roanoke Area Survey

The Roanoke Valley-Alleghany Regional Commission (RVARC) assisted with dissemination of the survey in the Roanoke area. The RVARC's territory includes five counties (Alleghany, Botetourt, Craig, Franklin, and Roanoke) and several cities and towns (Clifton Forge,

Covington, Roanoke, Salem, and Vinton). The RVARC provides staffing for the Roanoke Valley Area Metropolitan Planning Organization, which is involved in transportation planning in the urban area in and around Roanoke.

The RVARC periodically convenes a regional Freight Forum as a freight advisory group to the transportation planning process. It consists of the key freight transportation stakeholders in the region, including local government officials, shippers, carriers, and interested citizens. The survey was distributed at the June 2004 Freight Forum meeting in Roanoke.

In summer 2004, the RVARC mailed the survey to its membership and at least fourteen forms were returned.

3.1.2 I-81 Truck Intercept Survey

The second survey, the I-81 Truck Intercept Survey, was designed to capture "through traffic" that utilize I-81 for interstate trips with neither origin nor destination in the I-81 study area. The primary goal of the intercept survey was to identify the characteristics of long-haul truck transportation in the I-81 study area, especially for truck trips that neither originate nor terminate within Virginia. Data on commodity transported, origin, and destination would provide insight into goods movement on I-81. The second goal was an assessment of truck drivers' sensitivity to tolls. If tolls were imposed on I-81, theoretically some drivers would take alternative routes. The survey yielded a sense of how truckers might respond to a toll. The third goal was to provide data to ascertain the accuracy of existing freight transportation databases. The instrument was designed to collect data that would be compatible with the truck trip forecasting model.

The Survey Instrument

A copy of the survey instrument is attached in Appendix B. The intercept survey asked drivers about their truck type (single unit vs. tractor-trailer, number of axles) and their cargos. Another series of questions inquired about their trip characteristics (northbound vs. southbound, access and egress points on I-81, and home base city and state of the truck). Questions about the frequency of use of I-81 allow weighing a particular response, to determine if the trip is atypical. The frequency queries also indicated whether drivers use I-81 for one-way travel and whether they are more likely to drive empty northbound or southbound; i.e., an indicator of "triangular trade." In order to capture added data about origins and destinations, drivers were asked to list all of their stops inside Virginia. The impetus for this question was to obtain data about less-than-truckload (LTL) trips that use I-81. To help identify LTL movements, drivers were asked the reasons for each stop.

Finally, three toll questions assessed drivers' familiarity with toll roads. The survey excluded toll bridges and tunnels from the definition of "toll road" because such facilities are unavoidable on many routes. The survey sought information about "discretionary" use of toll roads.

Survey Locations

By its very nature, "pass-through" traffic on I-81 is difficult to survey because the trucks do not stop in Virginia to load or unload cargo. Theoretically a surveyor could drive the length of I-81 in Virginia and record trucking company names and vehicle identification numbers from tractors and trailers and later contact trucking companies to inquire about the cargo characteristics of the particular truck at that time. Such a process would not produce timely and accurate results. Weigh stations were also rejected because "weigh-in-motion" technology now allows trucks to speed through or bypass the weigh stations.

Surveys were completed at local truck stops to survey "pass-through" truck drivers. I-81 is of sufficient length that most truckers that pass through the state usually stop at least once to re-fuel, to eat, or to rest. Many drivers who were surveyed confirmed that many five-axle trucks re-fuel every 300 to 600 miles. Since I-81 is 325 miles in Virginia, many trucks need to re-fuel at least once in the state due to the length of the I-81 corridor and because the pre-tax price of diesel tends to be lower than most Northeast states. A truck driving at 65 miles per hour takes five hours to traverse Virginia's 325 miles of I-81. Since large trucks are not accommodated at most conventional eating establishments, most drivers take meal breaks at truck stops. Many trucks park at truck stops to sleep because parking regulations severely restrict where drivers can take rest stops.

A list of truck stops along I-81 was obtained from the National Association of Truck Stop Operators. The focus of the survey was on the more than two-hundred mile stretch of I-81 between I-66 (near Strasburg) and I-77S (near Wytheville). All truck stops in that section were called and permission sought to conduct the survey there. Only one company refused.

Administering the Survey

The survey was administered at nine truck stops along a two-hundred mile stretch of I-81 on June 2 and 3, 2004. In general, the surveyed facilities were spaced twenty to thirty miles apart. In recognition of the fact that truck drivers do not work during conventional hours, the survey was conducted during different parts of the day. Table 3-1 below lists the survey locations and the responses obtained at each site.

At each stop, two or three surveyors approached truck drivers as they fueled vehicles, cleaned windshields, checked tires, or entered or exited the truck stop's retail center or restaurant. In many cases, the surveyors followed the drivers as they performed their tasks, with both parties raising their voices to speak above the idling engines. Other drivers were approached as they walked through the parking lot or waited for their trucks to be washed or repaired. Approximately 95 percent of the drivers approached agreed to survey. The general idea was to be unobtrusive and to occupy as little of the drivers' "idle time" as possible, which contributed to the high response rate.

Table 3-1 Intercept Survey Locations

Truck Stop	Location	Exit/Mile Number	Date Surveyed	Time	Number of Responses
Lancer Truck Stop #5	Dublin	101	June 2, 2004	afternoon	12
Lancer Travel Plaza	Elliston	128	June 2, 2004	afternoon	6
Travel Centers of America	Roanoke	150	June 2, 2004	evening	42
Lee Hi Travel Plaza	Lexington	195	June 2, 2004	night	40
Pilot Travel Center #396	Staunton	213	June 3, 2004	morning and afternoon	67
Harrisonburg Travel Center	Harrisonburg	243	June 3, 2004	afternoon	16
Sheetz Travel Center #701	Mt. Jackson	273	June 3, 2004	afternoon	18
Shenandoah Truck Center	Mt. Jackson	273	June 3, 2004	evening	4
Love's Travel Stop #305	Tom's Brook	291	June 3, 2004	night	15
Total					220

3.2 2035 Freight Forecasting

3.2.1 Data Sources

Forecasts of 2035 truck movements in the I-81 study area were developed using a variety of data sources including the following:

- VDOT Traffic Counts in the I-81 Study Area
- Regional Economic Models, Inc. (REMI) Economic and Demographic Forecasts
- 1997 Vehicle Inventory and Use Survey (VIUS)
- Truck Trip Analyzer (TTA)
- Virginia Statewide Transportation Model
- National Transportation Statistics
- 1998 VDOT Freight Flow Database

The following sections provide a broad description of each of the data sources including the identification of the entity collecting and processing the data, the original purpose of the data collection program, the strengths and limitations of the data source, and the general use of the data in this study.

VDOT Traffic Counts

For the purposes of this initial forecast analysis at the individual count stations, the latest available data for the study area are the 2003 traffic counts compiled by the Virginia Department of Transportation (VDOT), which form the basis for all of the forecasts.

The Average Daily Traffic Volumes with Vehicle Classification Data includes information such as: estimates of the percentage of the annual average daily traffic (AADT) made up by six different vehicle types, ranging from cars to double trailer trucks; estimated Annual Average Weekday Traffic (AAWDT), which is the number of vehicles estimated to have traveled the segment of highway during a 24 hour weekday averaged over the year; and Peak Hour and Peak Direction factors used by planners to formulate design criteria.

The six vehicle types included in these counts are:

- 4-Tire: Motorcycles, passenger cars, vans and pickup trucks.
- Bus: Buses.
- 2-Axle Truck: 2-axle single unit trucks (not including pickups and vans).
- 3+Axle Truck: Single unit trucks with three or more axles.
- 1-Trailer Truck: Units with a single trailer.
- 2-Trailer Truck: Units with more than one trailer.

REMI Economic and Demographic Forecasts

Another important data input to truck traffic forecasts are estimates of economic and economic growth by industry and region. There is a proven, direct correlation between changes in economic activity and the movement of goods and commodities by truck.[14] These economic estimates are used to forecast various elements of truck traffic. For this study, these forecasts were obtained from Regional Economic Models, Inc. (REMI), a leading provider of regional forecasting and policy analysis models.

REMI Data

For this study, REMI provided data on output for 49 private non-farm industries that approximate the two-digit Standard Industry Classification (SIC) level. Data were provided for 1998 to 2035 in real 1996 dollars (the base year for all currently available state-based economic data) organized by industry for the following states and regions:

14 Typically this correlation is illustrated by comparing historical changes in the Industrial Production Index with the Truck Tonnage Index, as shown in Chapter 5.

- Alabama
- Arkansas
- Connecticut
- Delaware
- District of Columbia
- Florida
- Georgia
- Illinois
- Indiana
- Kentucky
- Louisiana
- Maryland
- Massachusetts
- Michigan
- Mississippi
- New Hampshire
- New Jersey
- New York
- North Carolina
- Ohio
- Oklahoma
- Pennsylvania
- Rhode Island
- South Carolina
- Tennessee
- Texas
- Virginia
- West Virginia
- Rest of United States

In addition REMI has provided several data series for the I-81 study area for the years 2002 to 2035 including:

- Employment Projections By Industry (in thousands of jobs)
- Employment Output Projections By Industry (in billions of 1996 dollars)
- Gross Regional Product (in billions of 1996 dollars)
- Population Projections (in thousands of people)

1997 Vehicle Inventory and Use Survey

The Vehicle Inventory and Use Surveys (VIUS) provide data on the physical and operational characteristics of the Nation's truck population. This survey is conducted every five years as part of the U.S. Census Bureau's economic census.

The 1997 VIUS is a probability sample of private and commercial trucks registered (or licensed) in the United States as of July 1, 1997. This survey excludes vehicles owned by Federal, state, or local governments; ambulances; buses; motor homes; farm tractors; un-powered trailer units; and trucks reported to have been sold, junked, or wrecked prior to July 1, 1996. A sample of about 131,000 trucks was surveyed to measure the characteristics of nearly 75 million trucks registered in the United States.

Truck Trip Analyzer (TTA)

The Truck Trip Analyzer (TTA), developed by Jack Faucett Associates, Inc. (JFA) is a travel demand model designed under Federal Highway Administration Small Business Innovative Research (SBIR) funding to estimate truck trip tables from commodity flows. The application models four different types of truck movements: regional freight movements, non-goods movements, hazardous waste, and through-traffic. The application encompasses both national and local data.

To estimate truck trips associated with freight movements, the model disaggregates standard commodity flow data, allocates it to traffic analysis zones, and converts it into truck trips. Economic input-output modeling techniques are used to identify and link production and supply centers with consumption locales. Freight movements through warehouses and freight consolidation facilities are addressed, as are transload movements (trucks transferring payloads to rail) through intermodal centers. Trip chains (connected destinations) are explicitly modeled through the use of probability data and calculations. Adjustments are made to reflect empty movements associated with freight deliveries.

The application produces truck-trip tables that can be assigned to a simulated transportation network using standard travel demand modeling procedures. The user can produce trip tables for different truck class schemes, passenger car equivalent and time/date metrics (year, day, and hour). The TTA is designed to estimate truck trips of all kinds, not just freight movements. For the forecast of base future truck travel estimated as part of this study, the TTA was used as a secondary source of data on load factors and empty rates by detailed commodity and type of carrier (truckload, less-than-truckload).

Virginia Statewide Transportation Model

At present, the Virginia Statewide Model is not being directly used in developing the 2035 truck trip estimates. However, data from the model and model documentation are used as a reference source and in quality control procedures to check general projections in corridor development.

National Statistics

A full set of transportation data has also been obtained from the Federal Highway Administration (FHWA) Office of Highway Policy Information, the Federal Aviation Administration (FAA), the Bureau of Transportation Statistics (BTS), the Federal Railroad Administration (FRA), the Surface Transportation Board (STB) and Amtrak.

1998 VDOT Freight Flow Database/Transearch™

The movement of freight reflects the movement of trucks. In order to accurately forecast freight movements it is first necessary to disaggregate data by industry and area of origin. In this study, the data used to disaggregate commodity movements were the VDOT freight flow databases based on the 1998 Transearch™ database developed by Reebie Associates. They contain estimated freight tonnage shipments traveling to, from or through the state of Virginia via truck (truckload, less-than-truckload and private truck), rail (carload), intermodal (rail and truck), air and water.

The origin-destination (OD) flows in the database are presented by 4-digit Standard Transportation Commodity Classification (STCC) code and cover all 134 counties and cities in Virginia. It also covers the District of Columbia, 20 counties in Maryland, two counties in

Pennsylvania, nine counties in West Virginia, 14 Bureau of Economic Analysis (BEA) areas (including parts of Tennessee), 11 states (not including areas covered by BEA economic areas) and eight multi-state regions.

The Transearch™ database ties multiple privately maintained and government produced sources of information on freight movement, production, consumption, and transport into a unified database. Data sources included:

- U.S. Census Annual Survey of Manufactures and Census Manufactures
- Data Resources, Inc. (DRI) Industrial Production Statistics
- Trade Association Production and Shipment Reports
- U.S. Geological Survey Mineral Industry Reports
- Reebie's Freight Locator
- County Street-Address Industrial Employment and Activity
- County Population Data
- Inter-industry Trade Patterns (Input/Output Table)
- Motor Carrier Industry Financial and Operating Statistics
- Railroad Industry Proprietary Rebill Factors
- Private Port Directories
- BTS Commodity Flow Surveys
- BTS Trans-border Freight Statistics

Rail traffic information is taken from the Surface Transportation Board (STB) Annual Railroad Waybill Sample. The Waybill Sample is a stratified sample of shipments hauled by U.S. rail carriers. This sample file contains detailed information on the origin, destination, commodity and volume of each sampled movement.
Transearch™ also incorporates data collected by the U.S. Army Corps of Engineers (USACE) regarding freight movements along the nation's waterways. These data provide state-to-state volumes of broad commodity groupings. Transearch™ bridges the various data sets to develop a more detailed picture of production and goods movement.

Air cargo is a small but fast-growing portion of freight movement. Air activity is described using BTS Airport Activity Statistics to determine airport-to-airport flow volumes, and flows from airports to counties.

To develop truck estimates, Reebie allocated the freight volumes left over from the air, water, and rail modes between the for-hire and private sectors of industry based on volumes reported in the Commodity Flow Survey. The for-hire category is split between "truckload" and "less than truckload" components using industry data. The data is then split into origin to destination flow volumes. Transearch™ proprietary data called Motor Carrier Data Exchange and Freight Locator Database are the starting points for developing truck flows.

After incorporating all the different types of data sources on production, consumption, origin, mode of transport, Reebie maps out freight movements using Geographic Information Systems (GIS). The Oak Ridge National Laboratory (ORNL) develops the highway network maps and the routes are defined by an equation that selects the fastest and cheapest routes between counties. Rail routes are defined by Reebie's routing model, which pairs counties using a similar algorithm for speed and cost-effectiveness. This is reconciled with Waybill traffic data.

3.2.2 Freight Analysis Framework (FAF)

The United States Department of Transportation (USDOT) estimates that by the year 2020, the US transportation network will handle almost 22.5 billion tons of freight cargo—up from 13.5 billion in 1998. Continued increases in freight volume have placed a strain on the transportation network in some locations and created conflicts between the commuting public and commercial freight carriers. Common issues include highway safety and congestion. To uncover trends in freight movement and identify potential problem areas, US DOT created the Freight Analysis Framework (FAF). FAF identifies areas with unbalanced freight demand and system capacity. This information is used to encourage multi-state and regional cooperative planning.

Overview

FAF is a database and analytical tool that improves planning, operations, and decision-making for freight movement. It focuses on identifying linkages between four transportation modes (highway, railroad, water, and air) and draws the relationship between freight movement and infrastructure capacity. FAF translates economic projections for the years 2010 and 2020 into transportation demands, which then are placed into a computer simulation of the transportation network. The simulation predicts the growth rate of freight tonnage and identifies commodity flows by origin and destination. Flows can be projected on national, regional, state, or local levels and illustrated using GIS maps.
The Framework's database, referred to as FAFD, contains county-to-county freight transportation flows for truck, rail, water, and air modes at the four-digit STCC level. The database is based on the 1998 Transearch™ data and contains the following components:

1. Domestic Production Statistics,
2. Domestic Modal Database Flows,
3. Truck Flows of Agricultural Goods, and
4. Domestic Flows of International Movements.

The FAFD also includes rail traffic for the international import and export of goods. This information is from BTS border crossing statistics. For traffic through ports, the port identification forms are used. This information is included under a separate data set, Latin America Trade and Transportation Study (LATTS).

FAF estimates county-to-county truck flows of agricultural goods. Data on country production figures by crop type, product or livestock is gathered from the USDA. Conversions are made to aggregate the goods by ton and origins are defined by locations of distribution facilities such as grain elevators or packaging plants.

Freight Forecasting

To develop a freight forecast to 2020, FAF links 1998 base year origin and destination data to economic forecasts. FAF relies upon a Data Resources Inc. and Wharton Econometric Forecasting Associates (DRI-WEFA) 2010 and 2020 forecasts for the price and value of domestic freight at a national level by STCC code. DRI-WEFA used their Macroeconomic Service's High Growth and Low Growth scenarios to develop alternative scenarios. Table 3-2 below outlines WEFA's long-term baseline forecast assumptions.

Long- and short-term economic growth forecasts are used to create two alternative price and value scenarios. FHWA used the weighted average of both to develop the final projection. By using a weighted average, changes in product demand and changes in pricing are both considered.

Table 3-2 DRI-WEFA Long-Term Economic Assumptions

Population and Labor Force	Population growth will slow from 1% to 0.8% annually, slowing civilian labor force growth.
Employment and Unemployment	Manufacturing employment will continue to decline as a share of total employment, while service sectors will generate an increasing share of employment growth.
Productivity and Aggregate Supply	Potential GDP growth will slow relative to historical rates due to slower growth in the labor force, while productivity growth will remain steady.
Government Policy	The government sector share of GDP will decline due to slower growth in defense spending and a reduction in the share of interest payments relative to the federal budget.
Monetary and Financial	The Federal Reserve Board will remain watchful of inflation while ensuring growth in output consistent with potential output.
Consumption	The share of real consumption devoted to services and durable goods will rise, while it falls for nondurable goods, such as energy.
Business Investment	The investment share of structures will decline, while equipment's share will rise. The fastest growing sector of the economy for the investment will be producers' durable equipment.
International Trade	Real export growth will slow growth in the trade deficit due to a decline in the value of the dollar and the reduction in U.S. real unit labor costs relative to the rest of the industrialized world.
Industrial Production	Manufacturing of durable goods, particularly non-electrical machinery such as computers, will grow faster than nondurable goods. Plastics and paper will lead nondurable goods production.

FHWA developed high and low economic growth scenarios for 2010 and 2020 using the same methodology as the price and value trends forecast. In the low growth scenario, it is assumed the economy will experience slower population growth, lower productivity gains, and slower

overall economic growth. Despite high inflation projections, the higher prices per ton of freight are not enough to offset the lower volume of freight movement due to the slower economy. Domestic freight value is lower in the low growth scenario than the trend for most STCC codes. In the high growth scenario, it is assumed that the economy will have faster growth than the population trend, higher productivity gains, and overall faster growth. Inflation is expected to be lower. Lower price per ton of freight is not enough to offset the higher volume of freight movement due to economic growth. Domestic freight value is higher in the high growth scenario than the trend for most STCC codes.

The WEFA forecasts were used to extrapolate shipments or purchases for a SIC code by region. The shipment growth rate is based on WEFA's Business Demographic Model output growth rates. Purchase growth rates are based upon WEFA's Business Transactions Matrix. This matrix records the purchases of a product made in one industry by industries in other SIC codes and the retail sector of a region. International freight flows were modeled using World Trade Monitor, which tracks flows outside of the US.

FAF's Implications for I-81 Study Commodity Flows Component

FAF could not be used as a direct source of commodity flow information for the study; although, the model does provide valuable information on the current and projected levels of freight movement in Virginia at the state and county level. More specific county-level data within the framework is proprietary and not available to the public (the model is also generally not calibrated for corridor-level analysis). Also, FAF forecasts scenarios only extend to 2020, and according to FHWA, FAF will not be updated at this time.

3.3 2035 Truck Trip Forecasting

Forecasts of 2035 truck movements in the I-81 study area were developed within the Truck Trip Analyzer (TTA) model by applying a variety of economic growth rates to existing traffic counts. The basic premise of the methodology is that there is a link between economic output and freight movements.

3.3.1 Correlation Between Industrial Output and Freight Movements

An underlying assumption employed in the TTA model is the link between economic output and freight movements. The TTA model follows protocol established by several other freight models, including the Federal Highway Administration's (FHWA) Freight Analysis Framework tool, to forecast commodity flows by using economic output projections as indicators of future changes in freight shipments. The rationale is that increases in industrial output create increases in freight demand because producers need to move their goods to the consumers. Increases in freight demand translate into increases in freight movements as

haulers respond to market pressures. The following sections provides an overview the FAF protocol and illustrates the relationship between economic growth and freight movement using data compiled by the Bureau of Transportation Statistics (BTS) and Bureau of Economic Analysis (BEA).

Historical data on freight movement by trucks, as measured by a Trucking Tonnage Index, were available from the *Monthly Trucking Report,* published by American Trucking Association (ATA).[15] The Trucking Tonnage Index provides monthly data with a 1996 base year and is a general indicator of the volume of all freight movements by trucks, including independent and private trucking.

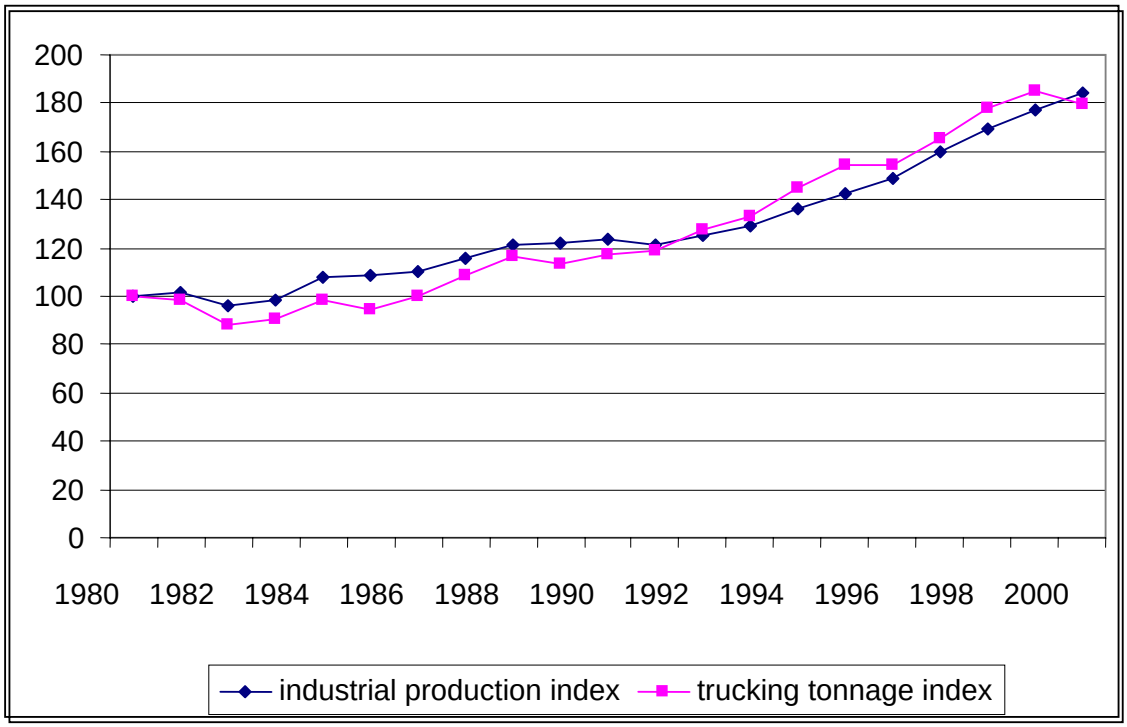
Historical data on industrial output, measured by an Industrial Production Index, were available from the *Federal Reserve Statistics,* published by the Federal Reserve. The monthly index of industrial production covers manufacturing, mining, and electric and gas utilities. It measures real output in the industrial sector and is expressed as an index of real output with a base year of 1997. The industrial output index helps illuminate structural developments in the economy.

The Industrial Production Index and Trucking Tonnage Index were compiled for the period of 1980-2000, the years for which both indices were available. Each index was adjusted to a common base year of 1980. A regression analysis found a close correlation between the Industrial Production Index and Trucking Tonnage Index, with a correlation coefficient of 0.99. This relationship, illustrated in Figure 3-1 below, shows that the growth trend in the industrial production index and the trucking tonnage index is consistent over time.

After a review of existing freight model methodology and an analysis of available economic and freight movement data, it was determined that the TTA model's use of industrial output growth factors to forecast is consistent with historical trends of freight movement and industrial output. This practice is also used by other freight models. Both the TTA and FAF model merge economic growth forecasts to project commodity flows. The FAF relies heavily on proprietary data and, as such, data on specific counties and corridors are not available. TTA bridges this information gap by developing commodity flow forecasts to the year 2035 for the I-81 study area and affected Virginia counties and cities.

15 The data on the Trucking Tonnage Index were published only in graphical form and as a result the data used in this study were estimated based on those published graphs.

Figure 3-1 Comparison of the Industrial Output Index to the Trucking Tonnage Index



Source: Federal Reserve Statistics and American Trucking Association.

3.3.2 The Freight Analysis Framework and TTA Protocol

A 2002 report entitled *Derivation of the FAF Database and Forecast* outlined a methodology used to link the forecast of freight movements to economic growth in the FAF.[16] The FAF relied upon Data Resources Inc. (DRI) and Wharton Econometric Forecasting Associates (WEFA) economic forecasts for real output. Domestic origin/destination freight flows in 1998 were increased to 2010 and 2020 levels based on WEFA forecasts of growth in real output at the two-digit STCC commodity level for the specified regions. The FAF translates economic projections for the years 2010 and 2020 into transportation demands and then forecasts freight movements on the national, state, and county-levels.

The TTA follows a similar procedure. The model combines Virginia specific commodity flow data with economic growth forecasts by industry developed by Regional Economic Models, Inc. (REMI). The end result is an annual forecast through 2035 for freight movements along the I-81 study area, measured in commodity tonnages and more importantly, truck trips.

16 Prepared by Battelle for the U.S. Department of Transportation, 2002.

The development of the 2035 forecasts included the following steps:

- Processing existing VDOT truck counts
- Forecasting of single-unit truck trips
- Processing of state/industry output growth factors for forecasting combination truck trips
- Development of state/industry commodity flow weights for combination truck trips
- Forecasting of combination truck trips
- Estimation of county/city truck trips

I-81 Base Year Truck Counts

The Virginia Department of Transportation network on I-81 includes some 261 links, or highway segments (130 northbound and 131 southbound). For each link, VDOT provides data on the route, jurisdiction, section start and end point, and AADT. AADT is further classified by vehicle class (i.e. passenger car, motorcycle, bus, or type of truck). Truck percentages, based on permanent classification count data, are subdivided into:

- Single-unit two-axle
- Single-unit three or more axles
- Tractor and single trailer combinations
- Tractor and multiple trailer combinations.

The distribution of truck counts on the I-81 study area is the key building block from which future truck traffic is estimated for the 2035 forecast year. The forecast procedures vary for single and combination trucks due to the differences in the nature of their operation. The forecasting methodology is explained in the following sections.

Forecast of Single-Unit Truck Trips

Single-unit trucks vary substantially from combination vehicles in terms of their operational characteristics. In particular, the vast majority of single-unit trucks operate primarily in their local area. Table 3-3 provides data on the primary range of operation for single-unit trucks by axle configuration. The top portion of the table republishes data from the 1997 VIUS, while the bottom portion of the data provides cumulative percentages for on-road vehicles that reported their primary range of operation.

Table 3-3 Primary Range of Operation for Single-Unit Trucks

Type of Single-Unit Truck	Total	Local <50 miles	Short-Range 51-100 miles	Short-Range Medium 101-200 miles	Long-Range Medium 201-500 miles	Long-Range >500 miles	Off-Road	Not Reported
Number of Trucks								
2-Axle	69726.0	51574.4	8867.3	2668.8	1449.5	1512.8	2714.4	938.9
3-Axle	475.0	320.9	63.9	18.6	5.0	3.0	51.9	11.8
4-Axle or More	111.2	85.9	16.6	3.2	0.6	0.3	4.3	0.4
All Single-Unit Trucks	70312.2	51981.1	8947.8	2690.6	1455.1	1516.1	2770.5	951.0
Cumulative Percent of On-Road Reported Trucks								
2-Axle		0.78	0.91	0.96	0.98	1.00	N/A	N/A
3-Axle		0.78	0.94	0.98	0.99	1.00		
4-Axle or More		0.81	0.96	0.99	1.00	1.00		
All Single-Unit Trucks		0.78	0.91	0.96	0.98	1.00		

Regardless of axle configuration, at least 90 percent of all single-unit truck types had a primary range of operation of 100 miles or less. This percentage exceeds 95 percent for single-unit trucks with a primary range of operation of 200 miles or less. (The Transearch™ database previously examined for the I-81 corridor study excludes both short haul intra-county moves and non-freight moves). Given the heavily local nature of single unit truck activity and the lack of specific origin-destination data, separate forecasts of single-unit trucks were not completed as part of this study. This portion of truck activity was simply forecast using trends in overall traffic growth, as previously discussed in section 4.1.3.

Forecasts for Combination Trucks

While single-unit trucks are primarily local in nature, combination trucks operate primarily in a long-range setting; therefore, these vehicles needed to be given special consideration in the forecasting methodology. According to the 1997 VIUS, only 12.8 percent of combination truck miles were by trucks whose primary range of operations was 50 miles or less, while only 26 percent were 100 miles or less.

The growth rates for combination vehicles trips were estimated to be a function of the growth in output for the states and industries producing the products that are consumed. The growth rates for each state and commodity were based on the output forecasts provided by REMI. They were calculated by dividing the 1996 constant dollar output provided by REMI for 2035 by the output in 2002. Data were provided for 26 states, the District of Columbia and the rest of the U.S. The median growth factor is 2.2, which means that output in the median industry is expected to grow 120 percent from 2002 to 2035.

State/Industry Weights

In order to apply the output growth factors calculated from the REMI data, a set of weights were developed for each state and industry combination. These weights were calculated separately for northbound and southbound truck counts for each of the nineteen I-81 county/city jurisdictions, as set by Reebie Associates. The weights were based on the number of truckloads of commodity movements originating by state and commodity combination. The weights are calculated in the following steps:

1. Extract I-81 commodity flow tonnages
2. Identify northbound and southbound flows
3. Convert the tonnages to truckloads
4. Forecast the truckloads to 2035
5. Bin and sum truckloads by I-81 county/city jurisdictions
6. Calculate weighted output growth factors

The following subsections describe each of the six data development steps in more detail.

Step 1. Extract I-81 Commodity Flow Tonnages

I-81 commodity flows were obtained from the VDOT freight flow database developed by Reebie Associates from their proprietary Transearch™ database. In the VDOT database, the commodity flows from the Transearch™ database were assigned to the highway network using a highway assignment algorithm designed by Oak Ridge National Laboratories (ORNL). A query in MS Access was designed for this study that identified flows that were likely to have used I-81 and separated those records for further analysis. The query examined entry and exit roads in Virginia, preceding states and following states, and travel in I-81 counties.

Step 2. Identify Northbound and Southbound Flows

For traffic forecasting purposes, I-81 represents two separate facilities, one that serves northbound traffic flows and one that serves southbound traffic flows. Traffic count stations measure flows in each direction and each facility connects different sets of states, industries, producers and consumers. In order to most accurately predict traffic flows in each direction, it was necessary to consider economic growth forecasts and commodity flows separately for each direction. Again, a query in MS Access was developed to identify flows from the VDOT commodity flow databases affecting the I-81 corridor and to separately identify northbound and southbound flows. The query examined preceding and following states, and counties.

Step 3. Convert to Truckloads

In order to use commodity flow volumes as a set of output growth factor weights, the estimates of tonnage flows first had to be converted to truckloads so that estimates of movements across commodities were on an equivalent basis. Estimates of empty percentages for detailed commodities were also compiled for use in developing output growth factor weights.

Truck load factors represent the average cargo weight of loaded trucks. Empty factors represent the estimated percentage of trips trucks that operate empty or without a payload. To tailor the TTA model to the I-81 corridor and develop detailed information on the number and type of truck trips occurring, a database of truck load and empty factors was compiled. One function of the TTA is to use truck load and empty factors to convert raw commodity flows, measured in tonnages by four-digit Standard Transportation Commodity Code (STCC), into an estimated number of truck trips.

Application of Load Factors

Once load factors were developed they were applied to each of the individual I-81 commodity tonnage movements identified from the 1998 VDOT freight flow data base. Each movement is defined by four-digit STCC code, state of origin, and type of service (truck-load, less-than-truckload, private). The four-digit STCC industries were assigned to the load factors for the corresponding two-digit industry. States of origin were matched to the originating state, if available, or to the rest-of US. Truck-load, and less-than-truckload were assigned to their corresponding load factors and movements by private trucks were assigned to the truck-load load factors.

Step 4. Forecast Truckloads to 2035

Once the 1998 tonnage commodity flows were converted to truckloads they were forecasted to 2002 and 2035. This is accomplished by assigning each individual commodity flow to a set of two growth factors, one measuring growth from 1998 to 2002 and one measuring growth from 1998 to 2035. The 2035 commodity flow model prepared for this study indicates that approximately 68 percent of all truck traffic has neither an origin nor a destination in Virginia and utilizes some portion of I-81 during their trip. The model was developed from user surveys and national freight information and was calibrated via actual truck counts at various locations along I-81. Each movement is defined by four-digit STCC code and state of origin. The four-digit STCC industries were assigned to the growth factors for the corresponding two-digit industry. States of origin were matched to the originating state, if available, or to the rest-of US.

Step 5. Bin and Sum Truckloads by I-81 County/City Jurisdictions

After estimates of truckloads were created for 1998, 2002, and 2035, each commodity flow was assigned to the jurisdiction or jurisdictions through which it flowed. For example, for the

case of an overhead flow that moved the entire length of the I-81 study area it would be necessary to assign that flow to all nineteen jurisdictions.

Once the individual flows were "binned" (essentially, commodity flows using multiple jurisdictions are accounted for to avoid double-counting), the number of truckloads in each year was summed to provide a total for each I-81 jurisdiction for each year for each direction. In essence, this "binning" process provides an estimate of the number of truckloads that pass each weigh station in each year in each direction (note that a sum of all truckloads after this step would involve substantial double-counting).

Step 6. Calculate Weighted Output Growth Factors

The summed estimate of truckloads for each jurisdiction and each direction for 2035 were divided by truckloads for 2002 to provide 38 weighted output growth factors. The 38 output weighted growth factors are shown in Table 3-4 by jurisdiction (some independent cities are encompassed in the County jurisdictions or were not included because they do not actually abut I-81 directly). The resultant growth rates vary from 2.3476 to 2.5096 (note that the growth rates within each direction do not vary substantially, which is expected as freight flows in each direction are dominated by the same set of overhead flows). Traffic growth between 135 and 151 percent, depending on the direction and jurisdiction, is expected for combination trucks, or heavy vehicles, along the corridor in 2035. The appropriate growth factor is applied to the existing heavy vehicle flows along the 261 traffic links to provide forecasts of combination truck activity for 2035.

Empty Trucks

One drawback of the use of estimates of the number of truckloads of commodities originating by state and industry to weight output growth factors is that it ignores empty backhauls. Ideally, empties should be weighted by commodity flows in the opposite direction as the need for these movements are driven by the industries requiring the transportation services. This is especially true on the I-81 corridors, where empty southbound backhauls are reported to greatly outnumber northbound backhauls. Absent any more specific data, southbound truck forecasts were adjusted upward to equal the northbound forecasts of truck movements along the corridor as a conservative estimate of future travel demand.

Table 3-4 Output Weighted Growth Factors for Heavy Trucks (By Jurisdiction)

Jurisdiction	Southbound	Northbound
Fredrick County	23647	2.5081
Winchester County	2.3646	2.4955
Warren County	2.3638	2.5080
Shenandoah County	2.3646	2.5078
Rockingham County	2.3639	2.5072
Harrisonburg City	2.3623	2.5071
Augusta County	2.3636	2.5061
Staunton City	2.3620	2.5060
Rockbridge County	2.3636	2.5059
Botetourt County	2.3626	2.5056
Roanoke County	2.3583	2.5055
Roanoke City	2.3601	2.4928
Salem City	2.3476	2.5055
Montgomery County	2.3636	2.5056
Pulaski County	2.3617	2,5057
Wythe County	2.3638	2.5085
Smyth County	2.3640	2.5096
Washington County	2.3625	2.5096
Bristol City	2.3634	2.5096

3.4 2035 No-Build Truck Trip Table Development

To estimate truck trips and construct the 2035 No-Build truck trip table, the 1998 Virginia Transearch™ database was also utilized.[17] The truck trip table serves two purposes. It provides inputs for the micro-level toll diversion analysis completed for the study. The table also provides inputs (as a measure of economic activity) to the economic analysis completed for the *I-81 Corridor Improvement Study*.

The Transearch™ database is organized in Microsoft Access and is made up of several tables: commodity flow tables for truck, rail, water and air transportation modes; a table which describes route assignments for each commodity flow record; a highway segment table which describes attributes of individual highway segments in the route assignment table; and

17 Supporting data in a report produced for VDOT called *Summary and Analysis of Goods Movement Data*, Wilbur Smith Associates was also used.

a region names table which describes the geographic units used in the commodity flow records. A copy of the completed truck trip table is provided in Appendix D.
In lieu of functional documentation or supporting materials for the tasks outlined in the following sections, input from Reebie Associates was used and certain assumptions were made regarding use of the commodity flows data.

3.4.1 Building the Truck Trip Table from Forecast Data

The following steps outline the process of creating the I-81 No-Build truck trip table. The process is similar to that used in the 2035 truck trip forecast, with additional steps taken to create the origin-destination table and to normalize the truck trips to observed base year heavy vehicle counts.

Step 1 — Identify Commodity Flows/Goods Movement in the I-81 Study Region

The 1998 truck trip estimates in the Transearch™ database were used as a starting point in estimating future commodity flows. The Transearch™ truck table contains over 500,000 records of commodity flow movements, of which about half use I-81 for some portion of their route. Each record consists of 17 fields of data:

1. Origin_Region: Designated numerical code identifying the Origin Region, i.e. Region "1" in the Transearch database is Accomack County , VA
2. Origin: The name of the origin region, i.e. Accomack County , VA
3. Origin_description: Description of the origin region size, i.e. "Individual County" or "BEA Region"
4. Destination_Region: Designated numerical code identifying the Destination Region, i.e. Region "1" in the Transearch database is Accomack County , VA
5. Destination: The name of the destination region, i.e. Accomack County , VA
6. Destination_description: Description of the region size, i.e. "Individual County" or "BEA Region"
7. First_VA_segment: Numerical attribute code identifying the first segment on the route assigned path in Virginia. In other words, what highway a truck movement would use to enter Virginia. This code is taken from the Oak Ridge National Laboratory (ORNL) National Highway Network (NHN) spatial database.
8. Last_VA_segment: Numerical attribute code identifying the last segment on the route assigned path in Virginia. In other words, what highway a truck movement would use to leave Virginia. This code is taken from the Oak Ridge National Laboratory National Highway Network spatial database.
9. Preceding_state: The state a truck movement entered Virginia from (this information was not used for the mode diversion analysis).

10. Following_state: The state to which a truck movement leaving Virginia entered (this information was not used for the mode diversion analysis).
11. Entry_road: The highway used to enter Virginia in the route assignment process.
12. Exit_road: The highway used to leave Virginia in the route assignment process.
13. STCC4: A code used by the rail industry to classify commodities. The acronym stands for "Standard Transportation Commodity Code." The commodity flow data is disaggregated to the 4 digit level in the Transearch database.
14. TL: The number of tons shipped by "Truckload" Carrier
15. LTL: The number of tons shipped by "Less than Truckload" Carrier
16. PVT: The number of tons shipped by "Private" Carrier
17. Truck: The total number of tons shipped by Truckload (TL), Less than Truckload (LTL), and Private (PVT) Carriers

The database also includes the *Routes* table, which describes the segment by segment path a commodity flow would follow through Virginia from origin to destination. The *Routes* table contains three data fields:

18. First_Segment
19. Last_Segment
20. SegmentID

A modified version of the Routes table was also provided with an additional field indicating direction of the commodity flow.

The *Highway* table contains detailed information about individual highway segments that make up the network assignments. Each record in the Highway table has 27 data fields, and two fields are important to the analysis, RTESIGN1 and SEGMENT_ID. SEGMENT_ID relates the Highway table to the Routes table, and RTESIGN1 is the highway segment identifier. The segments relevant to the I-81 study have a RTESIGN1 value equal to "I-81" for example.

The key to identifying commodity flows through certain geographic regions or road segments on highways in Virginia is the relationship between the fields: First_VA_Segment and Last_VA_Segment in the Transearch™ Table, and the First_Segment and Last_Segment fields in the Routes table.

Written documentation on the basic organization of the database was obtained from a report completed for the Ohio Department of Transportation in June 2002.[18] It describes in detail the

18 *Freight Impacts on Ohio's Roadway System*, Cambridge Systematics, June 2002.

methods for constructing queries to capture commodity flows through individual road segments along a route assigned path, and Reebie's use of the Oak Ridge National Laboratory's (ORNL) National Highway Network (NHN) GIS file as the basis for the route assignment procedures — and the basis for the data in the Routes and Highway tables. An ESRI shape file of the NHN is provided with the database. When the file is opened in a GIS application and overlayed with Virginia county boundary files and the interstate highway network, individual road segments can be identified along I-81, I-64, I-77 and I-66; within single counties; at the borders of the state; and/or at major interchanges such as the I-81/I-77 merge.

A query relating the three tables checks the records that pass through individual segments in Virginia. First_VA_Segment and Last_VA_Segment in the Transearch™ Table are also used to query records that have certain entry and exit highway combinations. The fields Origin_Region and Destination_Region can be used to further refine these queries as each county in Virginia and geographic region in the database has a unique ID (ID values greater than 136 signify a region outside of Virginia).

Step 2 — Convert Commodity Tons to Truck Trips

The next step in the process is to convert tons in the commodity flow records to actual truck trips. Three different sets of "Load Factors" are used to convert tonnage to truck loads, and then to truck trips (when an empty factor is applied). The three types of load factors used for the conversion are:

1. Local: Inside a given jurisdiction (e.g., origin = Pulaski County and destination = Pulaski County)
2. Short: Inside the I-81 study region of 37-county/city jurisdictions (e.g., origin = Pulaski County and destination = Fredrick County)
3. Long: The remainder (e.g., origin = Atlanta, Georgia and destination = Augusta County, Virginia)

Load factors represent the average payload carried by a truck with cargo and are used to convert commodity flow tonnages into truck trips. There is a load and empty factor for each of the three operational ranges. A truck load factor was assigned to each STTC commodity code for the three operating ranges. The payloads assignments were derived from data in the 1997 Vehicle Inventory and Use Survey (VIUS), published by the U.S. Bureau of Census.

Two kinds of service load categories—Truckload (TL) and Less-Than-Truckload (LTL)—were examined within each range of operation matrices (Long, Short, Local) using VIUS data. VIUS "Kind of Service" statistics provide information on the proportion of trucks operating in full truckload service and those operating in less than a full truckload service. Weighted averages of VIUS Kind of Service statistics were used to assign values to TL and LTL columns for both databases.

Step 3 — Apply Growth Factor Estimates

Different (BEA) regions report different rates of growth, and different commodities (corresponding to industries and sectors for the purpose of this study) have different growth rates. The project team developed a set of factors to apply to its estimates of 1998 truck trips, so that the resulting figures can reflect truck trips first for the baseline and 2035 conditions.

Once the 1998 tonnage commodity flows were converted to truckloads they were forecasted to 2004 and 2035 by multiplying the base 1998 truck trips by the growth factor described in Step 2. This was accomplished by assigning each individual commodity flow to a set of two growth factors, one measuring growth from 1998 to 2004 and one measuring growth from 1998 to 2035. Each movement is defined by four-digit STCC code and state of origin. The four-digit STCC industries were assigned to the growth factors for the corresponding two-digit industry. States of origin were matched to the originating state, if available, or to the rest-of US.

Step 4 — Create Truck Trip Table

The truck trip table is created in two sub steps:

- **Step 4-1:** The records identified and modified in Step 1, 2, and 3 are assigned to one of three categories:
  - An origin and destination to one of the 37 counties in the study area
  - An origin and destination from another county in Virginia outside the study area to a corridor county, "Rest of Virginia" county, or the "Rest of United States"
  - An origin and destination from another state "Rest of United States" to a corridor county, "Rest of Virginia" county, "Rest of United States"
- **Step 4-2:** A cross-tabulation query was then created with origin regions as the row headers and destination regions as the column headers. The 2035 truck trip estimate was then summed in each cell for each origin-destination combination.

The Region names contained in the Origin_Region and Destination_Region fields for regions outside the study area were updated to "Rest of United States" or "Rest of Virginia" where appropriate to execute the cross-tabulation query.

The truck trip estimates for certain origin-destination combinations were further disaggregated to break down truck estimates by entry and exit road, and origin or destination, as follows:

- Origin "Rest of Virginia" to Destination "Rest of Virginia" by entry and exit road in Virginia

- Origin "Rest of United States" to Destination "Rest of United States" by entry and exit road into and out of Virginia
- Origin "Rest of United States" to Destination "Corridor County" by entry road to Virginia
- Origin "Corridor County" to Destination "Rest of United States" by exit road out of Virginia

Step 5 — Normalize the Truck Trip Table Estimates to Actual Truck Counts

The resultant truck trip table was factored against actual count data to provide a more accurate estimate of truck trip traffic for each origin-destination pair. The table was normalized using data from the eight permanent count stations on I-81 in 2004. The comparison of the actual counts and the database estimates showed that the Transearch™ estimates were about 6 percent higher (on average) than the count data. Similar adjustments were made to calibrate the 2035 truck trip table. These tables were important input to the freight diversion analysis and the tolling impact study under separate cover (see the *I-81 Corridor Improvement Study Tolling Impact Study* that accompanies the Tier 1 Draft Environmental Impact Statement).

3.5 Transearch™ Commodity Flow Database

3.5.1 Overview

The Transearch™ commodity flow database is developed from a series of government and private surveys of shippers, receivers and carriers. These surveys are compiled to develop a detailed national database of the movement of goods by specific commodity code from their origin to their destination. Other models are used with the Transearch™ database to assign these flows to specific transportation facilities based on least cost transport assumptions.

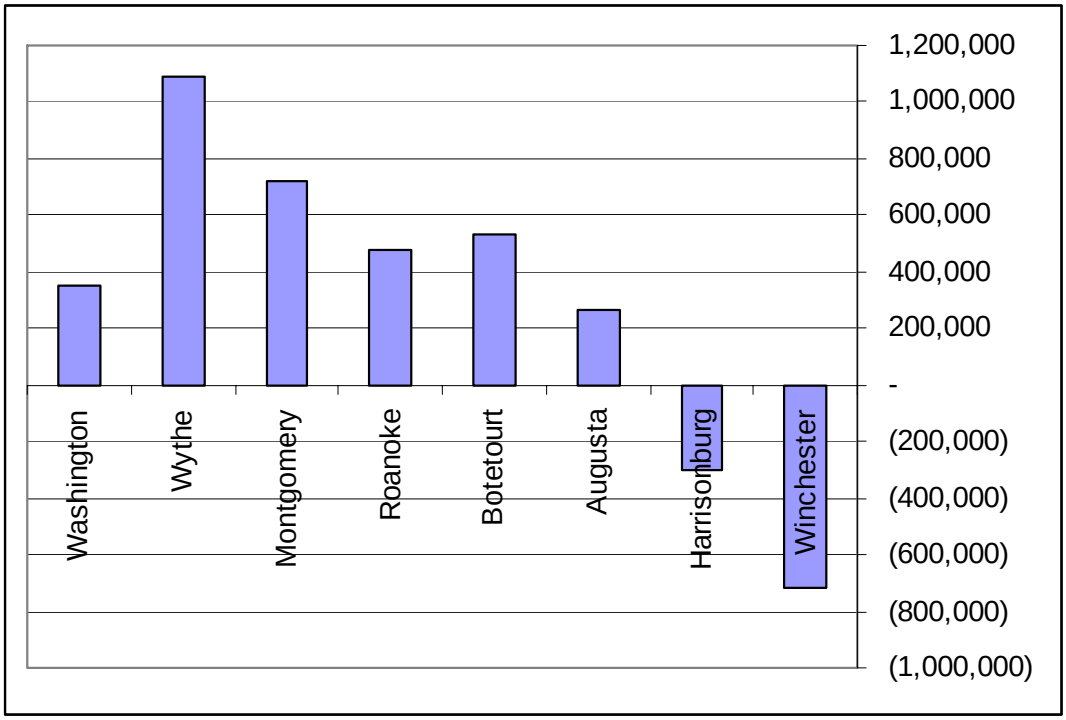
Transearch™ data is most reliable when used at the aggregate level. The reliability of the data may suffer from applications at more disaggregate levels. In order to develop Transearch™ information for individual facilities, it is necessary to assign the commodity flow to specific origin and destination routes and to convert those flows to truck trips. Each of these steps adds uncertainty to the resulting truck trip estimates. The Transearch™ data and vehicle count information can be used together, however, to effectively combine the rich detail in the Transearch™ data in commodity types, origins and destinations with the fundamental traffic demands along a corridor. For example, the Transearch™ information on origins, destinations and commodity mix can be combined with regional economic forecasts to grow the base year truck count information based on the specific commodities that move in the corridor under study.

The analysis completed as part of this study shows that the Transearch™ data correlates fairly well with on-the-ground I-81 truck counts. The 2004 counts compared to 2004 truck trip estimates derived from Transearch™ at the eight permanent count stations along I-81 showed variations of approximately 20 percent. Table 3-5 and Figure 3-2 illustrate the difference.

Table 3-5 Comparison of 2004 Actual Truck Counts to 2004 Transearch™ Truck Trip Estimates

Location	Jurisdiction	VDOT Truck Counts	Transearch™ Estimated Truck Trips	Delta (%)
Route 140 to Abingdon	Washington	3,277,700	3,626,651	+10.6
Route 11 to Wytheville	Wythe	4,985,900	6,075,015	+21.8
Route 177 to Route 8	Montgomery	4,011,350	4,728,656	+17.9
Route 581 to Route 115	Roanoke	4,672,000	5,146,083	+10.1
Route 11 to Route 11-614	Botetourt	4,354,450	4,884,136	+12.2
Route 606 to Augusta County	Augusta	5,069,850	5,338,088	+05.3
Route 11 to Route 659	Harrisonburg	4,693,900	4,390,544	-6.5
Route 50 to Winchester	Winchester	4,434,750	3,720,209	-16.1

Figure 3-2 2004 Truck Counts Compared to 2004 Transearch™ Truck Trip Estimates



The 2004 Transearch™ truck trip estimates were higher than the VDOT 2004 truck counts in the southern corridor, then correlated well from Roanoke to Harrisonburg, and under estimated truck trips in the northern end of the corridor.

3.5.2 Data Implications for the Study

The Transearch™ database provides the primary dataset for both the truck trip forecasting and mode diversion analysis completed for this study. Reebie Associates Transearch™ data product is often the only comprehensive source of commodity flow data that transportation agencies can use. (Previous studies were concerned only with freight movements, while this study is concerned with the movements of all trucks and the forecasted counts of trucks at multiple locations).

The Truck Trip Analyzer (TTA) model employed in this study further enhances the understanding of truck movements along I-81. The basis of the TTA model is the truck count data compiled by VDOT and growth factors from independent economic forecasts. The results of this study are unique in that they provide detailed forecasted counts specific to the counties and cities throughout the study area.

3.6 Freight Diversion Analysis

The purpose of the freight diversion analysis was to evaluate the potential for truck traffic currently using I-81 to divert to rail intermodal service, and to confirm assumptions from previous studies. Several steps were taken to develop a method for the modal diversion analysis:

- A literature review was conducted to evaluate previous studies that examined diversion potential in the corridor, and identify existing data sources for inputs to the model. An annotated bibliography summarizing a literature review on the topic of mode choice modeling is provided Chapters 7 and 8;
- Identified existing truck-to-rail diversion models and selected the FHWA's Intermodal Transportation and Inventory Cost Model (ITIC) for the analysis. A comprehensive annotated bibliography summarizing other existing mode choice models and research on the topic is provided in Chapters 7 and 8;
- Translated a set of assumptions provided by Norfolk Southern and others about rail capacity improvements into values which could be modeled in ITIC; and
- Developed a set of criteria to select certain commodity movements in the 1998 Virginia Transearch™ database which are considered modally competitive.

Each of these steps are described below.

3.6.1 Literature Review and Data Collection

The purpose of this step was to review studies that had been completed for the corridor relating to potential mode diversion and rail alternatives in Virginia and the I-81 study area, to identify existing assumptions, conclusions, and to select appropriate data sources. Key literature sources included:

- ***Northeast-Southeast-Midwest Corridor Marketing Study*, Virginia Department of Rail and Public Transportation (DRPT), 2003.** This study was completed in December 2003 by Reebie Associates. The study evaluates the marketplace demand for improved intermodal service in the I-81 corridor, service improvements that offer the greatest diversion potential in the corridor, and the levels of public investment needed to substantially impact the level of highway commercial traffic on I-81. Reebie conducted a diversion analysis for the study and provided results, indicating the effects of a low and high investment on Annual Average Daily Truck Traffic (AADTT) and Vehicles Miles Traveled. They estimate AADTT reductions in the I-81 study area of 9.8 percent and 10.4 percent (based on low and high rail investment scenarios) over three to five years, to 4.9 percent and 5.2 percent reductions in AADTT in the following ten to twelve years.

  The March 31, 2003 draft report provides a more detailed evaluation of the modeling process used for the freight diversion analysis. First, Origin-Destination market areas that make up the majority of intermodal or modally competitive commodity movements were identified, as well as major intermodal terminals in proximity to these areas. Reebie then broadly discusses a screening process to determine which dry van commodities have potential for diversion. They do not identify which commodities are used for the analysis. Reebie indicated in the study that movements of less than 500 miles (or even 700 miles) have not traditionally been considered modally competitive, but did examine moves of 350 miles or greater miles for the study. They also stated that intermodal traffic makes up less than 3% of the traffic of moves less than 500 miles. The next step in their modeling process determined shipping costs for intermodal and truck movements between selected origin-destination pairs. Reebie has a proprietary database known as CO$TLINE, that they used to determine the value.

- ***Desirability and Feasibility of Establishing Additional "Intermodal Transfer Facilities,"* House Document No. 23, HJR-704 Final Report, Commonwealth of Virginia, 2001.** This study was completed by Parsons Brinkerhoff Quade & Douglas (PBQ&D) for VDOT and DPRT. The intent of the study was to provide a guide for Virginia legislators in evaluating the construction of intermodal facilities. The authors conducted an analysis of the 1996 Virginia Transearch™ database to determine the amount of inbound and outbound traffic in the state that is suitable for intermodal diversion. The study supports assumptions made in the *I-81 Corridor Improvement Study* as well as the Reebie study:

  - Generally movements less than 500 miles are not considered modally competitive for rail intermodal service;

- Only certain commodities are presently suitable for diversion, which are described as "dry van container goods"; and
- Lane density must be 25,000 annual truck trips (referred to as containers) for a commodity movement to be considered for diversion.

The study also describes in detail the market areas that make good candidates for intermodal facilities. Based on their analysis of the 1996 Reebie Transearch™ database, PBQ&D determined that about 3,500,000 "potential divertible" long haul truck trips (>500 miles, dry van) origin, destination, or pass through Virginia highways. They also stated that I-81 handles 52 percent of the long haul traffic in Virginia. From this information the research suggests that there are 1,800,000 trips (3,500,000*.52) that have a potential for diversion on I-81.

- ***The Potential for Shifting Virginia's Highway Traffic to Railroad***, Senate Document No. 30, Commonwealth of Virginia, SJR-55 Final Report, 2001. This study also analyzed the potential of truck traffic to divert to rail intermodal service. The report provided several estimates of the potential for truck-to-rail diversion in the study area. A study cited in the report, completed by CSXT and Norfolk Southern for the Conrail acquisition, estimates that 179,946 truckloads in the I-81/77 study area could be diverted annually, of the 800,000 potential divertible truckload movements the railroads identified.

  Another Norfolk Southern study cited in the report estimated diversion potential anywhere from 2,000 annual "units" with the lowest level of speed and service improvements on the railroad to 760,000 "units" with the highest level of speed and service improvements. Norfolk Southern suggested to the state that 10% diversion could be expected, but that figure is highly dependent on improvements to transit time and reliability.

  Like the HJR-704 study, the analysis recommended excluding movements less than 500 miles for a diversion analysis, and also mentioned that movements of greater than 750 miles have more intermodal competition. The study also identified significant origin destination pairs, their intermodal market share and general distances between points south and New York. Charlotte to New York, for example, is between 600 and 700 miles. Texas to the Northeast is between 1,500 and 1,700 miles.

- ***1997 Commodity Flow Survey*, Bureau of the Census, U.S. Department of Commerce, and the Bureau of Transportation Statistics, U.S. Department of Transportation.** This survey provided statistics on goods movement in the United States. The results are disaggregated by transportation mode, distance, and by commodity group. The 1997 survey uses a new classification scheme for commodities, the "Standard Classification for Transported Goods" (SCTG) system which harmonizes data collection with Canada. The data is detailed to the three digit level, and a conversion method to STCC values should be manageable. This data specifically provides a commodity's value per pound, a required input for ITIC. The survey is conducted every five years. 2002 CFS preliminary data was just starting to be released in 2004.

- *Comprehensive Truck Size and Weight (TS&W) Study Final Report,* **US Department of Transportation, Federal Highway Administration, 2000.** The report examined the effects of various truck size and weight configurations on annual vehicle miles traveled, and truck-to-truck as well as rail-to-truck diversion potential. The TS&W report also provided the basis for the development of the ITIC model. The report outlined the methodology for using ITIC as well as the data that is required to run the model. It also provided the most comprehensive methodology for choosing modally competitive commodity movements. Information from the report is critical to understanding the model, the data that was used for FHWA's freight diversion modeling, and for selecting commodities suitable for mode diversion.

3.6.2 ITIC - Intermodal Transportation and Inventory Cost Model

The ITIC model was selected for use in the mode diversion analysis after a review of existing truck-to-rail diversion models. An advantage of this model is that it was developed and is maintained by the FHWA Office of Policy Studies in cooperation with the Federal Railroad Administration. Most of the data required for the model (except for rail variable costs and drayage distances) are readily attainable, and the model is well documented by the U.S.DOT. The model is currently being refined and upgraded by a steering group of rail and truck experts under the FHWA.

ITIC is non-proprietary and can be modified to fit various truck size and weight, rail and transportation cost scenarios. It was also used to evaluate route diversions based on tolling scenarios in the I-81 study area (see Chapter 8). ITIC predicts modal diversion by calculating and comparing the Total Logistics Costs for different modes of freight transportation.

Logistics Costs

Logistics costs such as inventory-carrying costs, storage costs, handling, insurance, taxes, obsolescence, and pilferage are considered in the model. There are additional assumptions made for claims costs (loss and damage), cycle and safety stock holding costs, in-transit stock and for protection for a receiver's "stock-out" of a particular commodity. These logistics values are default assumptions built into the model, and can vary by commodity and mode.

Transportation Costs

Transportation costs considered in the model include all costs to the shipper of moving commodities from an origin to a destination. Trailer-on-Flatcar (TOFC) intermodal transportation costs include rail line haul costs and truck drayage costs at the origin and destination of the shipment. Through a consultation with FRA officials it was determined that intermodal rail operators can typically compete with truck carriers by charging 95 percent of the truck rate to a shipper, where they can meet their variable and drayage costs plus 10 percent. This assumption was used by the model to compare and select the least

costly transportation mode. Truck rates per mile are also provided in the model, based on a study completed by Jack Faucett Associates[19]. For this analysis, the 2004 North American Truckload Rate Index produced by the KPMG Company was used because it provides dry van truckload rates for 120 market areas in the US.[20]

Assumptions in the ITIC Model

Several default assumptions are made in the model for values such as average speed, transit time reliability, and truck size and weight configurations. The assumptions can be modified for different scenarios. Average drayage speed is a default value of 30 mph, rail line haul speed is a default value of 40 mph, and average truck speed is a default value of 50 mph. Transit Time Reliability factors for truck and rail service are also built in as default assumptions, and the truck mode has a better transit time reliability by default. For this analysis the total logistics costs for shipping by a standard 3 by 2 truck configuration was compared against the costs for shipping using a trailer-on-flatcar (TOFC) intermodal service.

Limitations of ITIC

The ITIC model is data intensive and requires accurate estimates of line haul rail, highway, and drayage distances (ideally at the county level). ITIC simplifies the assignment process, applying an "all-or-nothing" rule in determining if a sample shipment will divert to rail. Another limitation in the data relates to product value. The product value input will be generalized to the STCC3 level or STCC2 level where necessary, and must also be converted from the Standard Classification of Transported Goods (SCTG) method of reporting commodity detail in the 1997 Commodity Flow Survey.

How ITIC Works — Data Inputs, Assumptions, and Output

ITIC is an Excel Spreadsheet with a series of interrelated worksheets for logistics and transportation assumptions, equipment configurations, input data, and output data. Table 3-6 provides an example for one transposed record of data that would be input to the model. Table 3-7 illustrates the process, taken directly from the model, for determining total logistics cost per cwt (hundred pounds) — it is a sample calculation for one record of data using a 3 by 2 truck mode.

ITIC takes several steps in assigning a record to a truck or TOFC intermodal mode:

- It reads each record through a macro linked to a data input worksheet.

19 Federal Highway Administration, Comprehensive Truck Size and Weight Study, *Intermodal Transportation and Inventory Cost Model Documentation*, April 1999, pg. 19.
20 The KPMG Company, *North American Truckload Rate Index 2004*, Report and Dataset. Accessed at http://www.us.kpmg.com/RutUS_prod/Documents/9/northamericantruckloadrateindexorderform.pdf on 7/07/2004.

- It calculates the total logistics costs for the TOFC and truck configuration.
- It chooses a mode based on the lowest Total Transportation and Logistics Cost.
- It calculates annual Vehicle Miles Traveled (VMT) using that mode.
- Through a macro, it outputs the mode selection and VMT calculation to an output worksheet.

Table 3-6 ITIC Data Input (One Record Transposed)

Input	Data Source
Serial Number	Assigned by database
STCC Description	1998 Transearch™ Database
STCC Code	1998 Transearch™ Database
Origin Region	1998 Transearch™ Database
Destination Region	1998 Transearch™ Database
Origin SPLC	Standard Point Location Code (SPLC)-Geographic reference used by Railroad operators
Destination SPLC	Standard Point Location Code (SPLC)- Geographic reference used by Railroad operators
oregion	Origin Region-Geographic designations of the United States used by the model, described in the TS&W Study ITIC Documentation (1-Northeast and 2-Southeast)
dregion	Destination Region- Geographic designations of the United States used by the model, described in the TS&W Study ITIC Documentation (1-Northeast and 2-Southeast)
pounds/yr	1998 Transearch™ Database
pounds/ship	1998 Transearch™ Database
lbs/cu ft	JFA Truckload Conversion Factors/ITIC Assumptions
$ per Pound (98)	*Freight Impacts on Ohio's Roadway System*, Ohio Department of Transportation, June 2002, pg. 1-3.
Shelf Life	Not applicable
Rail Miles	Rail miles of TOFC movement from Origin terminal to Destination terminal
tofc miles	Total drayage miles
tofc pu	Drayage Pickup miles — Origin to Rail Intermodal Terminal
tofc dlvr	Drayage Delivery miles — Rail Intermodal Terminal to Destination
3-S2 miles	Highway Distance — Origin to Destination
observed mode	Truck (default value)
observed eq body	1 (default value)
observed eq configuration	4 (default value)
Annual moves	JFA 2035 Truck Trip Forecast
Observed rail revenue per cwt	95% of Truck Rate where applicable (variable costs plus 10% contribution must be met)

Input	Data Source
reposition miles	---
rail varcost per cwt	Norfolk Southern Variable Costs (per cwt) Piedmont and Shenandoah line

Table 3-7 Sample Calculation of Total Logistics Costs for One Record Using a 3 X 2 Truck Configuration

Shipper/Commodity Characteristics	
Pounds/day	10,476.71
Pounds/yr	3,824,000
Pounds/Cubic Foot	16.63
Price Per Pound	$0.04
shelf life (days)	---
required protection (service) level	90%
inventory carrying cost factor	20%
Shipment Characteristics	
Option	4 (Mode)
mode/axle config	3-S2
network miles	314.01
repositioning miles	314
line-haul miles	628
pickup miles	0
delivery miles	0
days between orders	5.0
Modal Characteristics	3-S2
payload in lb	52,441
payload in cubic ft	999,999
linehaul cost/mile	$1.34
pickup $/ship	$0.00
pickup $/mile	$0.00
delivery $/ship	$0.00
delivery $/mile	$0.00
load/unload hrs	0.50
wage rate/hr w/fringes	$20.00
tare weight of the vehicle	27,559
Modal Performance	3-S2
wait time	0.50
transit time	1.26
Loss & Damage (L&D) as percent of gross freight revenue	0.07%
expected L&D claim per shipment	$0.59
claim payment days	60
legal payload	52,441

Shipper/Commodity Characteristics	
Shipment Output	3-S2
maximum shipment lbs by cube	14,963,463
maximum shipment lbs by weight	52,441
final lbs in shipment	52,441
GVW in lbs	80,000

Table 3-7 Sample Calculation of Total Logistics Costs for One Record Using a 3 X 2 Truck Configuration (Continued)

Shipper/Commodity Characteristics	
transport charges per ship	848
no. shipments/yr	73
transport charges/yr	61,866
days of safety stock	0.9
Non-Transportation Logistics Costs	3-S2
order cost	$1,094
in-transit stock carrying cost	$74
cycle stock carrying cost	$196
loss & damage claims	$43
capital cost on claims	$1
safety stock carrying cost	$73
total	$1,481
Annual Total Costs	3-S2
transportation	$61,866
transportation & logistics	$63,347
Annual Total Costs Per Cwt	3-S2
logistics (non-transportation)	$0.04
transportation	$1.62
transportation and logistics	$1.66

3.6.3 Norfolk Southern Staff Input to ITIC

After consultation with Norfolk Southern Railroad staff,[21] the mode diversion analysis was refined to include recommendations on estimating rail line haul costs, trailer equipment costs, and operating speeds on the railroad. The railroad indicated that initial estimates of current operating speeds were too high, and provided current operating speeds for intermodal service. The railroad also recommended the modification of estimates for rail line

21 Norfolk Southern meetings summarized in Appendix F.

haul costs using "Plan 1.0" in the Uniform Rail System Costing Model. Plan 1.0 provides costs by weight and distance for ramp to ramp service only on the railroad.

3.6.4 Modally Competitive Movements

The Transearch™ database provides the base data for this analysis. Transearch™ provides commodity detail to the four digit level as well as the annual tonnage for a particular commodity flow between an origin and destination. Only records that have been assigned to I-81 were analyzed. It is also important to note that only movements greater than 500 miles were assumed to be divertible to rail. Table 3-8 is representational of the truck trip table format, and provides a summary of the movements that were analyzed. The commodity flow movements that were analyzed are highlighted in gray. County to county movements in Virginia, and shorter inter-state movements were not included in the analysis. Movements that meet the following criteria were selected for analysis:

- **Lane Density —** Over 12.5 tons moved annually; and
- **Distance —** The distance between the origin and destination of the movement will be greater than 500 miles.

Table 3-8 Movements Evaluated for Diversion Potential in the I-81 Study Area (Shaded Areas)

Origin	All I-81 Counties (37)	Rest of Virginia	Rest of US
All I-81Counties (37)	No mode diversion is expected for shipments between Virginia Counties.		
Rest of Virginia			
Rest of US			

Some of these factors were supported by statements in reports summarized in the literature review as key to identifying modally competitive movements. The study by Reebie does not identify the commodities they selected for diversion analysis.[22] Other considerations about market potential and proximity to intermodal facilities are made when selecting commodity flow movements for analysis. The HJR-704 study and the Marketing study identify significant intermodal facilities operated by CSX and Norfolk-Southern on the East Coast. Proximity to these facilities was also evaluated.

22 *The Northeast-Southeast-Midwest Corridor Marketing Study,* Virginia Department of Rail and Public Transportation, 2003.

4

Existing Freight Movement

This chapter describes the characteristics of shippers/receivers, carriers, and truck movements on I-81 based on the surveys conducted for the *I-81 Corridor Improvement Study*. The I-81 Freight Shipper/Carrier Survey was designed for truck traffic that originates or terminates in cities and counties within the I-81 study area. The I-81 Truck Intercept Survey was designed to capture "through traffic" that utilize I-81 for interstate trips with neither origin nor destination in the I-81 study area. The results of both of these surveys are described in the following sections.

4.1 Freight Shipper/Carrier Survey

A total of 107 responses to the I-81 Freight Survey were returned. Survey responses were received from business and government entities in ten states. As shown in Table 4-1, a majority were from Virginia addresses. Responses were received from as far away as Kansas, Iowa, Wisconsin, and Arkansas.

Table 4-1 State of Respondents to I-81 Freight Surveys

State	Number of Responses	Percent
Virginia	84	78.5%
Tennessee	6	5.6%
Pennsylvania	5	4.7%
North Carolina	4	2.8%
All Others	9	8.6%
Total	107	100.0%

4.1.1 Class of Business

Approximately 72 percent of respondents were chain, branch, or franchise operations. Nearly 25 percent were independent operations (*e.g.*, sole proprietors, independent contractors,

governmental entities). Table 4-2 below summarizes the class of business for the survey respondents.

Table 4-2 Business Class of Respondents to I-81 Freight Surveys

Business Class	Number of Responses	Percent
Chain/Branch/Franchise	77	72.0%
Independent Operation	27	25.2%
Government	1	0.9%
Other/Unknown	2	1.9%
Total	107	100.0%

4.1.2 Number of Employees

Most of the respondents have operations that employ large numbers of workers. A majority of survey respondents employ 100 or more workers (see Table 4-3).

Table 4-3 Size of Business of Respondents to I-81 Freight Surveys

Number of Employees	Number of Responses	Percent
1 to 4	3	2.8%
5 to 9	4	3.7%
10 to 19	12	11.2%
20 to 49	20	18.7%
50 to 99	14	13.1%
100+	54	50.5%
Total	107	100.0%

4.1.3 Type of Business

A breakdown on business types of respondents is provided in Table 4-4 below.

Table 4-4 Type of Business of Respondents to I-81 Freight Surveys

Business Type	Number of Responses	Percent*
Motor Carrier/Truck Operator	50	46.7%
Manufacturing	35	33.6%
Distribution Center	29	27.1%
Truck Service/Fueling/Repair	4	3.7%
Construction	1	0.9%
Other	11	10.3%
Total	107	NA

* Percentages in the table sum to more than 100 percent because some respondents checked more than one box.

A number of survey respondents are in the motor carrier/truck operator business. Almost one-third of respondents indicated that they are manufacturers, while 27 percent indicated they are in the warehousing/distribution center business. Survey respondents in the motor carrier industry include national carriers, regional trucking companies, and an owner-operator. Manufacturers that responded to the survey reflect the broad variety of goods that are produced in the I-81 study area. Respondents in the warehousing/distribution center industry include national retailers, refrigerated and frozen food logistics centers, and a television and internet shopping order fulfillment center.

4.1.4 Shipper/Receiver and Carriers

Survey respondents were classified as a shipper/receiver or a carrier. The results are provided in Table 4-5. Over 51 percent of the 107 survey responses were classified as shipper/receivers only; 44 percent were carriers only. Two survey responses were from operations that were both carriers and shipper/receivers.

Table 4-5 Classification of Respondents to Survey

Types of Facilities	Total	Percent
Shipper/Receiver Only	55	51.4%
Carrier Only	47	43.9%
Both	2	1.9%
Neither/Other	3	2.8%
Grand Total	107	100.0%

Locations

For freight movement, the I-81 study area corridor is defined as the thirteen counties traversed by I-81 and the independent cities therein. As indicated in Table 4-6, the majority of the shipper/receivers that responded to the survey are inside the I-81 study area (86 percent). Nine percent are elsewhere in Virginia and the remainder are outside of Virginia (5 percent).

Table 4-6 Location of Shipper/Receivers

Location	Number of Facilities	Percent
Inside Virginia I-81 Corridor	49	85.0%
Elsewhere in Virginia	5	8.8%
Outside Virginia	3	5.3%
Total Shipper/Receivers	57	100.0%

As shown in Table 4-7 below, most motor carriers that responded to the survey were based outside of the I-81 study area. A number of the carrier companies were from outside Virginia (44 percent) and another 27 percent were based within Virginia, but outside of the I-81 study

area. Just 29 percent of responses were from motor carrier operations within Virginia's I-81 counties. The significance of a large share of carrier companies outside of Virginia demonstrates the importance of I-81 in serving enterprises throughout the country.

Table 4-7 Location of Carriers

Location	Number of Carriers	Percent
Inside Virginia I-81 Corridor	15	30.6%
Elsewhere in Virginia	13	26.5%
Outside Virginia	21	42.9%
Total Carriers	49	100.0%

Types of Products

The survey asked shipper/receivers about the types of products shipped and received at their facilities. Similarly, motor carriers were asked about products they transported. The product type categories are defined in Table 4-8. Respondents self-selected the product type categories based on these examples. They were invited to check as many categories as accurately reflected the cargo mixes through their facilities. The product type categories and definitions are based closely on those in the U.S. Census Bureau's Vehicle Inventory and Use Survey (VIUS) form.

Table 4-8 Definition of Product Type Categories

Product Type Categories	Examples of Products Within Category
Raw Agricultural and Animal Products	crops, livestock, animal feed
Food Products, Alcohol, and Tobacco	meat, bakery products, dairy products, prepared foodstuffs
Forestry, Wood, and Paper Products	logs, lumber, paper [EXCEPT furniture]
Chemicals & Chemical Products	basic chemicals, fertilizers, pharmaceuticals
Petroleum Products (Refined)	plastics and rubber, gasoline, fuel oils
Mining Materials (Raw Form)	coal, sand, gravel, ores, crude petroleum, salt, clay
Manufactured Metal and Mineral Products	metal bars, rods, pipes, nails, screws; cement; concrete products, bricks; glass
Other Manufactured Products or Equipment	furniture, tools, electronics, cameras, clocks, machinery, textiles, vehicles, aircraft, boats etc.
Waste, Refuse, Recycling	hazardous waste, trash, yard waste, recyclable products
Other	mail and courier parcels, mixed freight, unknown

* Some respondents checked only the "Other" box and listed all of the products that they handle next to it in lieu of checking off other boxes. Consequently, there was under-reporting of the other product types. Data analysis would be more accurate for this question if "other" cargos were re-assigned cargos to the appropriate product type categories.

Products Shipped/Received

Fifty-seven shipper/receivers responded to the survey. The eight facilities outside of the I-81 study area were removed from the analysis because they were not part of the target survey audience and did not have origin or destinations within the corridor. This left 49 shipper/receiver facilities located in the study area.

Table 4-9 shows the number of shipper/receiver facilities inside the I-81 study area that move each product type and the percentages out of all shipper/receivers.

Approximately 41 percent of shipper/receiver facilities in the I-81 study area reported that they receive Other Manufactured Products or Equipment. The other product types that are most commonly received are Manufactured Metal Products (39 percent) and Chemical Products (35 percent).

The shipping category with the highest percentage of facilities was "Other" (43 percent), followed by Other Manufactured Products (29 percent), and (Processed) Food Products, Alcohol, and Tobacco (25 percent).

Table 4-9 Product Types Received and Shipped at Facilities: I-81 Study Area

Product Type	Number of Facilities Receiving	Number of Facilities Shipping	Percent of Facilities Receiving*	Percent of Facilities Shipping*
Raw Agricultural & Animal Products	3	3	6.1%	6.1%
Food Products, Alcohol, & Tobacco	14	12	28.6%	24.5%
Forestry, Wood, and Paper Products	15	6	30.6%	12.2%
Chemicals & Chemical Products	17	5	34.7%	10.2%
Petroleum Products (Refined)	14	4	28.6%	8.2%
Mining Materials (Raw Form)	3	1	6.1%	2.0%
Manufactured Metal & Mineral Products	19	8	38.8%	16.3%
Other Manufactured Products or Equipment	20	14	40.8%	28.6%
Waste, Refuse, Recycling	2	6	4.1%	12.2%
Other	18	21	36.7%	42.9%
Number of Facilities	49	49	NA	NA

* Percentages in the table sum to more than 100 percent because respondents were permitted to identify multiple cargo types at each facility.

Products Transported

Table 4-10 presents information on the types of products transported by motor carriers in the I-81 study area.

A number of motor carriers responded that they transported Other Manufactured Products (42 percent) and products in the Other category (both 42 percent). The next highest category was Petroleum Products (33 percent). Many of the respondents who marked the "Other" category explained that they haul mixed freight. Some marked "Other" merely to emphasize that they were motor carriers and not shipper/receivers. In other cases, they were uncertain how to classify their products and checked "Other" to specify what they haul (e.g., "general commodities," mixed freight, household goods, milk, household goods).

Table 4-10 Product Types Transported by Motor Carriers: I-81 Study Area

Product Type	Number of Carriers	Percent
Raw Agricultural & Animal Products	7	14%
Food Products, Alcohol, & Tobacco	14	29%
Forestry, Wood, and Paper Products	14	29%
Chemicals & Chemical Products	10	20%
Petroleum Products (Refined)	17	35%
Mining Materials (Raw Form)	6	12%
Manufactured Metal & Mineral Products	13	27%
Other Manufactured Products or Equipment	21	43%
Waste, Refuse, Recycling	5	10%
Other	21	43%
Number of Carriers	49	NA

* Percentages in the table sum to more than 100% because respondents were permitted to identify multiple cargo types at each facility.

A number of motor carriers responded that they transported Other Manufactured Products (42 percent) and products in the Other category (both 42 percent). The next highest category was Petroleum Products (33 percent). Many of the respondents who marked the "Other" category explained that they haul mixed freight. Some marked "Other" merely to emphasize that they were motor carriers and not shipper/receivers. In other cases, they were uncertain how to classify their products and checked "Other" to specify what they haul (e.g., "general commodities," mixed freight, household goods, milk, household goods).

Length of Truck Hauls

As shown above in Table 4-6, forty-nine shipper/receivers inside the I-81 study area responded to the survey. Table 4-11 summarizes the ranges of trucks that serve these facilities. Most of the facilities that responded to the survey have long-distance truck traffic.

Some facilities indicated an inclination to mark both the "long distance" and "local" boxes. For example, a Roanoke soft drink bottler and distributor is primarily a "local" operation," but it does distribute beyond a 50-mile radius of its plant.

Table 4-11 Range of Most Trucks To/From Shipper/Receiver Facilities: I-81 Study Area

Range	Number	Percent
Long Distance (more than 50-mile radius)	44	89.8%
Local (within 50-mile radius)	4	8.2%
Unknown	1	2.0%
Total	49	100.0%

Table 4-12 below shows that most carriers also are "long distance." Some carriers consider themselves to be both "local" and "long distance" trucking service providers. For example, a national motor carrier says that its two terminals in the I-81 study area are "city operations" (local) by day but "long distance" by night when "road runs" move the outbound volume up and down I-81. This carrier explained that it has two types of terminals: (1) "hubs" and (2) "end-of-the-line" facilities. "Hubs" handle "through volume;" truckloads are broken and re-distributed to trucks heading to other destinations. "End-of-the-line" (EOL) facilities are more localized, handling only volume that they pick up or deliver to customers that they serve in the vicinity of the EOL terminal.

Table 4-12 Local vs. Long Distance for Carriers

Length of Trip	Number	Percent
Long Distance (more than 50-mile radius)	43	87.8%
Local (within 50-mile radius)	9	18.4%
Total	49	NA

Truck Activity

The survey asked shipper/receivers to indicate the number of trucks that enter and exit their facilities every working day. Many respondents did not provide answers for both "inbound" and "outbound" trucks, so the results may be skewed. The survey also asked motor carriers to identify the number of trucks that move through their facilities on a daily basis. Carriers submitted separate responses for each yard. Many are located outside of Virginia.

Days of Operation

As shown in Table 4-13, about one-half of the surveyed shipper/receiver facilities in the I-81 study area operate five days per week. The remaining half operate six or seven days every week. A Wythe County plastics factory added that although it ships and receives five days per week, its production line operates seven days per week.

Table 4-13 Days of Operation for Shipper/Receivers: I-81 Study Area

Number of Days	Number of Facilities	Percentage of Facilities
1 to 4	0	0.0%
5	24	49.0%
6	10	20.4%
7	15	30.6%
Total	49	100.0%

Motor carriers are more likely to be seven-days-per-week operations than shipper-receivers. Just under one-half of carriers operate every day; while one-fourth operate six days/week.

Table 4-14 Carrier Days of Operation

Number of Days	Number of Facilities	Percentage of Facilities
1 to 4	1	2.0%
5	12	24.5%
5½	1	2.0%
6	12	24.5%
7	22	44.9%
Unknown	1	2.0%
Total	49	100%

Peak Hours

Nearly 71 percent of the shipper/receiver facilities surveyed have hours when they are busiest (see Table 4-15).

Table 4-15 Peak Hours at Shipper/Receiver Facilities: I-81 Study Area

Peak Hour at Facility	Number of Facilities	Percentage of Facilities
Yes	35	71.4%
No	13	26.5%
Unknown	1	2.0%
Total	49	100.0%

Table 4-16 shows the peak hours identified by the 35 facilities that claimed to have them. The survey listed four peak-hour time periods. The percentage of facilities sums to more than 100 percent because survey respondents were permitted to identify with more than one time period. Nearly 63 percent of surveyed shipper/receivers in the I-81 study area said that 10

a.m. to 4 p.m. is their busiest time period. Some distribution centers indicated that the morning (5:00 to 10:00 AM) and evening (4:00 to 7:00 PM) time periods were their busiest.

Table 4-16 Peak Hours for Shipper/Receivers: I-81 Study Area

Peak Hour Time Period	Number of Facilities	Percentage of Facilities*
5-10 am	17	48.6%
10am-4pm	22	62.9%
4-7pm	12	34.3%
7pm-5am	1	2.9%
Number of Facilities	35	NA

* The "percentage of facilities" column sums to more than 100 percent because the survey permitted respondents to mark more than one box for peak-hour time period.

Most motor carriers that responded to the survey also have peak hours of operation. Table 4-17 indicates that nearly 80 percent of carrier respondents said that they have peak hours.

Table 4-17 Motor Carriers: Peak Hours

Peak Hour	Number of Carriers	Percentage of Carriers
Yes	39	79.6%
No	4	8.2%
Unknown	6	12.2%
Total	49	100.0%

Table 4-18 shows peak hours identified by motor carriers that have them. The busiest time period was 5 to 10 a.m.

Table 4-18 Motor Carriers: Peak Hours Identified

Peak Hour Time Period	Number of Carriers	Percentage of Carriers*
5-10 am	23	59.0%
10am-4pm	17	43.6%
4-7pm	10	25.6%
7pm-5am	10	25.6%
Total	39	NA

* The "percentage of carriers" column sums to more than 100 percent because the survey permitted respondents to mark more than one box for peak hour.

Peak Months

Over 63 percent of the shipper/receiver facilities surveyed have peak months of operation (Table 4-19).

Table 4-19 Presence of Peak Months for Shipper/Receivers: I-81 Study Area

Peak Month at Facility	Number of Facilities	Percentage of Facilities
Yes	31	63.3%
No	17	34.7%
Unknown	1	2.0%
Total	49	100.0%

Table 4-20 presents the peak months identified by the thirty shipper/receiver facilities that have them. The busiest month is September. The months that are least likely to be peak months are January through April.

Table 4-20 Peak Months Identified for Shipper/Receivers: I-81 Study Area

Peak Months	Number of Facilities	Percentage of Facilities*
January	6	19.4%
February	7	22.6%
March	9	29.0%
April	9	29.0%
May	13	41.9%
June	16	51.6%
July	15	48.4%
August	16	51.6%
September	22	71.0%
October	16	51.6%
November	16	51.6%
December	15	48.4%
Total	31	NA

* The "percentage of facilities" column sums to more than 100 percent because the survey permitted respondents to mark more than one box for peak month.

As shown in Table 4-21, 73 percent of surveyed motor carriers said that they have peak months of operation.

Table 4-21 Motor Carriers: Peak Months

Peak Month	Number of Carriers	Percentage of Carriers
Yes	36	73.5%
No	11	22.4%
Unknown	2	4.1%
Total	49	100.0%

Table 4-22 below shows the peak months identified by the 36 motor carriers that indicated they have them. September and October tied for the busiest months. January was a high-volume month for the fewest carriers. A national motor carrier explained that the late summer and early fall months are busiest because of manufacturing cycles and retail demands (i.e., Thanksgiving, Christmas).

Table 4-22 Motor Carriers: Peak Months Identified

Peak Months	Number of Facilities	Percentage of Peak Months
January	5	13.9%
February	8	22.2%
March	14	38.9%
April	9	25.0%
May	14	38.9%
June	13	36.1%
July	10	27.8%
August	19	52.8%
September	32	88.9%
October	32	88.9%
November	18	50.0%
December	7	19.4%
Total	36	NA

* The "percentage of peak months" sums to more than 100% because the survey permitted respondents to mark more than one peak month.

4.1.5 States of Origin and Destination of Cargo

Cargo Origin

The Census Bureau's 1997 Commodity Flow Survey (CFS) collected data about freight movements to and from Virginia as a whole. Table 4-23 lists the top states of origin for Virginia-destination freight movements (by value) in 1997.

Table 4-23 Origin State of Freight Movements to Virginia – 1997

State of Origin	Value($ million)	Percent of U.S. Total	Percent of U.S. Total Minus Virginia
Virginia	41,900	27.5%	-
North Carolina	12,966	8.5%	11.8%
Maryland	11,014	7.2%	10.0%
Pennsylvania	6,087	4.0%	5.5%
California	5,456	3.6%	4.9%
New York	4,851	3.2%	4.4%
Tennessee	4,664	3.1%	4.2%
Ohio	4,406	2.9%	4.0%
Texas	4,313	2.8%	3.9%
Illinois	4,123	2.7%	3.7%
Michigan	3,616	2.4%	3.3%
All Other States	48,765	32.0%	44.2%
U.S. Total	152,161	100.0%	100.0%

Source: U.S. Census Bureau, 1997 Economic Census, Commodity Flow Survey, Virginia, Table 8.

The dominant state of origin of freight movements to Virginia is the Commonwealth of Virginia itself. Virginia-to-Virginia movements accounted for more than one-quarter of freight movements to Virginia destinations in 1997, according to the CFS. The next largest states of origin for freight traffic to Virginia were North Carolina, Maryland, and Pennsylvania.

The statistics above include freight moved by all transportation modes from all parts of the state, not just cargo moved by truck from the I-81 study area. To get information specific to I-81, the shipper/receiver survey conducted for the *I-81 Corridor Improvement Study* asked respondents to identify the top three states of origin of cargo, other than Virginia. The results are shown in Table 4-24. The most common response to the survey was North Carolina, followed by Pennsylvania, Maryland, New York, and Tennessee. Interstate 81 traverses these five states. The only I-81 state that was not near the top of the list was West Virginia. [23]

23 The correlation between the Census and Project Team surveys is imperfect because the Shipper/Carrier Survey includes motor carriers that use Virginia's I-81 but do not necessarily ship from or deliver to locations within Virginia.

Table 4-24 States of Origin of Virginia-Destination Cargo, I-81 Freight Survey (2004)

Origin State	Number of Responses	Percentage of Respondents
North Carolina	45	42.1%
Pennsylvania	41	38.3%
Maryland	26	24.3%
New York	24	22.4%
Tennessee	22	20.6%
Ohio	18	16.8%
Georgia	11	10.3%
New Jersey	10	9.3%
South Carolina	9	8.4%
West Virginia	8	7.5%
California	6	5.6%
Illinois	6	5.6%
Michigan	5	4.7%
Texas	5	4.7%
International	4	3.7%
Other	20	18.7%
Total Survey Forms	107	100.0%

Cargo Destination

Table 4-25 lists the top states of destination for Virginia-origin freight movements (by value) in the 1997 Commodity Flow Survey (CFC). Note that these statistics include freight moved by all transportation modes from all parts of the state, not just cargo moved by truck from the I-81 study area. The CFS found that more than one-third of cargo (by value) shipped from Virginia was also received within the Commonwealth. North Carolina, New York, Pennsylvania, and Maryland were the next largest recipients of Virginia-origin freight.

Table 4-25 Destination State of Freight Movements from Virginia – 1997

State of Destination	Value ($ million)	Percent of U.S. Total	Percent of U.S. Total Minus Virginia
Virginia	41,900	34.1%	-
North Carolina	8,171	6.6%	10.1%
New York	6,436	5.2%	7.9%
Pennsylvania	6,272	5.1%	7.7%
Maryland	6,143	5.0%	7.6%
Georgia	4,234	3.4%	5.2%
New Jersey	3,990	3.2%	4.9%
California	3,979	3.2%	4.9%

Table 4-25 Destination State of Freight Movements from Virginia – 1997 (Continued)

State of Destination	Value ($ million)	Percent of U.S. Total	Percent of U.S. Total Minus Virginia
Ohio	3,596	2.9%	4.4%
Texas	3,158	2.6%	3.9%
Florida	3,124	2.5%	3.9%
All Other States	31,977	26.0%	39.4%
U.S. Total	122,980	100.0%	100.0%

Source: U.S. Census Bureau, 1997 Economic Census, Commodity Flow Survey, Virginia, Table 7.

Table 4-26 shows responses to the survey conducted specifically for the I-81 study area.

Table 4-26 State of Destination of Virginia-Origin Cargo, I-81 Freight Survey (2004)

Destination State	Number of Responses	Percent of Responses
Pennsylvania	41	38.3%
North Carolina	37	34.6%
New York	30	28.0%
Maryland	28	26.2%
Tennessee	22	20.6%
Ohio	12	11.2%
West Virginia	11	10.3%
South Carolina	8	7.5%
Georgia	8	7.5%
New Jersey	8	7.5%
Texas	7	6.5%
Florida	7	6.5%
Indiana	6	5.6%
California	6	5.6%
Michigan	5	4.7%
Illinois	5	4.7%
International	8	7.5%
Other	10	9.3%
Total Survey Forms	107	NA

The most common state of destination for their cargo was Pennsylvania, followed by North Carolina, New York, Maryland, and Tennessee. I-81 runs through all five of these states.

4.1.6 Freight Movement on I-81

I-81 is crucial to both shipper/receivers and to motor carriers. All of the survey respondents that answered the question said that their trucks use I-81 (see Table 4-27).

Table 4-27 Usage of I-81

Answer	Number of Responses
Yes	103
No	0
Unknown	4
Total	107

The survey also asked respondents to indicate the percentage of their trucks that travel on I-81. Table 4-28 presents the results for motor carriers. For approximately half of the carriers, over 50 percent of their trucks trips are on I-81. Seven carriers said that 100 percent of their trucks use I-81. Note that these responses are not weighted by the intensity of use. A respondent that has one truck is weighted the same as one that has more than one hundred. Also, there may have been a response bias since shipper/receivers and carriers that most heavily use I-81 in Virginia may have been more likely to respond to the survey.

Table 4-28 Motor Carriers: Percentage of Truck Trips Using I-81

From	To	Number of Carriers	Percent Total
0	10%	9	20.5%
10%	20%	4	9.1%
20%	30%	4	9.1%
30%	40%	2	4.5%
40%	50%	2	4.5%
50%	60%	2	4.5%
60%	70%	4	9.1%
70%	80%	1	2.3%
80%	90%	5	11.4%
90%	100%	11	25.0%
Total		44	100.0%
Mean			54.7%
Median			57.5%

Table 4-29 presents the percentages of truck trips to and from shipper/receiver facilities within the I-81 study area. Of the 49 shipper/receivers inside of the study area that responded to the survey, 46 answered this question. The responses were clustered at the high end of the range; the median facility said that 96.5 percent of its trucks use I-81. The mean is 90.9 percent. Eighteen facilities said that 100 percent of the trucks that serve them use I-81. The median percentage is higher than the mean because responses are skewed to the high end of the scale. Table 4-29 does not include shipper/receivers located outside of the I-81 study area.

Table 4-29 Shipper/Receivers in I-81 Study Area: Percentage of Truck Trips Using I-81

From	To	Number of Facilities	Percent of Total
0	10%	0	0.0%
10%	20%	0	0.0%
20%	30%	1	2.2%
30%	40%	0	0.0%
40%	50%	1	2.2%
50%	60%	0	0.0%
60%	70%	0	0.0%
70%	80%	7	15.2%
80%	90%	7	15.2%
90%	100%	30	65.2%
Total		46	100.0%
Mean			90.9%
Median			96.5%

4.1.7 Freight Movement on Rail

Railroad transportation is the primary alternative to trucking for movement of freight through the I-81 study area. Survey respondents were asked to indicate if they use railroad transportation, how much they rely on rail service, and why they use or do not use rail for freight movements.

Rail Usage

Table 4-30 presents the estimated rail usage by motor carriers. Three-quarters of the motor carriers surveyed said that they do not use railroad transportation. Many of the motor carriers that indicated use of rail in this survey are large national carriers that provide "piggyback" and other intermodal services that combine truck and rail in a single haul.

Table 4-30 Motor Carriers: Rail Use

Rail Use	Number of Carriers	Percent of Carriers
Yes	11	22.45%
No	37	75.51%
Unknown	1	2.04%
Total	49	100.0%

Table 4-31 shows the percentage of freight volume using railroad transportation that motor carriers reported in their survey responses. The rail volume is low at most carrier terminals; the median is 10 percent.

Table 4-31 Motor Carriers: Percentage of Freight Volume Using Railroad Transportation

Percent Freight on Railroad	Number of Carriers	Percent of Carriers
0-10	4	36.4%
11-20	2	18.2%
21-30	1	9.1%
31-40	0	0.0%
41-50	1	9.1%
51-60	0	0.0%
61-7-	0	0.0%
71-80	0	0.0%
81-90	1	9.1%
91-100	2	18.2%
Total	11	100.0%
Mean		33.6%
Median		10.0%

About one-third of shipper/receiver facilities in the I-81 study area that responded to the survey use rail, as shown in Table 4-32.

Table 4-32 Shipper/Receivers in I-81 Study Area: Rail Use

Rail Use at Facility	Number of Facilities	Percent of Facilities
Yes	17	34.7%
No	32	65.3%
Total	49	100.0%

Table 4-33 shows the extent to which individual shipper/receivers in the I-81 study area rely on railroad service. Thirteen facilities indicated their percentages of freight volume that use railroad transportation. Four facilities that answered that they use rail in Table 4-32 did not provide percentages. The median facility ships and/or receives 20 percent of its freight volume via railcars. A plastics plant stated that 70 percent of its freight volume is transported by rail; it noted that this was "inbound raw materials." That response did not specify if the 70 percent referred to just receipts. The facilities at the high end of the range include a distribution center in the northern Shenandoah Valley that receives 98 percent of its inbound products indirectly by rail through the Virginia Inland Port near Front Royal. The containers are drayed (trucked) from the Inland Port to the distribution center.

Table 4-33 Shipper/Receivers in I-81 Study Area: Percentage of Freight Volume Using Railroad Transportation

From	To	Number of Facilities	Percent of Facilities
0	10%	2	15.4%
11%	20%	3	23.1%
21%	30%	4	30.8%
31%	40%	0	0.0%
41%	50%	0	0.0%
51%	60%	0	0.0%
61%	70%	0	0.0%
71%	80%	2	15.4%
81%	90%	0	0.0%
91%	100%	2	15.4%
Total		13	100.0%
Mean			36.6%
Median			20.0%

Tables are not presented for the eight shipper/receiver facilities that are outside of the I-81 study area. Only two of the eight use rail services. The survey also asked respondents about their reasons for using or not using rail. Of the 106 responses to this question, 28 percent said that their facilities used rail. The facilities that use rail gave several different reasons for doing so:

- the intermodal nature of their business;
- their suppliers ship inputs by rail;
- their customers' request for rail;
- the products being transported are most suitable for rail; and,
- railcars have greater capacity and are cheaper than trucks.

The other 72 percent of respondents stated that they do not use rail in their operations. Their reasons break into six general categories:

- Time-sensitive cargo;
- Reliability of service;
- Rail movements are not feasible for short hauls;
- Not suitable for movement of many non-bulk products or just-in-time delivery systems;
- Not located on rail line or spurs; and,
- Insufficient quantities to justify rail deliveries or receipts.

4.1.8 Potential Improvements to I-81

The I-81 Freight Survey asked one open-ended question about improving I-81: "How can I-81 be improved to help your business?" The most common response was to widen I-81 to at least six lanes. Many respondents expressed concerns about specific segments and interchanges. Three respondents said that no improvements were needed or commended the highway's ease of use as it is currently built. The following sections describe responses in more detail based on category of responses.

Widen I-81

More than one-third of respondents expressed the need for additional lanes on I-81 in Virginia. A third-party logistics provider in Roanoke wrote, "Plain and simple, make [I-81] more truck friendly, widen the roads."

The highway presently is four lanes wide for most of its length. Many respondents suggested the addition of a third lane in each direction of travel, presumably throughout the 325-mile length of Virginia. One respondent said that the third lane would facilitate traffic flow past slower vehicles. Some respondents called for six-lanes through cities (especially Winchester, Harrisonburg and Roanoke) and on inclines (climbing lanes). Another respondent believed that merging lanes from on-ramps should be lengthened. A truck driver based in Iowa said that approaches to bridges on I-81 should be longer.

Some respondents believe that I-81 is now utilized beyond its capacity. A Virginia candy manufacturer wrote, "Presently there is to[o] much traffic on I-81 compared to what is was built for. I-81 needs [to be] updated with more traffic lanes."

At least one respondent believed that I-81 should have eight lanes, with trucks in the two outside lanes. A few of the survey responses suggested that a separate lane be constructed for the exclusive use of trucks. The Roanoke third-party logistics provider stated, "I like the idea of lanes for trucks separate from cars."

Other Potential Roadway Improvements

A handful of respondents suggested specific roadway improvements for I-81. A few concerned interchange structures. One recommended widening the off-ramps at Exit 317 (SR 37/Winchester). Elsewhere in the Winchester area another respondent said that I-81 and all interchanges from the West Virginia border (mile 325) to Stephens City (exit 307) should be upgraded. A Greensboro, NC trucking company said that overhead structures should provide greater clearance for I-81 traffic. A Stephens City trucking company called for yield signs to be installed at on-ramps. A Roanoke motor carrier says that all on and off ramps need to be extended "so slow trucks can have room to speed up & merge."

One respondent suggested interchange improvements at the Exit 247A cloverleaf (US 33/ Harrisonburg). He wrote, "The entrance & exit ramps merge & do not allow adequate room for three to four cars, much less a tractor-trailer. I travel by this exit daily and I have also experienced the same exiting/entrance problems when using this exit in my car."

A transportation safety administrator for a processing plant in upstate New York said that pavement quality on I-81 in Virginia should be improved in order to prevent driver back injuries and to decrease truck maintenance costs. A driver based in Iowa said that bumps on I-81 should be removed.

Finally, an intermodal transportation services provider in Roanoke says, "The same improvements that were done to 81 in Montgomery county need to be done in the Roanoke area as soon as possible to keep local traffic and thru traffic on separate segments of the interstate." The goal would be to minimize the number of exits and reduce problems associated with merging traffic.

Responding to Accidents and Re-scheduling Construction Projects

A few respondents said that travel on existing I-81 would be more efficient if the flow of traffic was more regular. They said that clean-up operations after accidents (e.g., removal of wrecked vehicles) could be streamlined. A response from Staunton says, "Don't take 5 hours to clear a wreck that could be cleared in 30 minutes." Another concern was the timing of construction projects so as to minimize the negative effects on traffic.

Improve Rest Areas

Five respondents replied that VDOT's truck rest areas were inadequate in terms of space constraints and time limits. They said that more spaces should be provided for heavy-duty trucks and that time limits for such vehicles should be significantly extended or eliminated.

Concerns about Possible Tolls

Approximately 20 respondents expressed concerns regarding possible tolls on I-81. Although the survey instrument made no mention of toll issues, the American Trucking Associations website link to the survey stated, "The results of this survey will be used to assess the impact of imposing tolls on I-81. Therefore we urge all members who use I-81 to complete and return this important survey to let the researchers know how tolls on I-81 will impact your business and customers."

Some survey respondents expressed disapproval of a scheme that would only impose tolls on trucks. A few said that the roads are already paid for with existing taxes and fees. At least one respondent said that if tolls are necessary to finance capacity improvements, then all users should be subject to the toll. "This cost needs to be shared by all who use I-81. Anything

less will force the backbone of this economy [trucks] to avoid I-81 altogether and potentially inhibit the economic future of this great state," said a manager at a small motor carrier in Danville, Virginia. Shipper/receivers within the I-81 study area expressed concern about how tolls would affect their finances. A purchasing director at a Pulaski County factory stated, "Keep it toll free! The tolls will be passed on to my company which will make [it] more difficult to compete in the market place. When we lay off people they do not pay taxes or spend money in the local [Virginia] economy." A Salem manufacturer wrote, "Tolls on trucks will put us at a competitive disadvantage!!"

A manager at a Roanoke motor carrier believes that truck-related taxes should be increased in lieu of tolling I-81. He wrote, "No tolls. Add tax to gasoline, tires, truck manufacturers to pay their way. Remember interstates were for moving goods + military use."

One respondent predicted that the toll for Virginia's portion of I-81 would exceed $100 one way, which he deemed too high. Several said that the competitive nature of the trucking industry, especially for owner-operators, makes it difficult to pass toll costs on to customers. Some speculated that shipper-receivers in the I-81 study area would suffer from the higher transportation costs. A Kansas truck driver wrote, "[W]ise up VA and look at other states that have toll roads and see how much their truck tolls [revenue] have dropped when they raised the cost... with fuel costs owner operators and companies will be cutting costs [else]where. I see a decline in toll roads being used first."

Amend Laws and Regulations

Some respondents had concerns about traffic laws and regulations on I-81 in Virginia. Approximately seven responses mentioned traffic speed. While some said that the speed limit should be increased (e.g., to 70 miles per hour), others believed that trucks were driving at unsafe speeds at the existing limit. Several respondents requested tighter enforcement of speed laws. The manager of a beverage manufacturing plant said that the existing 80,000 pound weight limit should be increased to the 100,000 to 120,000 pounds range. He said, "Tire number and width could be increased to cover the increased wear of heavier loads on the road surface. By increasing the payload, the number of trucks on the road could be decreased substantially."

Improve Rail Access as Alternative to or in Addition to I-81 Improvements

One survey respondent alluded to a proposal to reduce truck traffic on I-81 by improving railroad infrastructure and service in the region. A Lynchburg motor carrier wrote, "We keep hearing that rail could be the alternative to reduce truck traffic on I-81. Unfortunately we can't get the rail[road] to accept traffic from this area moving to and from the Northeast area."

4.1.9 Traffic Problems on I-81

The final question on the survey was an open-ended one that asked respondents to identify traffic problems related to truck movements on I-81. It asked, "Please identify any traffic problems related to I-81 truck movements (i.e., bottlenecks, congestion, safety)."

Only two respondents explicitly said that there were no traffic problems. A manager at a Pulaski County factory comments, "[I-81] seems to be working just fine the way it is." In contrast, another response simply states that "the entire corridor" is a traffic problem. The overwhelming majority of respondents gave answers that fit into two main categories: (1) congestion and (2) safety.

Congestion

About one-quarter of respondents cited congestion on I-81 as a traffic problem. A Roanoke shipping manager generally contends, "Congestion is terrible." "The volume of cars and trucks" is a traffic problem, says a manager at an Augusta County logistics/distribution center. Many specified the locations that experience it. Here is a sample of the comments, beginning at the northern end of I-81 in Virginia heading south:

- A Shenandoah Valley poultry distributor reports that there is congestion at the Harrisonburg exits that makes it difficult to enter/exit in both cars and tractor/trailers.
- A motor carrier based in the Staunton area says that there is truck congestion on the 80 miles between Buchanan and Harrisonburg.
- More than one respondent says that the I-81 segment near Exit 150 is a bottleneck. A plastics company in Botetourt County says that southbound I-81 near the truck scales (Exit 150 vicinity) is "very hazardous with southbound traffic merging with trucks trying to enter [the] scales. Since that area has developed, traffic is congested (because of traffic lights) entering at 150 South."
- Another company in Botetourt County says that the Daleville exit (150A/150B) is problematic and that I-81 is congested from Botetourt County (around the truck scales) through the Roanoke area to Salem.
- A Roanoke manufacturer/distributor believes that the entrance and exit ramps on I-581 are problematic.
- The Christiansburg and Wytheville-to-Bristol segments of I-81 are also said to have traffic problems.

The mountainous sections of I-81 (mostly four-lane) appear to hinder traffic. A Roanoke third-party logistics provider wrote, "[The] [o]nly traffic problems I really see are the mountains with trucks slowing down on the hills, when trucks get beside each other, slows down traffic, cars get frustrated and want to hurry around trucks." His remedy to provide "easier driving" is more traffic lanes or separate truck lanes.

Respondents also attributed the problem of congestion to traffic accidents, weather, construction, inclines, and cities. Eight respondents cited construction as a reason for the traffic congestion.

One respondent said, "Give more warning time for lane closures at construction sites. Try to do more work at night when traffic volume is lowest." Another respondent suggested better communication with drivers about weather conditions and traffic accidents.

Safety

Truck traffic congestion is also blamed for safety issues. The purchasing manager at a Roanoke factory says, "The accident rate in a 50 mile radius up + down I-81 is extremely high. The highway is far to[o] congested." A manager at an Alleghany County factory commented, "Heavy congestion (tractor trailer) makes passenger car safety a concern."

Respondents are concerned about the sizes of trucks and trailers, the volume of traffic, the speed of vehicles, unsafe driving behavior, and the incompatibility of passenger cars and trucks. A Shenandoah Valley distribution manager observed that trucks and trailers (53 feet) are longer now and "piggybacks" are more commonly used, possibly contributing to safety hazards.

The transportation manager for a distribution center in the Shenandoah Valley is critical of the I-66/I-81 junction. He wrote, "At the I-66 / I-81 interchange heading south, there is great potential for disaster. The oncoming lane to I-81 is the right lane and the ramp is short."

Seven survey responses note excessive speed of trucks and other vehicles on I-81. One respondent said, "Trucks travel beyond the speed limit constantly," and recommended enforcing the speed limit on trucks especially in the mountainous area near Christiansburg. Another two respondents note that passenger cars exceed speed limits and drive unsafely. Other respondents want trucks to stay only in the right hand lane. Another respondent believes that all vehicles should have a minimum speed limit or stay in the right lane because slower traffic is a safety hazard.

Some respondents believe that the highway patrol has under-enforced unsafe driving behavior such as tailgating, unsafe lane changes, aggressive, and distracted driving. A respondent from Roanoke thinks that tailgating trucks should be cited more frequently. A manager of linehaul operations for a motor carrier writes, "[L]aw enforcement seems lacking, not enough patrolmen."

A Mount Jackson food processor says that rainy days cause traffic problems and that congestion occurs before and after holidays.

Another safety issue on I-81 is vehicle incompatibility because of the high volume of trucks that travel the corridor. A motor carrier company in Cloverdale responds that passenger vehicles do not know how to travel with trucks, especially on southbound I-81 near Daleville (Exit 150), where cars merge with trucks that are entering weigh stations. A Winchester manufacturer says that the mixing of tractor-trailers with cars in the passing lane is "very dangerous" and would like to see trucks separated from cars.

A Kansas truck driver echoes the sentiment that passenger vehicles do not appropriately share the highway with trucks, "Maybe [Virginia] should teach their people how to share the road with trucks instead of acting like Californians that truckers are a menace to the general public - ask them how much they like eating and sleeping in beds and driving their fancy cars and wearing cloth[e]s, all of which moves by trucks."

Other Deficiencies

Traffic Information

A beverage manufacturer in the I-81 study area said that communication about accidents and weather conditions should be improved.

Enforcement

A manager of a motor carrier company in the Staunton area believes that law enforcement is insufficient along I-81. She also noted that more patrols are necessary in order to reduce unsafe driving behavior.

Rest Areas

Two respondents said that I-81 rest areas are insufficient. A Roanoke-based motor carrier company wants VDOT to build more rest areas for trucks. A soft drink bottler says, "Rest areas not sufficient."

Miscellaneous

A few comments do not fit with the other categories:

- A Roanoke motor carrier observed that VDOT had installed electronic signs on I-81 and asked that they be turned on.
- A Roanoke manufacturer says that snow removal is a problem.

One comment observed that truck mobility is impaired within cities and towns in the I-81 study area. A shipping supervisor from a Blacksburg factory thought that the mobility of large tractors was impeded by city traffic. He also complained about the lack of parking for local deliveries.

4.2 Truck Intercept Survey

4.2.1 Truck Type

Of the 220 truck drivers surveyed, 216 disclosed the type of truck they drove. An overwhelming majority of trucks surveyed at the nine truck stops were single-trailer. The five double-trailer vehicles were all surveyed at the two small Lancer truck stops in Elliston (Exit 128) and Dublin (Exit 101). Double-trailer vehicles tend to use the smaller stops because they are more advantageous for "relay" operations, where tractors from the same trucking company meet to exchange trailers.

As shown in Table 4-34, the majority of trucks captured in the intercept survey were Single Trailer types (90.5 percent), followed by Single Unit (3.6 percent), Multiple Trailer (2.3 percent), Tractor Only (1.4 percent) and Multiple Tractors (0.5 percent). The "Multiple Trailer" category was exclusively double trailers; triple trailers are illegal in Virginia. The "Other" category consisted of several tractors "piggybacking" on another tractor; these were new tractors that were being transported from the Volvo truck factory in Dublin, Virginia.

Table 4-34 Truck Types Surveyed

Truck Type	Number of Trucks	Percentage
Single Trailer (tractor + trailer)	199	90.5%
Single Unit	8	3.6%
Multiple Trailer (tractor + 2 trailers)	5	2.3%
Tractor Only	3	1.4%
Other (piggybacking tractors)	1	0.5%
Unknown	4	1.8%
Total	220	100%

Table 4-35 shows the breakdown of the number of axles on trucks. Ninety percent of all trucks surveyed had five axles; most of them were Single Trailer trucks. Double-trailer trucks may be under-represented in the survey because most of them stop at small truck stops or private truck yards; they also tend to have shorter hauls than the Single Trailer trucks making them less likely to utilize truck stops. Vehicles with fewer than five axles may be slightly over-represented in the survey because they were so rare at the large truck stops that the Project Team made a special effort to learn why they were there. The truck in the "Other" category was a tractor towing other tractors from the Volvo truck factory in Dublin, Virginia. Some vehicles have "liftable" axles; these axles were included in the count only if they were touching the pavement.

Table 4-35 Number of Axles on Trucks Surveyed

Number of Axles	Number of Trucks	Percentage
2	4	1.8%
3	5	2.3%
4	4	1.8%
5	198	90.0%
6	3	1.4%
11	1	0.5%
Other*	1	0.5%
Unknown	4	1.8%
Total	220	100.0%

* Special case with multiple tractors piggybacking

4.2.2 Cargo

Truck drivers carried a variety of types of cargo as indicated in Table 4-36. In order to analyze the survey data more effectively, it was condensed into 12 cargo types, including an 'Empty' and 'Unknown' category.

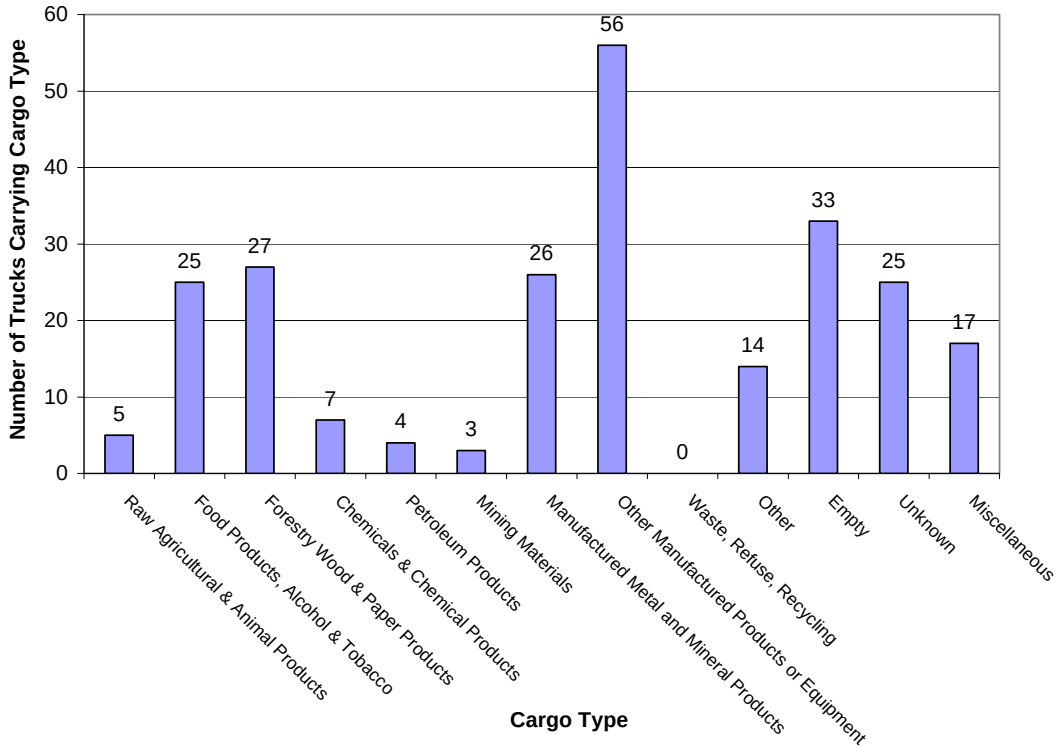
Over a quarter of truck drivers were hauling 'Other Manufactured Products or Equipment' (56 trucks). The reason for such a large number is probably due to the variety of products came under this category. Next, in number of trucks is by 'Forestry Wood & Paper Products' (27 trucks), followed by 'Manufactured Metal and Minerals Products' (26 trucks), and 'Food Products, Alcohol & Tobacco' (25 trucks).

Figure 4-1 below shows the distribution of number of trucks carrying each type of cargo. In some cases, a single truck was carrying more than one type.

Table 4-36 Type of Cargo Carried by Trucks

Cargo Category	Number	Percentage of all Respondents
Raw Agricultural & Animal Products	5	2.27%
Food Products, Alcohol & Tobacco	25	11.36%
Forestry Wood & Paper Products	27	12.27%
Chemicals & Chemical Products	7	3.18%
Petroleum Products	4	1.82%
Mining Materials	3	1.36%
Manufactured Metal and Mineral Products	26	11.82%
Other Manufactured Products or Equipment	56	25.45%
Waste, Refuse, Recycling	0	0.00%
Other	14	6.36%
Empty	33	15.00%
Unknown	25	11.36%
Miscellaneous	17	7.73%
Grand Total	N/A	N/A

Figure 4-1 Number of Trucks Carrying Each Cargo Type



As shown in Table 4-37, the survey also found that 16 percent of trucks on Virginia's section of I-81 are empty. The number of empties was essentially the same in both the northbound and southbound directions. More loaded trucks tended to be northbound than southbound. Out of the 84 percent trucks that were loaded the number of northbound trucks to southbound trucks was about four percentage points greater.

Table 4-37 Empty vs. Loaded Trucks

Empty/Load	Direction	Number of Trucks	Percent
Empty	Northbound	18	8.22%
Empty	Southbound	17	7.76%
Loaded	Northbound	94	42.92%
Loaded	Southbound	86	39.27%
Non 81		3	1.37%
Unknown		1	0.46%
Total		219	100.0%

4.2.3 Location of Home Base

The home base of a truck is the place where the vehicle is usually parked when it is not on the road. This definition was borrowed from the Census Bureau's Vehicle Inventory and Use Survey (VIUS). The top state for home base of trucks was Virginia. Almost fourteen percent of truck drivers surveyed said that their trucks were based in Virginia, while North Carolina and Tennessee each had 9.2 percent of trucks, followed by Pennsylvania (8.3 percent). These locations were located along the I-81 study area, or in the case of North Carolina connected to I-81 by Interstate I-77. As with the origins and destinations results, this survey result demonstrates the reliance of trucking companies on I-81 for moving goods.

4.2.4 Direction on I-81

The surveyors asked truck drivers about the direction they were headed and approximately half of the truckers surveyed answered that they were headed northbound and approximately 46 percent answered that they were heading southbound. Table 4-38 presents these data.

Table 4-38 Truck Heading

Truck Heading	Number of Trucks	Percent
Northbound	112	50.9%
Southbound	103	46.8%
Non-81	2	0.9%
None	3	1.4%
Total	220	100.0%

4.2.5 Origin/Destination

The top six origin states accounted for almost two-thirds of all the origins, as shown in Table 4-39. The largest share of the truck drivers originated their trips from Virginia (26 percent), followed by North Carolina (10.8 percent), Pennsylvania (10 percent), Tennessee (7.3 percent), Maryland (5.5 percent), and New Jersey (5.9 percent). Most of these states were along the I-81 Study area, except for North Carolina and New Jersey which are connected to I-81 through other interstate freeways, such as I-77.

Table 4-39 States of Origin

Origin State	Number of Trucks	Percent
VA	57	25.9%
NC	23	10.5%
PA	22	10.0%
TN	16	7.3%
NJ	13	5.9%
MD	12	5.5%
AL	7	3.2%
MA	7	3.2%
GA	6	2.7%
All Others	57	25.9%
Total	220	100.0%

Table 4-40 shows that again the top six states accounted for 58.2 percent of all destinations. Virginia accounted for the largest portion (22.7 percent).

Table 4-40 Destination States

Destination State	Number of Trucks	Percent
VA	50	22.7%
PA	20	9.1%
NC	19	8.6%
NJ	16	7.3%
TN	12	5.5%
TX	11	5.0%
MD	10	4.5%
NY	10	4.5%
AL	6	2.7%
All Others	66	30.0%
Total	220	100.0%

Approximately 131, or 58.4 percent, of all origin-destination pairs are from outside Virginia. Further analysis of the origin-destinations of each truck revealed that only 19 of the trucks were traveling intrastate (8.6 percent), the other 201 trucks were either coming from (38 trucks), going to (31 trucks), or going through Virginia (131 trucks). Since the survey was designed to capture the "through traffic" of this study area, therefore the fact that the majority of the trucks entered and exited from I-81 outside of Virginia was not a surprise. See Appendix C for a complete chart of all origin-destinations for the trucks surveyed. Note that not all Virginia origins and/or destination traffic visits I-81 truck stops, which is why there is a higher percentage of origin-destination pairs that are through traffic.

4.2.6 Entry and Exit Points

Close to half the trucks entered I-81 from outside of Virginia (47 percent) while more than half were planning on exiting I-81 outside of Virginia (54 percent). Table 4-41 reveals that most entries to I-81 were from other interstate freeways that connect to I-81. From north to south the entries were I-66 (10 percent), I-64 (12.3 percent), I-581 in the Roanoke Area (8.6 percent), and I-77 (11.4 percent). Almost nine percent of the trucks entered I-81 from other highways or from cities along I-81. Exits within Virginia from north to south were I-66 (7.3 percent), I-64 (12.7 percent), I-581 (4.5 percent) and I-77 (6.4 percent). Other exits from other highways or cities accounted for 13.2 percent of the trucks. There was imbalance of traffic at the northern boundary of I-81 with more trucks exiting from this location than entering. The complete list of entry-exit pairs is located in Appendix C.

Table 4-41 Total Number of Entries and Exits at Each Location on I-81

Locations	Entries	Percent	Exits	Percent
On I-81 at WV/VA Line	58	26.4%	67	30.5%
I-66	22	10.0%	16	7.3%
I-64	27	12.3%	28	12.7%
Roanoke Area	19	8.6%	10	4.5%
I-77	25	11.4%	14	6.4%
On I-81 at TN/VA Line	45	20.5%	51	23.2%
Other Interchanges within VA	19	8.6%	29	13.2%
Non 81	3	1.4%	3	1.4%
Unknown	2	0.9%	2	0.9%
Grand Total	220	100.0%	220	100.0%

4.2.7 Use of Toll Roads

The survey revealed toll roads were used by more than a third of all truck drivers, as shown in Table 4-42. Many drivers expressed displeasure at high tolls in certain states, but truck drivers who were not owner-operators did not mind tolls because their companies would pay the cost. Owner-operators were more concerned with the time it took to get to their destination. The questionnaire excluded toll bridges and tunnels because they are unavoidable on some routes, especially in the metropolitan areas of the northeast.

Table 4-42 Use of Toll Roads

Toll Roads	Number of Trucks	Percent
Use Toll Roads	74	33.6%
Do Not Use Toll Roads	137	62.3%
Unknown	9	4.1%
Total	220	100.0%

4.2.8 Use of Alternative Roads to Avoid Tolls

Most truck drivers noted that there was no real alternative to taking I-81. Some that were opposed to tolling said that they would have to take a look at a map to figure out another route, others said they would be forced to pay the toll because of the time-savings I-81 provided.

Table 4-43 shows that when all the truck drivers were asked whether they would use alternative routes to avoid tolls, the majority, almost 74 percent, stated that they would not use alternate routes. Of the respondents who indicated that they were using toll roads on this

trip, about one-fifth said that they were using alternate routes to reduce or avoid tolls. (As an example, a driver from the Philadelphia area to North Carolina used I-695 through the Baltimore area to bypass the toll tunnels and bridges in Baltimore Harbor).

Table 4-43 Respondents Who Would Use Alternate Routes if I-81 is Tolled

Alternate Routes	Number of Trucks	Percent
Use Alternate Routes	43	19.5%
Not Use Alternate Routes	162	73.6%
Unknown	15	6.8%
Total	220	100.0%

Some drivers used alternate routes to avoid tolls entirely. About 10 percent of respondents indicated that they were using alternate routes to avoid all toll roads on this trip. The results from this question could be skewed because many of the truck drivers were owner-operators that are strongly opposed to tolls along the I-81 study area.

Many respondents said that a toll on I-81would be most palatable if it were collected via an electronic system. First, an electronic system does not require a stop to pay a toll, allowing the driver to reach their destination faster. More than one driver complained about the toll collection practices in Illinois which require several payment stops. These drivers generally complained about the frequent stops rather than the toll amount. Second, the electronic toll-paying system spares some drivers of the burden of "fronting" the toll money and getting reimbursed for their toll expenses.

4.2.9 Other Observations

Some drivers expressed other concerns about I-81. A driver based in Arkansas complained about the parking time limits at state-run rest stops in Virginia. He said that the current two-hour limit is unreasonable. The driver was awoken from his nap at 2:00 AM and given a $166 fine for parking beyond his limit. He said that four or five hours is a more reasonable time limit.

5

Freight and Truck Trip Forecasts

5.1 2035 Freight Forecast

5.1.1 FAF Forecasting Results

The Freight Analysis Framework (FAF) outputs projects a growth in domestic freight flows of 3.4 percent from 1998 to 2010 and 2.4 percent from 2010 to 2020. The fastest growing sectors in the 1998-2010 projection segment are small packaged freight shipments, mail and other contract traffic. It is believed that small light packages will make up a larger share of total freight in the future. Areas showing the largest decline are shipper association traffic and fresh fish/marine products.

High and low growth forecasts were also included to forecast freight movement in light of stronger and weaker economic growth. A 3.7 percent growth average is expected in the high estimate and a 3.1 estimate is provided for the low in the period 1998-2010. Slower growth is projected in both scenarios, with an average growth rate of 2.7 percent in the 2010-2020 for the high scenario and 2.0 percent in the low scenario.

5.1.2 Virginia Specific Forecasts

According to FAF projections, trucks will continue to move the greatest tonnages of freight for the state of Virginia. Table 5-1 below shows highway movements are projected to increase from 339 million tons in 1998 to 612 million tons by 2020. Freight movement via rail is also projected rise from 158 million tons in 1998 to 234 million in 2020.

FAF also isolated the top five commodities moved to, from and within Virginia. These are illustrated in Table 5-2. Coal and nonmetallic minerals are projected to be the top two high volume commodities shipped throughout the forecast period.

Table 5-1 Virginia Freight Shipments 1998-2020 (To, From, and Within)

	Tons (millions)			Value (billions $)		
Virginia	1998	2010	2020	1998	2010	2020
State Total	530	753	904	346	680	1,115
By Mode						
Air	<1	1	1	30	73	129
Highway	339	495	612	290	560	914
Other[1]	9	13	16	1	2	3
Rail	158	209	234	19	33	52
Water	24	34	40	5	11	17
By Destination/Market						
Domestic	457	647	777	290	567	915
International	73	105	126	56	113	200

Note: Modal numbers may not add to totals due to rounding.
1 The "Other" category includes international shipments that moved via pipeline or by an unspecified mode.

Table 5-2 Top Commodities Shipped To, From, and Within Virginia by All Modes, 1998 - 2020

	Tons (millions)			Value (billions $)	
Commodity	1998	2020	Commodity	1998	2020
Nonmetallic Minerals	124	148	Transportation Equipment	63	157
Coal	121	169	Secondary Traffic	50	208
Secondary Traffic	49	135	Chemicals/Allied Products	28	74
Clay/Concrete/Glass/Stone	32	69	Machinery	27	111
Lumber/Wood Products	28	59	Food/Kindred Products	22	84

5.2 2035 Truck Forecast

Table 5-3 provides traffic forecasts at the VDOT permanent count station locations for the base year and 2035 design horizon. Traffic volumes are provided for combination trucks or heavy trucks. The final columns provide the annual and aggregate percent growth for trucks for each of the eight count stations. Truck traffic levels for 2035 at each of the 261 I-81 links are summarized in the future conditions network in Appendix E.

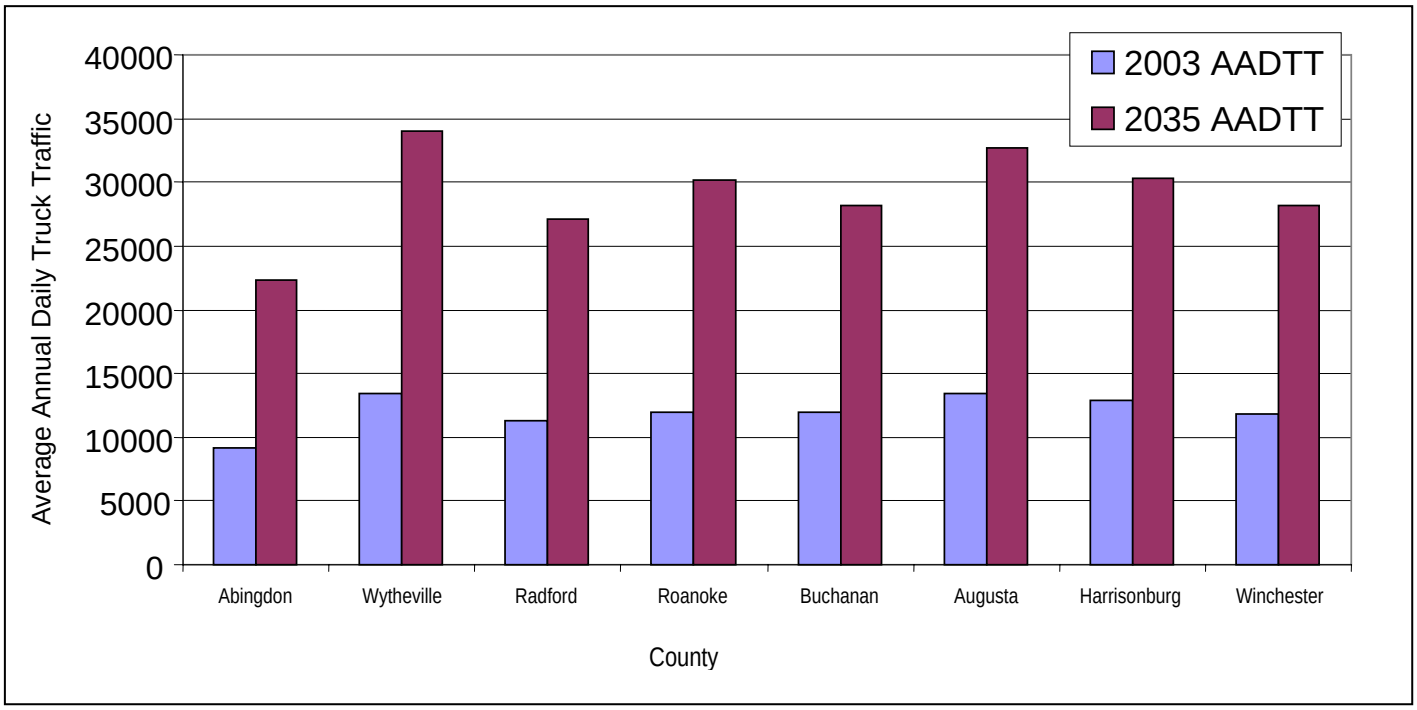
The growth of total trucks at individual count stations varies from 135 to 153 percent. These translate to directional compounded average annual growth rates of approximately 2.8 percent per year through 2035. These growth rates compare favorably to a compounded average annual growth rate for I-81 truck traffic of 2.96 percent predicted for the 1998 to 2020

period by the FAF model and a compounded average annual growth rate for I-81 freight flows of 2.45 percent predicted for the 2005 to 2020 period by the Virginia Statewide Model.

Table 5-3 Summary of I-81 Count Station Final Truck Volume and Growth Data

VDOT I-81 Count Station Identifiers I-81 Segment	Existing Average Annual Daily Heavy Truck Volume	2035 Average Annual Daily Heavy Truck Volume	Annual Growth	Aggregate Growth
Route 140 to South City Line of Abingdon	9,180	22,310	2.8 %	143 %
Route 11 to North City Line of Wytheville	13,450	33,970	2.9 %	153 %
Route 177 to Route 8 (near Radford)	11,240	27,120	2.8 %	141 %
Route 581 to Route 115 (Roanoke)	11,990	30,210	2.9 %	152 %
Route 11 to Route 11-614 (Buchanan)	11,970	28,130	2.7 %	135 %
Route 606 to Augusta County Line	13,480	32,750	2.8 %	143 %
Route 11 to Route 659 (Harrisonburg)	12,870	30,330	2.7 %	136 %
Route 50 to South City Line of Winchester	11,850	28,220	2.7 %	138 %

Figure 5-1 Summary of I-81 Count Stations Truck Volume Forecasts



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6 Freight Diversion Analysis

Future truck traffic on I-81, and the resultant corridor needs, will be determined in part by the portion of forecasted freight traffic that might divert to rail. This is especially important if the potential diversion reaches levels that are significant enough to affect the lane requirements of the roadway in 2035. Three studies funded by Virginia's Department of Rail and Public Transportation (DRPT) found potential for rail diversion and have heightened interest in this issue.[24] This chapter describes the results of the truck-rail modal diversion analysis completed for the *I-81 Corridor Improvement Study*.

6.1 Background

This study assumes that diversions to rail may occur due to two primary factors. The first is truck service may degrade due to increased congestion or added costs of tolls on I-81 which may cause shippers to use rail an alternative. The second is improved rail service speeds, reliability and cost reductions that result from rail improvements and the application of improved intermodal service. The rail improvement concepts considered in this study examined rail improvements only within the borders of Virginia[25]. It is logical to conclude that rail improvement could be made by the railroad owners or public entities outside of Virginia that would accrue additional benefits beyond those identified in this analysis by removing operational chokepoints, and increasing speeds and service reliability. This study assumed that the railroads will make the necessary improvements in the future to maintain capacity for expansion in their existing rail system both within and outside the borders of Virginia.

24 SJR-55 The Potential for Shifting Virginia's Highways to Railroads, HJR-704 The Virginia Intermodal Feasibility Study, and The Northeast-Southeast-Midwest Corridor Marketing Study.

25 The study also considered publicly-funded improvements outside Virginia's borders, and documented publicly-funded capital improvement plans in other states. However, no plans for the non-Virginia portions of the rail system were identified.

6.2 Rail Capacity Parameters

Previous DRPT studies examined the potential for rail diversion in the medium and long-term (2020) for both corridor-wide and Virginia only investments. Given the current study parameters to evaluate in-state rail improvements, the assumptions made by these previous studies regarding public capital spending outside the state, and the regional multi-state results were not considered applicable. The DRPT Virginia-based investment scenario is consistent with this study's assumptions as it limits public spending to Virginia, while assuming railroads will make additional capital improvements outside the state. The DRPT report states that this scenario represents a case where:

> "The Commonwealth takes independent action to invest in rail inside its borders, while its railroad partners act both outside and within the state."[26]

As a result, only the Virginia-based investment scenario and levels of diversion are relevant, and are summarized in Table 6-1.

Table 6-1 DRPT Estimates of the Diversion Impact of Virginia Based Investments (High Case)[27]

Period	Annual Loads Diverted	AADTT One-Way Loads Diverted	Percent of VA I-81 Forecast AADTT Diverted
Medium Term (2010)	501,000	686	10.4%
Long Term (2020)	501,000	686	5.2%

In the medium-term, the DRPT study estimates that 501,000 loads per year will be diverted, which represents an average of about 700 trucks per day in each direction. Moreover, there are no additional long-term diversions produced by the Virginia-based program. The DRPT report states that:

> "The reason for this [lack of additional diversions] is that all the capital is expended for medium-term improvements, and the Norfolk Southern system thereafter has reached capacity. More traffic cannot be absorbed without improvements in other states. Consequently, while freight traffic on the highway will continue to grow along with the economy, rail traffic cannot grow, and by the long term the effect of rail diversions will have diminished as a percent of I-81 truck volume."[28]

26 *The Northeast-Southeast-Midwest Corridor Marketing Study*, Virginia Department of Rail and Public Transportation, December 2003, 34.
27 *Ibid* 16.
28 *Ibid*,47.

The DRPT analysis assumes that the rail capacity required to accept the diverted trips will essentially remained fixed regardless of market forces. The assumption used in the analysis is that part of the agreement to secure public funds for capital investment will require a commitment by Norfolk Southern that the new intermodal service will be maintained regardless of the growth in captive or base load traffic. To maintain this agreement, especially until 2035, Norfolk Southern would have to invest in additional capital improvements or limit increases in the types of captive traffic that provide higher rates of return than the intermodal service.

Based on the findings of the previous studies, and using information obtained from Norfolk Southern, DRPT, and Reebie Associates, it is a distinct possibility that future diversions of truck freight on I-81 to rail mode could be restricted unless additional public investments are made to the rail infrastructure both inside and outside the Commonwealth of Virginia.

While rail improvements outside of Virginia are beyond the scope of this study, such improvements, if made, could accrue additional benefits beyond those identified in this analysis by further removing chokepoints and improving rail speeds and service reliability.

6.3 Initial Rail Concept Analysis

6.3.1 Screening

Initial Rail Concepts Tested

This study considered four "Build" rail improvement concepts, which are listed in Table 6-2 and described below. In accordance with study conventions, the assumption was made that the railroad will continue to make their normal capital improvements inside and outside Virginia.

Table 6-2 Initial "Build" Rail Improvement Concepts ($, Millions)

Rail Concept #	Rail Infrastructure (source)	Rail Rolling Stock (source)	Total
#1 Star Solutions	$111 (Source: Star Solutions proposal, page E-1, dated Sept. 5, 2003)	$0 (Same source - did not include rolling stock costs)	$111
#2 Piedmont Line	$267 (Source: Reebie report, Appendix 7 Attachment E table showing $39.1 Column A + $227.5 Column B = $267)	$229 (same source)	$496
#3 NSRR Pilot Intermodal	$280 (Source: NSRR spreadsheet titled "Pilot Project Capital Improvements 8-20-04" from Steve Eisenach, NS.)	$229 (same source – assumed as this is building on concept #2)	$509
#4 Steel Interstate	$3,200 (Source: Rail Solution, public data and confirmed with D. Foster.)	$300 (same source)	$3,500 ($3.5 billion)

A No-Build and four "Build" rail improvement concepts were modeled using the ITIC model described in Chapter 3, *Methodology*. The modeling results are discussed below. In each model run, certain assumptions about truck and rail modes were modified. An "Investment Recovery Factor" was built into the transportation costs to "recover" the investment in the rail improvements. In Rail Concept 1 no recovery factor was used because it did not include rolling stock costs, while for Concepts 2, 3 and 4, only the rolling stock costs were recovered, not the capital costs associated with the project. The amortization of the recovery costs were spread out over a period of 20 years, and as charged back to the shipper as a unit cost per hundred pounds.

The Recovery Factor was spread out over a portion of all tons projected to travel through the I-81 corridor. In Rail Concept 1 no investment recovery factor was used, while in Concepts 2 and 3 investment recovery factors were calculated estimating that five percent of all truck traffic would shift to rail. In Concept 4 it was spread over 46 percent of the tonnage projected to divert to rail (this represents the amount of diversions estimated by Rail Solution).

Calibration

The calibration stage of the model run assumed the defaults in the model for average truck speed at 50 mph and average rail speeds of 22.5 miles per hour on the Piedmont line. An estimate of existing average speeds was provided by the Norfolk Southern railroad. Transit time reliability defaults are provided in the model, and truck is presumed to be a more reliable mode than trailer-on-flat-car (TOFC) service by default. Intermodal load/unload times are assumed to be approximately one-half hour.

No-Build

In the No-Build case scenario, average speeds for truck were reduced by seven miles per hour to reflect the deterioration of level of service in the corridor, and the estimate of truck level of service deterioration was developed due to anticipated increases in congestion along I-81. These reductions were determined based on 2035 No-Build vehicle speeds calculated as part of the No-Build traffic analysis. Transit time reliability for truck was reduced by five percent while transit time reliability for rail service was unchanged. Load/unload times are also unchanged from the calibration estimate. The 2035 commodity flow model prepared for this study indicates that approximately 68 percent of all truck traffic has neither an origin nor a destination in Virginia and utilizes some portion of I-81 during their trip. The model was developed from user surveys and national freight information and was calibrated via actual truck counts at various locations along I-81.

Rail Concept 1— Star Solutions Proposal

The Rail Concept 1 modeled the Phase one level of rail improvements as recommended in the Star Solutions proposal *Phase Three Detailed Proposal – Improvements to I-81 Corridor*. This proposed concept calls for infrastructure investments of $111 million, but does not include

rolling stock costs. For this study, based on discussions with NSRR staff and analysis of the improvements, it was estimated that the infrastructure improvements would provide ten percent improvements to rail speeds, two percent improvements to transit time reliability, and no improvements to load/unload times at intermodal terminals. In this concept, shippers were also not charged a unit cost to recover a portion of the investment in rail.

Rail Concept 2 — Piedmont Line Improvements

The Rail Concept 2 expands upon the improvements described in Rail Concept 1, and modeled rail improvements as recommended in the Virginia Department of Rail and Public Transportation *Northeast-Southeast-Midwest Corridor Marketing Study*[29]. The concept includes capital improvements to the NS Piedmont Line from Danville to Manassas, Virginia, and extensive improvements west to Front Royal and then to the West Virginia line. One key feature is that it employs the Canadian Pacific (CP) Expressway technology which is an improvement to existing trailer-on-flatcar (TOFC) intermodal service. The CP service provides "drive-on, drive-off" capability, allows truck shipper to use existing trailer equipment, improves trailer load/unload times at terminals, and improves customer service operations at terminals. For the *I-81 Corridor Improvement Study*, it was estimated (based on extensive coordination with NSRR) that the infrastructure improvements would provide 25 percent improvements to rail speeds, five percent improvements to transit time reliability, and an improvement of 75 percent to load/unload times at intermodal terminals. For this concept, shippers would be charged a unit cost of 14 cents over 20 years to recover the rolling stock investment in rail.

Rail Concept 3 — Norfolk Southern Railroad Pilot Intermodal

Rail Concept 3 is a new Norfolk Southern pilot intermodal program that is based on a modified version of Rail Concept 2, and includes additional costs for infrastructure improvements. It uses the same rolling stock costs as shown in Rail Concept 2. For purposes of this study, it is estimated that the infrastructure improvements would provide the maximum improvement in rail speeds to 33 miles per hours (based on data provided by Norfolk Southern Railroad), 7.5 percent improvements to transit time reliability, and an improvement of 75 percent load/unload times at intermodal terminals. Shippers would also be charged a unit cost of 14 cents over 20 years to recover the rolling stock investment in rail.

Rail Concept 4 — Steel Interstate

Rail Solution is a rail advocacy group that proposes a major upgrade of the NS rail line in the Shenandoah Valley that would closely parallel the I-81 corridor. While the previous concepts focused on the NS Piedmont Line, Rail Concept 4 looks to turn the Shenandoah line into a

29 Ibid, Appendix 7, Attachment E

rail "steel interstate" described as "a modern, dual-track, high speed rail line, grade separated from all road crossings, capable of carrying intermodal and passenger trains at average speeds of 60-80 mph along Norfolk Southern's line between Harrisburg, PA, and Knoxville TN, and possibly beyond to Memphis and New Orleans."[30] Using publicly available data and interviews with Rail Solution, the concept would:

- closely parallel to I-81 the length of the corridor using the NS Shenandoah Line;
- include major upgrades to reduce vertical and horizontal curves and add double track through the entire corridor;
- include a second rail bridge over the Potomac River to reduce congestion;
- include new intermodal facilities near the I-64 and I-77 interchanges and Roanoke;
- include new railroad equipment that offers an "open intermodal technology," capable of handling all highway trailers, complete trucks or containers, and facilities capable of loading and unloading them quickly.
- consist of intermodal trains that could carry 50 equivalent truckloads each.
- allow travel at much higher speeds and at greater frequency than they do today.
- cost about $3.5 billion for capital improvements and rolling stock.

The source of the cost estimate is a 1999 NS Corporation study that showed a $2.3 billion estimate for various improvements to the Shenandoah Line. Rail Solution extended these improvements to include double-tracking, a new bridge over the Potomac River, new intermodal facilities and rolling stock, which add $1.3 billion to this base estimate. Unlike the previous concepts, specific locations of improvements have not been provided by the concept developer.

These improvements were modeled using an average operating speed improvement of 40 miles per hour, and increases in reliability for TOFC service of 10 percent. It was assumed in the analysis that average operating speeds on I-81 would deteriorate to 43 miles per hour, based on speed and delay calculations completed for the 2035 No-Build traffic volumes. Assumptions were made about improvements that rail variable costs would be reduced. An "Investment Recovery Factor" was built into the transportation cost for intermodal moves to "recover" the investment on the rail. In Rail Concept 4, only the rolling stock costs were recovered (as was done with the previous concepts). The amortization of the recovery costs were spread out over a period of 20 years, and as charged back to the shipper as a unit cost per hundred pounds.

Based on the results on the analysis, the levels of diversion were six percent of all truck trips diverted to rail. This represents about 1.2 million annual trips diverted to rail service.

30 Source: Rail Solution web page http://www.railsolution.org/ ; telephone meeting with David Foster.

6.4 Diversion Analysis Results

The results of the analysis are provided in Table 6-3 using the Uniform Rail Costing System (URCS) Plan 1.0 estimates for rail line haul variable costs. Variable costs are defined by the Federal Highway Administration Office of Highway Policy Information as costs incurred before a "contribution to their capital infrastructure and profit." The model was calibrated after rail line haul costs were raised by 35 percent above the variable cost. It was estimated that a low of 147,100 truck trips would be diverted for both directions with Rail Concept 1, to a high of 1,224,500 truck trips diverted annually in 2035 with Rail Concept 4.

Table 6-3 Mode Diversion Analysis Results Using URCS Plan 1.0 Estimates of Norfolk Southern Rail Variable Cost/Intermodal Transportation Costs

	No Build	Rail Concept 1 Star Solutions	Rail Concept 2 Piedmont Line	Rail Concept 3 NSRR Pilot Intermodal	Rail Concept 4 Steel Interstate
Truck Assumptions					
Speed (mph)	43	43	43	43	43
Transit Time Reliability[1]	0.42	0.42	0.42	0.42	0.42
Toll	$0.00	$0.00	$0.00	$0.00	$0.00
Rail Assumptions					
Speed (mph)	22.5	24.8	28.1	33.0	40.0
Transit Time Reliability[1]	0.45	0.44	0.43	0.42	0.38
Investment Recovery[2] (per hundredweight)	$0.00	$0.00	$0.14	$0.14	$0.02
Load/Unload Time (hours)	0.57	0.57	0.15	0.15	0.15
Truck Trailer Equipment Lease Rate	$20/day	$20/day	$20/day	$20/day	$20/day
Drayage Charge	$340.00	$340.00	$340.00	$340.00	$340.00
Drayage Distance (miles)	80	80	80	80	80
Drayage Charge/Mile	$2.00	$2.00	$2.00	$2.00	$2.00
Infrastructure Investment (Mil)	$0.0	$111.0	$267.0	$280.0	$3,2000.0
Rolling Stock Investment (Mil)	$0.0	$0.0	$229.0	$229.0	$300.00
URCS Estimate Method	Plan 1.0+35%	Plan 1.0+35%	Plan 1.0+15%	Plan 1.0+15%	Plan 1.0+15%
2035 >500 Mile Total Truck Trips (000)	7,363.8	7,363.8	7,363.8	7,363.8	7,363.80
2035 Diverted Truck Trips (000)	107.2	147.1	606.4	744.8	1,224.5
Percent Diversion of >500 Mile Trips	1.5%	2.0%	8.2%	10.1%	16.60%
2035 Total Truck Trips (000)[3]	21,031.2	21,031.2	21,031.2	21,031.2	21,031.2
2035 Diverted Truck Trips (000)	107.2	147.1	606.4	744.8	1,224.5
Percent Diversion of All Trips	0.5%	0.7%	2.9%	3.5%	5.8%

1 Reliability is a factor equal to the standard deviation of transit time divided by the mean transit time. A lower value improves reliability.
2 Investment recovery is a fee expressed in dollars per hundredweight.
3 Represents an estimate based on the maximum count station on I-81 from 2004 VHB estimates.

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Acronyms and Glossary

Government and Public Agencies

BEA: Bureau of Economic Analysis
DRPT: Virginia Department of Rail and Public Transportation
FHWA: Federal Highway Administration
FRA: Federal Railroad Administration
FTA: Federal Transit Administration
RVARC: Roanoke Valley-Alleghany Regional Commission
STB: Surface Transportation Board
USDOC: United States Department of Commerce
USDOT: United States Department of Transportation
VDOT: Virginia Department of Transportation

Data Sources

AADT: Annual Average Daily Traffic
AADWT: Annual Average Daily Weekday Traffic
CFS: Commodity Flow Survey. The Census Bureau States, "The 1997 Commodity Flow Survey is undertaken through a partnership between the Bureau of the Census, U.S. Department of Commerce, and the Bureau of Transportation Statistics, U.S. Department of Transportation. This survey produces data on the movement of goods in the United States." The CFS was also conducted in 2002.
DRI-WEFA: Data Resources Inc. and Wharton Econometric Forecasting Associates are two organizations that provided price and value of domestic freight at a national level by STCC code for the Freight Analysis Framework (FAF).
FAF: The Freight Analysis Framework is a database and analytical tool that improves planning, operations, and decision-making for freight movement. The FAF is produced by the US DOT.
GIS: Geographic Information Systems is computerized data this is geographically referenced for mapping and analysis purposes.

ITIC: The Intermodal Transportation and Inventory Cost Model is a rail/truck mode diversion model developed by the Federal Highway Administration in cooperation with the Federal Railroad Administration.

LATTS: Latin American Trade and Transportation Study.

NHN: National Highway Network. The NHN is a GIS representation of the US transportation network created by the Oak Ridge National Laboratory.

ORNL: Oak Ridge National Laboratory

REMI: Regional Economic Models, Inc. (REMI) is a company which produces economic growth forecasts for US industries

SASE: "Self-Addressed Stamped Envelopes" used with surveys completed for the study.

STCC: The Standard Transportation Commodity Code (STCC) is a numeric code representing 38 commodity groupings used by the railroad industry.

Transearch™: A commodity flow database produced by Reebie Associates.

TTA: The Truck Trip Analyzer (TTA) is a travel demand model developed by Jack Faucett Associates, Inc. (JFA). The model was developed with Federal Highway Administration Small Business Innovative Research (SBIR) funding to estimate truck trip tables from commodity flows

VIUS: The Vehicle Inventory and Use Survey is conducted every 5 years as by the US Census Bureau as part of the economic census. As stated by the Census Bureau, the survey provides data on the physical and operational characteristics of the Nation's truck population.

Organizations

ATA: American Trucking Association

VTA: Virginia Trucking Association

Technical Terms

EOL: Facilities handling "End of the line" truckloads serving local customers in the vicinity of an EOL terminal.

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8

Annotated Bibliography – Mode Choice

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The paper estimated elasticities of mode choice probabilities and market elasticities of demand in the intercity freight transportation market. Following an econometric modeling approach, a system of simultaneous equations was constructed to simulate the joint choice of mode and shipment size. The elasticities were derived from a mixed discreet/continuous choice model of mode and shipment size. The modes considered included rail and regulated common carriers (full truck load). Data were drawn from Commodity Flow Survey where individual shipments of manufactured goods identified at the most disaggregate level were summarized.

The system of three switching simultaneous equations consists of the discrete mode choice decision (1) and the choice of shipment size by truck (2) and rail (3). Equation (1) is a binary probit model, while equations (2) and (3) are linear regression equations.

$$I_i^* = X_i\gamma + Y_{1i}\eta_1 + Y_{2i}\eta_2 - \varepsilon_i \quad (1)$$

Truck: $Y_{1i} = X_{1i}\beta_1 + \varepsilon_{1i}$ iff $I_i^* > 0$ (2)

Rail: $Y_{2i} = X_{2i}\beta_2 + \varepsilon_{2i}$ iff $I_i^* \leq 0$ (3)

where X_i, X_{1i}, X_{2i} are vectors exogenous independent variables such as commodity, market and modal attributes. There are in total 18 variables. $\beta_1, \beta_2, \gamma, \eta_1, \eta_2$ are vectors of estimate parameter, and $\varepsilon_i, \varepsilon_{1i}, \varepsilon_{2i}$ are residual terms. They are assumed to be serially independent and have a trivariate normal distribution with mean vector 0 and a non-singular covariance matrix

$$\Sigma = \begin{bmatrix} \sigma_1^2 & \alpha_{12} & \alpha_{1\varepsilon} \\ \sigma_{21} & \sigma_2^2 & \sigma_{2\varepsilon} \\ \sigma_{\varepsilon 1} & \sigma_{\varepsilon 2} & \sigma_\varepsilon^2 \end{bmatrix}.$$

The covariances $\sigma_{1\varepsilon}$ and $\sigma_{2\varepsilon}$ respectively represent the interdependence between the mode choice and the truck and rail shipment size choices.

The model was estimated by the maximum likelihood (ML) method using commodity flow survey data at the five-digit STCC (individual commodity) level and at the individual Standard Metropolitan Statistical Area (SMSA; major city) level. The disaggregate and aggregate elasticities are distinguished and calculated. The disaggregate elasticity denotes the responsiveness of a shipper's probability to a change in the value of some attribute. The direct elasticity denotes the responsiveness of a shipper's probability of choosing mode i, which, in the case of probit model, is in the following form:

$$E_{X_{ik}}^{P_{ni}} = \frac{\partial P_{ni}}{\partial X_{ik}} \cdot \frac{X_{ik}}{P_{ni}} = \frac{\partial}{\partial X_{ik}}(\Phi(V_i - V_j)) \cdot \frac{X_{ik}}{\Phi(V_i - V_j)} = \pi_k X_{ik} \frac{\phi(V_i - V_j)}{\Phi(V_i - V_j)}$$

where π_k is the parameter estimate of X_{ik} in the reduced form probit mode choice model.

Likewise, the cross elasticity of the probability of choosing mode i with respect to a change in the value of some of mode j's attributes (X_{jk}) is $E_{X_{jk}}^{P_{ni}} = \frac{\partial P_{ni}}{\partial X_{jk}} \cdot \frac{X_{jk}}{P_{ni}} = -\pi_k X_{jk} \frac{\phi(V_i - V_j)}{\Phi(V_i - V_j)}$.

Aggregate elasticities, on the other hand, summarize the responsiveness of a group of shippers to a change in some modal attributes, for example, the effect of an incremental change in a variable on the expected share of the shippers choosing some mode, i. Provided that the expected share is estimated as the average probability of all shippers choosing mode i, the aggregate elasticity can be represented as:

$$E_{X_{ik}}^{\overline{P_{ni}}} = \frac{\sum_{n-1}^{N} P_{ni} E^{P_{ni} x_{ik}}}{\sum_{n-1}^{N} P_{ni}} = \frac{\pi_k \sum_n x_{ik} \phi(V_i - V_j)}{\sum_n \phi(V_i - V_j)}.$$

This is simply the weighted average of the disaggregate elasticities, $E_{X_{ik}}^{P_{ni}}$, with the choice probabilities as weights. Likewise, the aggregate cross elasticity can be represented by:

$$E_{X_{jk}}^{\overline{P_{ni}}} = \frac{-\pi_k \sum_n x_{jk} \phi(V_i - V_j)}{\sum_n \phi(V_i - V_j)}.$$

Let aggregate demand for mode i be $D_i(x_i(t)) = \sum_n w_n P_{ni}(x_{ni}(t))$. Replacing the sampling weight, w_n, by the shipment size of the nth shipper, $S_n = S_n(x_{ni}(t))$, the aggregate market elasticity of demand with respect to x_{ni}^k turns out to be:

$$E_i^k = \frac{\sum_n x_{ni}^k \{\pi_k \cdot S_n \cdot \phi(x_{ni}) + \alpha_k \Phi(x_{ni})\}}{\sum_n S_n \cdot \Phi(x_{ni})}$$, while the cross elasticity of demand is:

$$\xi_{i/j}^k = \frac{\sum_n x_{nj}^k \{-\pi_k \cdot S_n \cdot \phi(x_{nj}) + \alpha_k \Phi(x_{nj})\}}{\sum_n S_n \cdot \Phi(x_{nj})}.$$

The results were compared to those done in previous studies and comparisons were made. The own-price and cross-price elasticities of mode choice probabilities were found to be 1.44-1.88 and 1.54-1.75, respectively. The market price elasticities of demand were found to vary significantly across commodity groups and geographic areas. Among the 40 market segments considered, the truck price elasticity of demand ranged between -0.749 and -2.525; whereas the rail price elasticity of demand ranged between 0.-904 and 2.532.

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The calculation of travel impedances is the basis of the highway assignments. The simplest form of impedance contains only travel time, while a more refined procedure incorporates both time

and cost. This combined impedance measure is the basis of various trip distribution and traffic assignment models. The generalized costs form a common impedance unit. On non-toll links, $Cost_{Total}$= $Cost_{Distance}$+$Cost_{LinkTime}$, i.e., total link impedance equals travel cost due to link distance and travel cost due to time required to traverse the link. The cost of travel distance for traffic assignment was calculated in other studies as roughly $0.10/mile, taking account of gas and maintenance. This value may vary from location to location. In regard to travel cost due to the time on the link, one can use the value of time from the model choice model to convert travel time to travel cost. Likewise, for toll facilities, $Cost_{Total}$= $Cost_{Toll}$+$Cost_{ServiceTime}$, i.e., total link impedance equals travel cost due to the toll and travel cost due to the delay at the toll booth. The cost of tolls can be the actual toll paid, while the travel cost associated with the time paying the toll such as decelerating, queuing, and acceleration can be applied the same value of time similar to the non-toll link calculation.

As traffic volumes increase, travel speeds decrease due to the increased congestion. Thus, travel speed is a function of link-based variables such as free-flow speed, link capacity, and a function of that incorporates changes in travel speed due to the increase in travel volume. The free flow speed and link capacity look-up table used in the Urban Transportation Planning Software (UTPS) is as follow:

		Functional Class				
Area Type		Freeway	Class 1 Arterial	Class 2 Arterial	Class 3 Arterial	Collector
Urban	Capacity	2000	1000	870	670	470
	FF Speed	50	35	25	20	15
Suburban	Capacity	2000	1000	870	670	470
	FF Speed	55	40	35	25	20
Rural	Capacity	2000	1000	870	870	470
	FF Speed	60	45	40	35	25

The Bureau of Public Roads (BPR) function calculates travel speed in relation to travel volume change. The final link travel time (T_f) is a function of original free-flow link travel time (T_o), assigned traffic volume (V), and the link capacity (C): $T_f = T_o * (1 + \alpha * [\frac{V}{C}]^{\beta})$, where alpha = coefficient (often set at 0.15), and beta = exponent (often set at 4.0).

Alan Horowitz updated the BPR parameters to be the following:

	Freeways			Multilane		
Coefficient	70 mph	60 mph	50 mph	70 mph	60 mph	50 mph
alpha	0.88	0.83	0.56	1.00	0.83	0.71
beta	9.80	5.50	3.60	5.40	2.70	2.10

Where the speeds are designed speeds of the facility, used in the BPR curve, while capacities used in the V/C ratio are ultimate capacity.
The curves based on the HCM exhibit a speed of about 35 mph at a v/c ratio of 1.0. This is consistent with standard capacity rules that the denser traffic flows occur at this speed. Note that the BPR curve has a much higher speed at a v/c equal to 1.0 than does the HCM curves.

The ultimate capacity used for these curves was 1800 vehicles per hour per lane for a one mile section. This value is the ultimate capacity for typical prevailing conditions, not those under ideal conditions which would have a capacity of 2000 vehicles per hour per lane (and even higher based on recent changes to the Highway Capacity Manual). The curves extend beyond the point where the v/c ratio is 1.0, or where the flow has reached capacity. In capacity analysis, this portion of the curve is considered unstable. However, for travel demand modeling, the curve must extend beyond 1.0 to account for the theoretical assignment of the traffic.

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___. *North American Transportation in Figures*. It provides a comprehensive overview of transportation statistics in North America. The report contains over 90 data tables, supported by graphs, figures, maps, and a number of appendixes.

___. *Service Annual Survey*. Truck Transportation, Messenger Services & Warehousing (NAICS 484/49). The Service Annual Survey is a sample of the service industries of the United States.

Bureau of Transportation Statistics. 2004. *Transportation Services Index*.

Caldwell, Harry. *North American Freight Flows and Trends*. Federal Highway Administration, Office of Freight Management and Operations.

The slides present FHWA Freight Productivity Program and schedule for Federal reauthorization; discuss the Freight Analytical Framework, NAFTA and Niagara freight flow estimates, and trends; and examine data and forecast applications to support Niagara awareness.

Cambridge Systematics, Inc. (1995). *Characteristics and Changes in Freight Transportation Demand: A Guidebooks for Planner and Policy Analysts.*

This guidebook is intended to be used as a reference document to assist transportation planners and others in conducting a variety of different types of analyses involving freight demand. References are provided to other documents for more details on procedures and data sources.

Cambridge Systematics, , in cooperation with Leeper, Cambridge & Campbell, Inc.; Sydec, Inc.; Thomas M. Corsi; and C. M. Grimm. 1997. *A Guidebook for Forecasting Freight Transportation Demand*. Transportation Research Board, Incorporated. NCHRP Report 388. 169p Project 8-30 FY '93.

This report provides reference information on freight transportation planning processes, techniques, tools, data, and applications. The report is organized in a Guidebook format to assist

planning practitioners and policy analysts to effectively integrate freight planning and demand forecasting into the broader multimodal transportation planning process. Because freight issues are now major concerns to the state departments of transportation, metropolitan planning organizations, port and airport authorities, rail and trucking providers, shippers, and various federal agencies, this Guidebook will provide much needed assistance to a wide range of practitioners. The appendices of the Guidebook contain useful information concerning factors impacting freight demand; freight demand forecasting studies; freight data sources; descriptions of survey procedures; statistical forecasting techniques; transport cost estimation; modal diversion and descriptions of related models; case studies; and public agency information needs. This Guidebook is intended to support a range of planning including strategic and policy planning, statewide or regional systems planning, and more detailed project-level analyses. It will also serve as a basic educational resource into the components of effective freight planning.

Cambridge Systematics, Inc. 1997. *Quick Response Freight Manual; Final Report DOT-T-97-10*. Prepared for the U.S. Department of Transportation and the Environment Protection Agency.

___. 2000. *Surface transportation efficiency analysis model (STEAM 2.0) user manual*. Final Report. Prepared for the U.S. Department of Transportation.

___. 2001. *Review of the Literature and Operational Models*. Prepared for the Puget Sound Regional Council.

___. 2002. *Mid-Atlantic Rail Operations Study Summary Report.* Prepared for the I-96 Coalition.

Campbell, James F. ( ). "Transportation Data" Chapter 8 of *SAILS Optimization Software Handbook*. University of Missouri-St. Louis.

Canadian National. 2001. *Unlocking the Full Potential of Canada's Railroads: A New Transportation Policy Direction for the Benefit of all Canadian Stakeholders.*

Casgar, Christina S., D. J. Deboer, and D. L. Parkinson. 2003. *Rail Short Haul Intermodal Corridor Case Studies: Industry Context and Issues*. Prepared by Foundation for Intermodal Research and Education (FIRE), in association with U.S. Department of Transportation, Federal Railroad Administration and CSX Transportation, Norfolk Southern Corporation, and the Port Authority of New York and New Jersey.

Chabini, Ismail and M. A. Zeid. 2003. *The Minimum Cost Flow Problem in Capacitated Dynamic Networks*. Massachusetts Institute of Technology.

The authors study the minimum cost flow problem in capacitated (time-dependent) dynamic networks, in which flows from supply nodes should be sent, in minimum cost, to demand nodes such that the flows on used links do not exceed their capacities. They address one variant of the problem, where a given amount of flow needs to be sent in minimum cost from one origin node at departure time zero to one destination node. They present a generic minimum cost-path flow augmentation approach to solve the problem. They illustrate the approach by first reviewing an

existing algorithm in the literature. Then they develop two other more efficient solution algorithms for the same problem. An example is given to illustrate the solution approach adopted. The three algorithms are implemented for the purpose of experimental testing, using large capacitated dynamic networks. Numerical results indicate that the algorithms developed in this paper led to significant computational time savings, as compared to the solution algorithm that is known in the literature.

Cho, Sungbin, S. Cho, P. Gordon, J. E. Moore II, H. W. Richardson, and M. Shinozuka of University of Southern California and S. Chang of University of Washington. 2000. *Analyzing Transportation Network Reconstruction Strategies: A Full Cost Approach*. Research Supported by NSF Award Number: CMS 9812503. NSF Program 1499: Earthquake Systems Integration. US-Japan Cooperative Research in Urban Earthquake Disaster Mitigation.

An earlier version of this paper was presented at the 39th Western Regional Science Association Meetings at Kauai I, Hawaii.

Policy makers interested in evaluating the costs and benefits of earthquake retrofit and reconstruction strategies require a way to measure the benefits (costs avoided) of competing proposals. This requires an integrated, operational model of losses due to earthquake impacts on transportation and industrial capacity, and how these losses affect the metropolitan economy. Our approach to this problem advances the information provided by transportation and activity system analysis techniques in ways that help capture the most important economic implications of earthquakes. These full cost results have four dimensions: structure damage, business interruption, network performance, and infrastructure damage. Preliminary results for all four measures are summarized for a magnitude 7.1 earthquake on the Elysian Park blind thrust fault in Los Angeles. July, 2000.

Chung, Woodam and J. Sessions. 2001. *NETWORK 2001 – Transportation Planning Under Multiple Objectives*. Department of Forest Engineering, Oregon State University. The International Mountain Logging and 11th Pacific Northwest Skyline Symposium 2001.

NETWORK 2001 has been developed to provide transportation planners with additional flexibility in analyzing road systems. While NETWORK 2000 was limited to minimizing costs, NETWORK 2001 can use weighted objective function components to minimize road system length. This paper presents NETWORK 2001 and the new algorithm implemented in the program with its applications. Total open road length can be constrained while minimizing road and transportation costs. This method can extend to include road deactivation and obliteration as optional activities.

Clark, David B. 2000. *Local and Regional Rail Freight Transport*. Clemson University. A1B10: Committee on Local and Regional Rail Freight Transport. Transportation Research Board.

Commonwealth of Virginia. 2001. Report of the Secretary of the Transportation on the *Potential for Shifting Virginia's Highway Traffic to Railroads*. Senate Document No. 30. Prepared for the Governor and Assembly of Virginia.

___. Report of the Secretary of the Transportation on the Desirability of Establishing Additional "Intermodal Transfer Facilities." Senate Document No. 23. Prepared for the Governor and Assembly of Virginia.

COMSIS Corporation.1983. *UTPS Highway Network Development Guide*. Prepared for the U.S. Department of Transportation, Federal Highway Administration. Contract No. DTFH61-81-C-00070.

The Urban Transportation Planning System (UTPS) Highway Network Development Guide is both a user's manual to UTPS software and an overview of current network development planning and analysis techniques.

Coogan, Matthew A. and S. Campbell at TransManagement, Inc. 1995. Prepared for Transportation Research Board. 1998. *NCHRP Web Doc 9 Innovative Practices for Multimodal Planning for Freight and Passengers: Project Bibliography.*

Cook, Peter D., S. Das, A. Aeppli, and C. Martland. 1999. *Key Factors in Road-Rail Mode Choice in India: Applying the Logistic Cost Approach*. Proceedings of the 1999 Winter Simulation Conference. P. A. Farrington, H. B. Nembhard, D. T. Sturrock, and G. W. Evans, eds.

There have been major changes in the share of road and rail traffic in India as the economy and the population has grown and become more urbanized. This paper summarizes the key factors for mode choice in freight transport that were found in India in a recent survey based on the Logistics Cost Model of shipper behavior. Both the relative importance of these factors and customer rating of satisfaction is presented.

Cox, Wendell. 2001. *Freight Rail's Potential to Reduce Traffic Congestion.* Texas Public Policy Foundation. Also http://www.tppf.org/transit/rail/toc.html.

Center for Transportation Research and Education (CTRE), Iowa State University. Souleyrette, Reginald R., Z. N. Hans, and S. Pathak (ongoing). *Statewide Transportation Planning Model and Methodology Development Program.* Funded by Iowa Department of Transportation and Midwest Transportation Center.

Includes *Developer's Guide for the Multimodal Statewide Fright Transportation Model, Developer's Guide FAQs, User's Guide for the Multimodal Statewide Freight Transportation Model, and Discussion of Issues Affecting Freight Transportation,* etc.

___.. Walter, Clyde K. et. al. (ongoing). *Multimodal Investment Analysis.*
The purpose of this project is to develop a multimodal transportation investment analysis methodology that will permit the analysis of transportation investments from a system wide perspective. This project consists of three phases:

Phase One involves the review of transportation planning literature and review of existing planning methods, plus the development of a conceptual multimodal transportation investment analysis model.

Phase Two will involve the mathematical specification of the model, as well as the identification and evaluation of data sources needed to make the model operational.
Phase Three will consist of the empirical testing and the documentation of the model.

Cullinane, Kevin and N. Toy. 2000. "Identifying Influential Attributes in Freight Route/Mode Choice Decision: a Content Analysis". *Transportation Research Part E: Logistics and Transportation Review Volume 36, Issue 1,* Pages 1-77.

In justifying the selection of attributes to be included in the stated preference experiment, a content analysis is conducted and the top five attributes affecting mode choice are cost/price/rate, speed, transit time reliability, characteristics of goods, service (unspecified).

The Center of Urban Transportation Research (CUTR) at the University of South Florida. 2002. *Analysis of freight Movement Mode Choice Factors*. Report for Florida Department of Transportation Rail Planning and Safety.

CUTR's efforts entailed a survey of available and relevant publications, reports and studies, an examination of the industry sectors where mode shift from road to rail might be most likely to occur, an investigation into the mode choice factors considered by shippers, and an overview of potential activities and policy direction to achieve an optimal split between road and rail movement of goods.

Danielis, Romeo and L. Rotaris. 2000. *Analyzing freight transport demand using stated preference data: a survey and a research project for the Friuli-Venezia Giulia Region.*

Deakin, Harvey, Skabardonis, Inc., Berkeley, CA. 1993. *Manual of Regional Transportation Modeling Practice for Air Quality Analysis*. Sponsored by The National Association of Regional Councils, Washington, D.C.

Recent changes in the context of transportation planning have increased the importance of regional transportation analysis methods. In particular, the Clean Air Act Amendments of 1990 set forth requirements for detailed planning and analysis which apply to many states and metropolitan areas. This Manual, prepared for the *National Association of Regional Councils* as part of NARC's Clean Air Project, was designed to help transportation planning agencies, including metropolitan planning organizations, state departments of transportation, and other entities, respond to the issues raised in carrying out transportation modeling for air quality planning efforts. The Manual reviews transportation modeling today, focusing primarily on travel demand forecasting as it is practiced by regional agencies, and suggests strategies for responding to specific analysis needs and for overcoming common problems. The emphasis is on identifying

issues which MPOs should consider in reviewing their models, and on recommending sound options for addressing such issues in accordance with local objectives and resource availability.

de Jong, Gerard, H. Gunn, W. Walker, and J. Widell of RAND Europe. 2001. *Study on Ideas on a New National Freight Model System for Sweden*. Prepared for the SAMGODS Group

This study is intended to provide most recent and very best concepts that provide coherent and innovative framework suitable for policy oriented analyses and modeling for freight transport in a Sweden.

de Jong, Gerard, A. Daly, M. Pieters, C. Vellay, M. Bradley, and F. Hofman. 2003. "A model for time of day and mode choice using error components logit". *Transportation Research Part E 39 (2003)* 245–268.

U. S. Department of Transportation. 2000. *NHS Intermodal freight connectors : a report to congress*.

Section 1106(d) of the Transportation Equity Act for the 21st Century (TEA-21) directed the Secretary to conduct a review of the National Highway System (NHS) freight connectors that serve seaports, airports, and major intermodal terminals and report to Congress by June 9, 2000. The Federal Highway Administration (FHWA) conducted this study with the following objectives: (1) evaluate the condition of NHS connectors to major freight intermodal terminals; (2) review improvements and investments made or programmed for these connectors; and (3) identify impediments and options to making improvements to the intermodal freight connectors. NHS freight connectors are the public roads leading to major intermodal terminals. This report presents a summary of conditions on the connectors, reviews levels of investment on them, assesses institutional impediments to freight improvements and identifies key issues to explore to improve these highways. This effort was conducted in cooperation with state transportation departments and metropolitan planning organizations (MPOs). Industry representatives also contributed.

Dewey, James F. et al., Bureau of Economic and Business Research, University of Florida (BEBR). 2002. *The Response of Railroad and Truck Freight Shipments to Optimal Excess Capacity Subsidies and Externality Taxes: An Empirical Study of Florida's Surface Freight Transportation Market*. Report for Florida Department of Transportation.

Florida's public highways are congested. At the same time there is excess capacity on private railroads. Further, the social costs of moving a ton-mile of freight—including costs from air pollution, accidents, congestion, and wear on the nation's transportation system—are lower by rail than by truck for many types of freight movements. Given this situation, should the state design policies to increase utilization of the state's railroads? Would a policy that subsidizes freight shipment by railroad, and taxes the generation of harmful externalities, be beneficial to residents of the state? This report examines whether such policies can be economically justified. BEBR's efforts entailed a consideration in economic terms of the justification for policies designed to alter the mode split from a traffic management, social cost and infrastructure utilization

perspective. The level of subsidies and taxes necessary to achieve a shift are explored, and the potential consequences of such policies are reviewed. This report is a complimentary study of *Analysis of freight Movement Mode Choice Factors* conducted by the Center of Urban Transportation Research at the University of South Florida.

DeWitt, William and J. Clinger. 2000. *Intermodal Freight Transportation*. A1B05: Committee on Intermodal Freight Transport, Transportation Research Board.

Dube' Jean-Pierre, P. Chintagunta, and A. Petrin; B. Bronnenberg, R. Goettler, P. B. Seetharaman, K. Sudhir, R. Thomadsen, and Y. Zhao. 2001. *Structural Applications of the Discrete Choice Model.* This paper is based on the session ''Structural Models and Discrete Choice'' at the 2001 Choice Symposium, hosted by UC Berkeley.

A growing body of empirical literature uses structurally-derived economic models to study the nature of competition and to measure explicitly the economic impact of strategic policies. While several approaches have been proposed, the discrete choice demand system has experienced wide usage. The heterogeneous, or ''mixed'', logit in particular has been widely applied due to its parsimonious structure and its ability to capture flexibly substitution patterns for a large number of differentiated products. We outline the derivation of the heterogeneous logit demand system. We then present a number of applications of such models to various data sources. Finally, we conclude with a discussion of directions for future research in this area.

Duong, Tarn. 200?. *Stochastic Traffic Assignment*. Department of Mathematics & Statistics, University of Western Australia.

Eatough, Christopher J., S. Brich, and M. J. Demetsky. 1998. *A Methodology for Statewide Intermodal Freight Transportation Planning.*

The study contained a methodology for statewide freight transportation planning with emphasis on identifying and prioritizing infrastructure needs to improve the intermodal freight transportation system. It is designed to provide the framework for state DOTs and MPOs to meet the freight transportation planning requirements as mandated by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and The Transportation Equity Act for the 21st Century.

Evans, Randy. 2001. *I-95 Corridor Coalition Mid-Atlantic Rail Operations Study? An Integrated Strategy to Eliminate Choke Points*.

Faris, Jerry M. and D. Ismart. 1999. *Freight Modeling Techniques for Small and Medium-Sized Areas.* Sixth National Conference on Transportation Planning for Small and Medium-Sized Communities; Session #4.

This paper presents a practical and low cost modeling technique to include freight demand and truck movements in the development of long range transportation plans. The Intermodal Surface

Transportation Efficiency Act of 1991 (ISTEA) and the new Transportation Equity Act for the 21st Century (TEA21) requires that States and Metropolitan Planning Organization (MPOs) consider urban freight in their long-range plans, transportation improvement programs, and annual work elements. However, in the last rounds of MPO long-range plan update certification reviews by the Federal Highway Administration (FHWA), one of the negative themes was the lack of freight and goods movement analysis within the current plans. This lack of analysis has occurred because most States and MPO's have little experience in freight planning, current and historical data on truck movements are limited, and most of the old freight models are extremely complicated. In September 1996 the U.S. Department of Transportation released the final report on the Quick Response Freight Manual through the Travel Model Improvement Program.

This manual provides the transportation modeler with simple techniques and transferable parameters which can be used to develop commercial truck movements within a conventional four-step planning model. This paper combines the techniques presented in the Quick Response Freight Manual and a simple four-step TranPlan travel demand model to develop, assign and analyze commercial truck trips in a small to medium urban area. Using the simple techniques and transferable parameters, the model could be developed with a limited amount of actual truck data. In this model, truck trips are broken into three types: four-tire; single unit; and, combination. By keeping the truck trips and the auto driver trips in separate purposes, the modeler can pre-assign or assign the truck trips (all, four-tire, single unit, and combination) to a regular network or special truck network under a full equilibrium process.

Energy and Environmental Analysis, Inc. and Cambridge Systematics. 1999. *Assessment of GHG Models for the Surface Transportation Sector.* Prepared for Federal Highway Administration. Under Contract to Louise Berger and Associates.

Federal Highway Administration, Department of Transportation. 1998. *U.S. Freight: Economy in Motion.* Publication No.: FHWA-PL-00-029

___. 1999. *Public Policy Impacts on Freight Productivity. Final Report with Annotated Bibliography.*

___. 2000. *Comprehensive Truck Size and Weight Study*. Publication No.: FHWA-PL-98-034.

Federal Highway Administration (Office of Asset Management), Department of Transportation. 2002. *Induced Demand and Elasticity. HERS-ST v2.0. Highway Economic Requirements System-State Version*. Prepared by Douglass B. Lee Jr. at Volpe National Transportation Systems Center.

Federal Highway Administration, Department of Transportation. *Freight Financing Options for National Freight Productivity.*

Fehmarnbelt Traffic Consortium. 2003. *Fehmarn Belt Forecast* 2002 Final Report.

Foster, David L. 200?. *Truck-ferry concept for maximum I-81 truck diversion to rail*. Salem, Virginia.

Franzese, Oscar and S. Joshi. 2002. *Traffic Simulation Application to Plan Real-Time Distribution Routes.* Proceedings of the 2002 Winter Simulation Conference, E. Yücesan, C.-H. Chen, J. L. Snowdon, and J. M. Charnes, eds.

This paper studies the effect of real-time information on optimal routes employed by distribution vehicles that supply goods from distribution centers to the stores in any retail environment. This methodology uses simulation models to mimic actual traffic conditions as functions of times of the day along the distribution routes to suggest meta-optimal routes over the ones provided by the routing algorithms. This yields optimized routes based on the times of the day in addition to aiding the planner in sequencing the routes to increase driver productivity and decrease operating costs.

Feenstra, Robert C. 2003. *Transportation Economics: Analysis of Demand*.

Friedrich, Markus. ?. *Mode Choice, Route Choice and Assignment*.

United States General Accounting Office. 1996. "Intermodal Freight Transportation". *Projects and Planning Issues*. GAO/NSIAD-96-159.

___. 2000. *Highway infrastructure: FHWA's model for estimating needs is generally reasonable, despite limitations*. GAO/RCED-00-133.

___. 2001. Freight Railroad Regulation. *Surface Transportation Board's Oversight Could Benefit From Evidence Better Identifying How Mergers Affect Rates*.

Georgia Institute of Technology. 2001. *Scientific Approaches to Transportation Research Volumes 1 and 2*. Prepared for: National Cooperative Highway Research Program, Transportation Research Board of the National Academies. NCHRP 20-45: Scientific Approaches to Transportation Research.

Graham, Daniel J., A. Couto, W. E. Adeney, and S. Glaister. 2003. "Economies of scale and density in urban rail transport: effects on productivity". *Transportation Research Part E 39 (2003),* p. 443–458.

Hancock, Kathleen L. and R. Munipalle. ?. *Regional Freight Flow Assignment Using Geographic Information Systems.*

The paper presents an approach to estimate traffic volumes by commodity type on the transportation network from inter-region commodity flow data. Freight tons of different commodities originating, traveling within and ending in the Metropolitan area are converted to truck numbers and distributed to different areas in the state using industrial employment density as an indicator variable. Truck flows have then been assigned to the highway network using the user-equilibrium technique, and the resulting link volumes are validated against existing survey counts. The result shows that most of the estimated truck counts were within a tolerable error margin.

Hancock, Kathleen L. 2000. *Freight Transportation Data*. University of Massachusetts at Amherst. A1B09: Committee on Freight Transportation Data. Transportation Research Board.

Hancock, Kathleen L. and A. Sreekantg. 2001. *Conversion of Weight of Freight to Number of Rail Cars*. Transportation Research Record 1768. Report No. 01-2056.

The paper provides conversion for estimating rail traffic volume in numbers of vehicles/cars from aggregated commodity flows based on the 1992 waybill sample. The results were evaluated using the 1993 Commodity Flow Data. Conversions are made for total rail waybill sample (simple (52.03 tons/car) and weight (80.61 tons/car) average), three groupings (TOFC: trailers on flat cars (15.82 tons/car); COFC: containers on flat cars (11.59 tons/car); and General Rail: goods shipped directed in rail cars (95.26 tons/car)); three groupings and commodity classifications (CFS and STCC); car types (ARCI and STB); and car types and commodity groups. Comparisons of these conversions are made. Despite that the simple average for the entire data sets overestimates the number of rail cars, the weighted average for the entire data sets appears to suffice at a large regional or national level. As conversions become more detailed, the difference is generally 3 percent or less, indicating that detailed conversions may not be necessary for regional and national planning; for local level planning, conversions involving more specific information on commodity type or car type should be used if data are available.

Hazelton, Martin L. 2003. *Total Travel Cost in Stochastic Traffic Assignment.* School of Mathematics & Statistics, University of Western Australia.

HDR. 2001. *I-81 Traffic Development & Analysis MP 312 – 320 Frederick County*. Traffic Forecasting Report. Revised Final. May 3, 2001

___. *I-81 Traffic Development & Analysis MP 240.6 – 253 Rockingham County*. Traffic Forecasting Report. FINAL January 19, 2001.

Hearn, Donald W. and M. V. Ramana. 1998. *Solving Congestion Toll Pricing Models.*

Heiss, Florian. 2002. *Specification(s) of Nested Logit Model*. Mannheim Research Institute for the Economics of Aging (MEA).

The Highways Agency Guide to Freight. (A collection of information about freight transport in Great Britain). 2003. Simple Guide to Freight Models.

Hoel, Lester and J. Peek. 1999. *A Simulation Analysis of Traffic Flow Elements for Restricted Truck Lanes on Interstate Highways in Virginia*. VTRC Report No. 99-R1. http://www.virginiadot.org/vtrc/main/online_reports/pdf/99-r1.pdf

Holguín-Veras, José. 1999. *Discussion of Alternative Modeling Frameworks*. New Jersey's Licks to the 21st Century: Maximizing the Impact of Infrastructure Investment. Working Paper No. 2.

This paper discusses the alternative modeling frameworks and identifies some of the key issues of the modeling components of the *New Jersey's Links to the 21st Century* project. It reviews the a wide range of modeling options with emphasis on the scope, level of specification (network and zoning), modeling options and computer tools, and data needs.

Holguín-Veras, José, et. al. 2001. *An Assessment of Methodological Alternatives for a Regional Freight Model in the NYMTC Region.* Prepared for New York Metropolitan Transportation Council (NYMTC). Also: http://www.utrc2.org/research/assets/6/regionalfreight1.html.

This report assesses the different freight transportation modeling methodologies. It begins with a definition of the scope of the regional freight model, followed by a discussion of the main freight transportation issues in the NYMTC region, and the potential role of the regional freight model. The main methodological alternatives are discussed next. This includes a brief description of the different models and a preliminary assessment of: (a) data requirements, (b) staff requirements; (c) computing power required; (d) adequacy to NYMTC's conditions; (e) practicality; and (f) conceptual validity. The final section presents a summary of the key findings of this project.

Holguín-Veras, José. ?. *The Practice of Freight Transportation Planning and Major Modeling Platforms*. Department of Civil and Environmental Engineering, Rensselaer Polytechnic Institute.

Horowitz, Alan J. and M. H. Patel. 1998. *Through Trip Tables for Small Urban Areas: a Method for Quick Response Travel Forecasting*.

Hu, P., B. Boundy, T. Truett, E. Chang, and S. Gordon. 2002. *Cross-Cutting Studies and State-of-the-Practice Reviews: Archive and Use of ITS-Generated Data.* Prepared for Federal Highway Administration, Federal Transit Administration, U.S. Department of Transportation. Center for Transportation Analysis, Oak Ridge National Laboratory, Managed by UT-Battelle LLC for the U.S. Department of Energy under Contract No. DE-AC05-00OR22725.

Husdal, Jan. 2002. *Analyzing the reliability and vulnerability of transportation lifelines*. University of Utah.

Inaba, Fred S. and N. E. Wallace. 1989. "Spatial Price Competition and Demand for Freight Transportation". *The Review of Economics and Statistics, Vol. 71, No.4,* p.614-25.

Indra-payoong, N. ?. *Factors influencing modal choice for freight transportation: a case study of freights transported between Bangkok and the Eastern region of Thailand*.

Ingalls, Ricki G., M. Kamath, and A. Karthik. ?. *Freight Movement Models - A Literature Survey*. School of Industrial Engineering and Management, Oklahoma State University.

Jack Faucett Associates. 1996. *Assessment of the Effects of Proposed Locomotive Regulations on Goods Transport Modes and Locomotive Emissions*. Contract Number 92-930. Prepared for the California Air Resources Board.

___. 1997. *NCHRP Web Doc 3 Multimodal Transportation Planning Data: Final Report*, prepared for Transportation Research Board.

___.*California Freight Energy Demand Model Update*. Contract Number 300-96-301. Prepared for the California Energy Commission.

Jiang, Fei, P. Johnson, C. Calzada. 1999. "Freight Demand Characteristics and Mode Choice: An Analysis of the Results of Modeling with Disaggregate Revealed Preference Data". *Journal of Transportation and Statistics Vol.2 No.2.* p.149-158.

Considerably less research has been done on modeling freight demand with disaggregate discrete models than on modeling passenger demand. The principal reason for this imbalance is the lack of freight demand data. Freight demand characteristics are expensive to obtain and are sometimes confidential. This paper analyzes the freight demand characteristics that drive modal choice by means of a large-scale, national, disaggregate revealed preference database for shippers in France in 1988, using a nested logit. Particular attention is given to private transportation (own account transportation) and combined public and private transportation. After aggregation and validation of discrete choice models, the influence of demand characteristics on freight modal choice is analyzed. The maximum probability of choosing public road transportation takes place at approximately 700 kilometers, while that of choosing rail transportation take place at 1,300 kilometers.

Kaliski, John. 1998. I*TS Data for Freight Planning*. Prepared for ITS America.

Kaori, Mizutani and A. Takamasa. 2000?. *Construction of Modal Choice Model with a Descriptive Utility Function using Fuzzy Reasoning*.

It is important in travel behavior analysis to construct precise discrete choice models. Stochastic models based on the random utility theory such as logit models and fuzzy reasoning models can be combined in order to create advanced models for the estimation of travel behavior as hybrid models. Particularly, logit models with fuzzy logic utility functions have been proposed. It is known that the utility function described with fuzzy inference rules can reflect human decision with vagueness on the logit models. Multinominal fuzzy logit models are applied to a modal choice problem in this study. In particular, the fuzzy inference rules and parameters of membership functions are determined using Genetic Algorithm.

Levinson, David and B. Yerra. 2002. *Modeling Transportation Network Dynamics as a Complex System.* http://www.hhh.umn.edu/centers/slp/projects/transroundtable/ The Humphrey Institute, State and Local Policy Program. University of Minnesota.

Mahmassani, Hani S., H. A. Sbayti, and X. Zhou. 2003. *DYBASMART-P Versopm 0.930.7-DHV User's Guide*. Maryland Transportation Initiative, University of Maryland, College Park. Prepared for Federal Highway Administration, Office of Operations Research and Development.

Marcos, Cristina Borra and L. P. Martos (). *Estimating the Demand for Freight Transport: the Private versus Public Trade-off in Andalusian Food Industry*.

Maring, Gary. 2001. *National Multimodal Freight Trends/Issues/Forecasts and Policy Implications*. FHWA Office of Freight Management and Operations, USDOT

MDS Transmodal Ltd. 2003. *The GB Freight Model*. Document 1: Methodology. Draft Report. Meinert, Timothy S., A. D. Youngblood, G. D. Taylor, and H. A. Taha. *Simulation of the Railway Component of Intermodal Transportation*.

Middendorf, David P. and M. S. Bronzini. 1994. *The Productivity Effects of Truck Size and Weight Policies*. Center for Transportation Analysis, Energy Division, Oak Ridge National Laboratory.

Miller, Harvey J. 1997. *Towards Consistent Travel Demand Estimation in Transportation Planning: A Guide to the Theory and Practice of Equilibrium Travel Demand Modeling*. Department of Geography, University of Utah.

This research report addresses the gap between the state-of-the-art and the state-of-the-practice in travel demand modeling. This report is an *accessible* review of the theory and practice of equilibrium travel demand modeling. This review is intended for practitioners and beginning students in transportation analysis, modeling and planning. Key features of this review include: i) a focus on *practical* travel demand models, i.e., models that can be implemented at the urban or regional-scale; ii) a focus on the behavioral assumptions, data requirements, parameter estimation procedures and solution procedures that are key to model application.; iii) placement of mathematical formulae are in appendices, allowing the less mathematically-incline reader to skip the formulae but still receive an intuitive understanding of the models' structures. These features should render this review accessible to its intended audience, transportation analysts and planners.

Mohammadian, Abolfazl and P. S. Kanarogolou. 2003. *Applications of Spatial Multinomial Logit Model to Transportation Planning*. Conference paper presented at the 10th International Conference on Travel Behavior Research, Lucerne, August 2003.

Nagurney, Anna. 2002. *Traffic Network Equilibrium*. Isenberg School of Management, University of Massachusetts.

___. *Tradable Permits for System-Optimized Networks*. Isenberg School of Management, University of Massachusetts.

National Commission on Intermodal Transportation. 1994. *Toward a national intermodal transportation System. Final Report.*

Norfolk Southern. 2000. "Railroads can ease highway congestion". *Thoroughbred Paces*, September-October issue.

Noekel, K., J. Janko, and PTV. 2004. *Transportation Modeling*. Methods and their Background.

Describe the background of the traffic assignment methods applied in the transportation model. A detailed description can be found in the software documentation.

Nolen, Frank W. ?. *I-81 Congestion, the Nolen solution – a rail ferry.*

Center for Transportation Analysis, Oak Ridge National Laboratory. 1996, 2004. *Oak Ridge National Highway Network*.

Ontario Trucking Association. *Truck-Rail Co-operation/Competition*.

Oswald, R. K., W. T. Scherer, and B. L. Smith. 2000. *Traffic forecasting: nonparametric regressions*. Center for Transportation Studies, University of Virginia.

Oum, Tae Hoon. 1979. "A Cross Sectional Study of Freight Transport Demand and Rail-Truck Competition in Canada". *The Bell Journal of Economics, Vol. 10, No.2,* p.463-82.

Oum, Tae Hoon, W. G. Waters, II, and J. S. Yong. 1990. *A Survey of Recent Estimates of Price Elasticities of Demand for Transport*. Policy, Planning, and Research Working Papers: Transportation. Infrastructure and Urban Development. The World Bank. WPS 359.

Ozment, John. 2001. *Mode choice; Intermodal transportation; Logistics; Modal shift; Economic analysis; Trucking; Railroad transportation.*

Intermodal transportation offers many benefits to shippers and society yet represents a very small portion of the total freight market. Many shippers who use truck transportation concern about the service times of intermodal movements, while those who use rail service concern about the transportation costs of intermodal. In reality, few shippers base their mode selection on total cost. The purpose of this study is to examine the role that intermodal transportation plays in today's logistics environment and to assess its potential for further growth and adoption by examining the potential for intermodal service based on total logistics costs. Based on data provided in the DOT's 1997 Commodity Flow Survey, a selection of products of different values were used as examples to assess the total cost of movements between hypothetical origins and destinations. The result of the total cost of these movements provide insight into their potential impact of shifting freight from truck to truck-rail intermodal.

___. *Demand for Intermodal Transportation in Arkansas*. At the Oren Harris Chair of Transportation, Walton College of Business, University of Arkansas.

Parsons Brinkerhoff Quade & Douglas, Inc. 2000. *Virginia Intermodal Feasibility Study*. Prepared for the Virginia Department of Transportation.

Parsons. *Indiana Rail Plan*.

Pendyala, Ram M. 2002. *Urban Highway Freight Modeling Including Intermodal Connectors for Florida*.

With the emphasis on Florida, the research project reviews freight transportation modeling methods on urban freight transportation modeling practice. Freight transportation model development issues on the freight trip generation, trip distribution, modal choice, and assignment steps of the modeling process, as well as the data sources for truck modeling are identified. A freight transportation modeling system is designed to recognize intermodal connectivity, multimodal choices, and commodity and truck types. The last chapter addresses the statistical and econometric issues associated with development, specification, and estimation of urban freight transportation models from aggregate freight transportation data sets.

Polydrom

Reebie Associates. 2003. *The Northeast-Southeast-Midwest Corridor Marketing Study: Examining the Potential to Divert Highway Traffic From Interstate 81 to Rail Intermodal Movement*. Final Report. Prepared for Virginia Department of Rail and Public Transportation.

Regan, Amelia, J. Holguin-Veras, G. Chow, and M. H. Sonstegaard. *Freight Transportation Planning and Logistics*. A1B02: Committee on Freight Transportation Planning and Logistics, Transportation Research Board.

Regan, Amelia C., and R. A. Garrido. 2002. *Modeling Freight Demand and Shipper Behavior: State of the Art, Future Directions.*

The paper reviews research regarding freight demand and shipper behavior modeling. Various approaches to freight demand modeling are analyzed and their advantages/disadvantages discussed. These models are categorized according to their data requirement and geographical scope (aggregate, disaggregate, international, intercity (interregional), and urban). Later in the paper, research regarding the shipper behavior modeling is analyzed and emerging issues and opportunities are discussed.

Reggiani, Aura, P. Nijkamp, and W. F. Tsang. 1997. *European Freight Transport Analysis Using Neutral Networks and Logit Models*. Tinbergen Institute Discussion Paper (TI 97-032/3).

Roberts, Paul O. 1999. *Logistics and freight transportation: review of concepts affecting bulk transportation.* Presentation to the World Bank supply chain management course. February 10, 1999.

___.?. *Trends in inter-regional goods movement.*

Ross, Keith W. and J. F. Kurose. 1999. *Point-to-Point Routing Algorithms.*

___.2000. *Routing Principles.*

Rowinski, Jakub, M. P. Boilé, L. N. Spasovic, and Y. Wang. ?. *A Multi-Commodity, Multi-Class Generalized Cost User Equilibrium Assignment Model*. TRB ID: 01-2596. Accepted for presentation at the 80th Annual Meeting of the Transportation Research Board.

The paper presents the development of a transportation demand forecasting model for assigning multi-commodity, multi-class truck trips between various origin and destination points. The model takes into account the impacts of congestion on truck route choice and is implemented as a Geographic Information System (GIS) within the TransCAD software package and Microsoft Access. It is used to ascertain impacts of proposed capital improvements on the transportation network performance. The objective is to demonstrate how the model can provide the freight transportation planner with an initial assessment of the magnitude of changes in the traffic flow and the user costs. This will enable the planner to better understand the problem at hand so that s/he can identify an issue/area that requires further study. As an application, the model is used to analyze freight traffic on New Jersey highways and five transportation policy scenarios.

Ruiz-Torres, Alex J. and J. E. Tyworth. 1997. *Simulation Based Approach to Study the Interaction of Scheduling and Routing on a Logistic Network*. Proceedings of the 1997 Winter Simulation Conference, ed. S. Andradóttir, K. J. Healy, D. H. Withers, and B. L. Nelson.

Russo, F. and A. Vitetta. 1997. *The parallelization level for stochastic assignment to the transportation network*. Engineering Faculty, University of Reggio Calabria.

In this paper an analysis of parallel algorithm for transportation assignment model are developed. Algorithm for generating All or Nothing and Stochastic Network Loading are studied in relation to parallel process. A numerical application on a multiprocessor computer for a real network is done.

Russo, Giovanni, A. Reggiani, and P. Nijkamp. 2001. *Modelling and Estimating Modal Share in European Transport*. Tinbergen Institute Discussion Paper (TI 2001-095/3).

Samuel, Peter, R. W. Poole, Jr., and J. Holguin-Veras. 2002. *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation*. Reason Foundation. Policy Study No. 294.

http://www.rppi.org/060602.html

The United States needs a fresh approach to long-distance inter-city trucking. The current system, which integrates large trucks and smaller passenger vehicles in mixed traffic lanes, leads to frequent conflicts between cars and trucks. It also unduly limits the potential productivity of long-haul trucking.

This policy study offers a viable alternative: self-financing toll truckways. These toll truckways would consist of one or more lanes in each direction for sole use by large trucks, separated from existing lanes by concrete barriers, and generally equipped with their own ingress and egress

ramps. These truck "freeways-within-the-freeway" would be custom-built and designed for use by longer and heavier trucks, which would have exclusive rights to the lanes, and would keep the general motoring public free from exposure to big rigs in the mixed-traffic lanes. If permitted by the 2003 reauthorization of the federal surface transportation program, the first toll truckways could be in service by the end of the decade.

Sheu, Jiuh-Biing. 2003. "A hybrid fuzzy-based approach for identifying global logistics strategies". *Transportation Research Part E 40 (2004)* 39–61.

Shinghal, Nalin and T. Fowkes. 2001. "Freight Mode Choice and Adaptive Stated Preference". *Transportation Research Part E 38 (2002)* 367-378.

This paper provides empirical results form an adaptive stated preference survey of freight mode choice in India. The Leeds Adaptive Stated Preference (LASP) software was used for the survey. Attribute values included are transit time, reliability, intermodal container service alternative, rail service alternative, and discount required for tri-weekly/weekly service as compared to a daily service. Respondents' ratings for alternatives were analyzed pair wise (so that four ratings give three paired choices and nine LASP iterations give 3*9=27 observations). For each pair, a pseudo-probability of choosing the first alternative was derived and converted into a 'log-odd' value. Then, the log-odds were regressed against the difference between the two alternatives in terms of time, cost, reliability, and dummies for two levels of frequency and two alternative modes (rail and intermodal). A weighting is used and the coefficients were divided by the coefficient of cost. As a result, intermodal services can be viable in India for high value and finished goods, but they would require higher frequency, reliable and fast service. On the other end, rail can be a viable service for the bulk goods.

Small, Kenneth A. and C. Winston. *The Demand for Transportation: Models and Applications*. Essays in Transportation Economics and Policy: A Handbook in Honor of John R. Meyer (1999). Edited by José A. Gómez-Ibáñez, William B. Tye, and Clifford Winston.

Jungyul Sohn, T. J. Kim, G. J.D. Hewings, J. S. L. Sung-gheel Jang. 2003. *Retrofit Priority of Transport Network Links under an Earthquake*, Journal of Urban Planning and Development, American Society of Civil Engineers. Also EPIL Discussion Paper Series: 02-0202.

This paper analyzes the economic impact of an earthquake on transportation network that contains more detail for the Midwest states. Two aspects of cost are considered in the paper: final demand loss and transport cost increase. The 1812 New Madrid earthquake is used to develop a scenario for the analysis. The modeling system includes a transportation network loss function, a final demand loss function and an integrated commodity flow model. After running the earthquake scenario, the analysis identifies the most significant link on the network in an economic sense as well as the link with the greatest physical disruption. The results reveal that the links with greater physical disruption are not always the ones exhibiting the greater economic damage. The resulting outputs can provide information to perform accost-benefit analysis as well

as to support a decision-making process on the optimal retrofit priority of bridges and links on the transportation network.

Soliman, A. H., A. M. Gadi, D. A. Wyatt, and S. M. Easa. 1991. "Regulatory Reform and Freight Mode Choice". *Transportation 18*: p. 261-284.

The paper presents the effects of reform of trucking Vehicle Weights and Dimensions (VWD) regulations in Canada on mode choice between truck and rail. The authors used an Abstract Mode Model using aggregate economic data and regression analysis. The model does not generate absolute estimates for freight tonnage, but constructs an equation which calculates the effect of a policy change on an existing system. The output of the model is not future volume (for which a gravity-type model may provide), but a comparison of volumes with and without policy change. The model takes into account both socio-economic and modal service characteristics in interpreting trucking volumes over each link (O-D pair). The general structure of the model is: $V_{ijm} = f(S_i, D_j, X_1, X_2, ..., X_m, ..., X_n)$.

More specifically, the factors included for modeling inedible end product commodity include product of population and industrial index at origin; product of per capita income and market index at origin; travel time by truck; cost by truck; product of population and industrial index at destination; product of per capita income and market index at destination; travel time by rail; and cost by rail. The form of the selected model is:

$$V_{ijk} = \alpha_0 * (POP_i * IND_i)^{\alpha_1} * (INC_i * MK_i)^{\alpha_2} * TT_k^{\alpha_3} * C_k^{\alpha_4}$$
$$* (POP_j * IND_j)^{\alpha_5} * (INC_j * MK_j)^{\alpha_6} * TT_r^{\alpha_7} * C_r^{\alpha_8}$$

where

$C_r = D_{od}^{\beta}$ (That is, cost of rail as a function of distance).

These structures are applied three configurations of the available data (83-84, 83-85, & 83-86) and the results are found fairly consistent and all of them satisfy the pragmatic and statistical conditions.

Sorratini, Jose A. 2000. *Estimating Statewide Truck Trips Using Commodity Flows and Input-Output Coefficients. Journal of Transportation and Statistics*.

Southworth, Frank, D. Xiong, and D. Middendorf. 1997. *Development of Analytic Intermodal Freight Networks For Use Within A GIS*. Center for Transportation Analysis. Oak Ridge National Laboratory.

This paper discusses the practical issues involved in constructing intermodal freight networks that can be used within GIS platforms to support inter-regional freight routing and subsequent (for example, commodity flow) analysis. The procedures described can be used to create freight-routable and traffic flowable interstate and intermodal networks using some combination of

highway, rail, water and air freight transportation. Keys to realistic freight routing are the identification of intermodal transfer locations and associated terminal functions, a proper handling of carrier-owned and operated sub-networks within each of the primary modes of transport, and the ability to model the types of carrier services being offered.

Tavasszy, Lóránt A., C. Groothedde, and C. Ruijgrok. 2000. *Aggregate Models of Spatial Logistics – Improving the Behavioral Content of Freight Transport Models*. Paper prepared for the third International Meeting for Research in Logistics (IMRL) conference. Trois-Rivières, Québec, Canada.

The paper presents research on the modeling of freight transport flows within the Netherlands. Models that are innovative, combining traditional aggregate models of freight transportation, the normative models of firm-level logistics processes, and system dynamics, are introduced. The report is intended to provide a more comprehensive and flexible models that aids public policy analysis on freight transportation.

Transportation Research Board. 2003. *Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles*. Special Report 267.

Testerman, Michael. 2003. "I-81 corridor plans will shape national policy course". *RAIL Solution*, May 30, 2003.

Thommana, Jose. 1997. *Real-Time Advanced Warning and Traffic Control Systems for Work Zones: Examination of Requirements and Issues*. Master Thesis. Department of Civil Engineering, Virginia Tech.

The I-81 Corridor in Virginia traverses the western part of the state, connecting Bristol in the south to Winchester in the north. A study carried out at the Virginia Tech Center for Transportation Research identified traffic safety, work zone safety and traffic control, trucking issues, and intercity traveler information needs as important issues that deserve attention on the I-81 Corridor in Virginia. Analysis of work zone accident statistics showed a need for real-time systems to enhance work zone safety.

Real-time advanced warning and traffic control systems provide a means of dynamic information dissemination and advanced warning, thereby enhancing work zone safety and facilitating traffic control.

The focus of this research was on the development of functional and system requirements for a real-time advanced warning and traffic control system for work zones. This task was based on the examination of work zone accidents and their causes. The functional requirements include advanced warning, surveillance, advisory, and control functions. Each of these functions consists of several sub-functions. The needs with respect to each of these functions have also been identified. System requirements such as real-time operation, credibility, portability, ease of installation, and adaptability were also identified.

Evaluation criteria and potential Measures Of Effectiveness (MOEs) for the evaluation of the system were also identified. Additionally, issues related to the evaluation of the system, such as time duration for evaluation and data collection techniques were identified and examined.

Transportation Research Board. 1994. *Travel demand modeling and network assignment models*. Transportation research record 1443. Contents include:

1. *Transportation Network Analysis Techniques for Detailed Travel Forecasts, Cathy L. Chang and David L. Kurth*
2. *Enhancements to Circulator-Distributor Models for Chicago Central Area Based on Recently Collected Survey Data, David L. Kurth, Cathy L. Chang, and Patrick J. Costinett*
3. *Using 1990 Census Public Use Microdata Sample to Estimate Demographic and Automobile Ownership Models, Charles L. Purvis*
4. *Practical Approach to Deriving Peak-Hour Estimates from 24-Hour Travel Demand Models, Charles C. Crevo and Uday Virkud*
5. *Shopping Trip Chains: Current Patterns and Changes Since 1970, Hyungjin Kim, Ashish Sen, Siim Sööt, and Ed Christopher*
6. *Estimation of Travel Demand Models with Grouped and Missing Income Data, Chandra Bhat*
7. *Improved Kalman Filtering Approach for Estimating Origin-Destination Matrices for Freeway Corridors, Nanne J. van der Zijpp and Rudi Hamerslag*
8. *Introducing "Feedback" into Four-Step Travel Forecasting Procedure Versus Equilibrium Solution of Combined Model, David E. Boyce, Yu-Fang Zhang, and Mary R. Lupa*
9. *Faster Path-Based Algorithm for Traffic Assignment, R. Jayakrishnan, Wei K. Tsai, Joseph N. Prashker, and Subodh Rajadhyaksha*
10. *Cost Versus Time Equilibrium over a Network, Fabien Leurent*
11. *Traffic Assignment Under Environmental and Equity Objectives, Laurence R. Rilett and Christine M. Benedek*
12. *Application of Dynamic Assignment in Washington, D.C., Metropolitan Area, E. de Romph, H. J. M. van Grol, and R. Hamerslag*
13. *Multiperiod Network Improvement Model, Chien-Hung Wei and Paul Schonfeld*

Transportation Research Board. 2003. *Freight Capacity for the 21st Century*. Special Report 271.

Transportation Research Board. 2003. *A Concept for National Freight Data Program*. Special Report 276.

U.S. Department of Transportation. *Three Modal-Diversion Models*.

von Haefen, Roger H. 2003. *Latent Consideration Sets and Continuous Demand System Models*. Department of Agricultural & Resource Economics, University of Arizona.

Victoria Transport Policy Institute. 2003. *Transportation Elasticities: How prices affect travel behavior*.

Virginia Association of Railway Patrons (VARP). 2003. "Coalition Seeks Rail Inclusion for I-81 Corridor Plans". From VARP's *On Track* newsletter, Summer 2003.

Virginia Department of Aviation, Virginia Department of Rail and Public Transportation, Virginia Department of Transportation, Virginia Port Authority. 1995. *Statewide Intermodal Long-Range Transportation Long-Range Plan*. June 1995.

Wachs, Matin et. al. 1998. *Transportation Models in the Policy-Making Process: Uses, Misuses, and Lessons for the Future.* Proceedings from a Symposium in the Problems of Transportation Analysis and Modeling in the World of Politics. Pacific Grove, California.

Wang, Hua and Dr. N. J. Garber. 2003. *Estimation of the Demand for Commercial Truck Parking on Interstate Highways in Virginia*. Final report of ITS Center project: Truck stop information. A Research Project Report for the National ITS Implementation Research Center, A U.S. DOT University Transportation Center. Center for Transportation Studies, University of Virginia. Research Report No. UVA-CTS-5-14-65

Washington State Department of Transportation. 2001. *Benefits of Rail Freight Study*.

Wellman, Michael. 1993. "The WALRAS Transportation Economy and A market-oriented programming environment and its application to distributed multicommodity flow problems". *Journal of Artificial Intelligence Research, 1*:1-23, 1993.

Market price systems constitute a well understood class of mechanisms that under certain conditions provide effective decentralization of decision making with minimal communication overhead. In a market oriented programming approach to distributed problem solving, we derive the activities and resource allocations for a set of computational agents by computing the competitive equilibrium of an artificial economy. Walras provides basic constructs for defining computational market structures, and protocols for deriving their corresponding price equilibrium. In a particular realization of this approach for a form of multi-commodity flow problem, we see that careful construction of the decision process according to economic principles can lead to efficient distributed resource allocation, and that the behavior of the system can be meaningfully analyzed in economic terms.

Wilbur Smith Associates (ongoing). *Virginia Statewide Transportation Model*. For Virginia Department of Transportation.

___. 2002. *Summary and Analysis of Goods Movement Data. Draft Report*. Prepared for Virginia Department of Transportation.

___. 2002. *Virginia Statewide Traffic Model: Review of Available Data. Draft Report*. Prepared for Virginia Department of Transportation.

___. 2003. *Technical Memo Virginia Statewide Transportation Demand Model Macro Model Development Draft* (March 31, 2003). Prepared for Virginia Department of Transportation.

___. 2002. *Technical Memo Virginia Statewide Transportation Demand Model Micro Model Development Draft.* Prepared for Virginia Department of Transportation.

Williams, Ian, al. 2002. *DfT Integrated Transport and Economic Appraisal: Review of Freight Modelling. Inception Report.*

The study reviews current freight modeling techniques. After assessing the suitability of the options potentially available, the study makes recommendations on the most appropriate techniques for use in Great Britain. The review will include road, rail and other freight modes and the modeling of light goods vehicles.

___. *DfT Integrated Transport and Economic Appraisal: Review of Freight Modelling. Report B2 – Review of Models in Continental Europe and Elsewhere*.

The study reviews current freight modeling techniques in the continental Europe and North America and assess its suitability for use in Great Britain.

Winston, Clifford. 1981. "A Disaggregate Model of the Demand for Intercity Freight Transportation". *Econometrica, Vol.49, No.4*, p.981-1006.

Xu, Jinghua, K. L. Hancock, F. Southworth. 2002. *Simulation of Regional Freight Movement on the TTMNet: Trade & Transportation Multi-Networks*. TRB 2003 Annual Meeting CD-ROM.

The paper describes a simulation model called TTMNet, constructed for the purpose of studying the effects of highly developed information technologies and logistic strategies (e.g., e-commerce and the real-time information) on freight transportation. TTMNet is formulated as a multi-level product supply chain system that integrates the financial, informational, logistical, and physical aspects of transportation networks, with interactions between each of these networks. Several simulators, including a freight traffic simulator, a supply chain decision-making simulator, and a pseudo-real-time information simulator, are involved. The freight traffic simulation is the focus of this paper. As part of this simulator, a learning model is set up to help decision-makers estimate transportation cost based on past experiences. Given the stochastic nature of these transportation costs and of the freight demands simulated by the system, the route for an origin-destination shipment may not remain optimal during a trip, and may change along the way. A vehicle redirection procedure is presented to handle this. A numerical example is designed to compare a set of freight movements under two scenarios, one supported by and the other not supported by pseudo-real-time information on traffic conditions.

Yan, Jia, K. A. Small, and E. C. Sullivan. 2001. *Choice Models of Route, Occupancy, and Time-of-Day with Value Priced Tolls.*

Zhan, F. Benjamin. 1997. "Three Fastest Shortest Path Algorithms on Real Road Networks: Data Structures and Procedures". *Journal of Geographic Information and Decision Analysis, Vol.1, No.1*, p.69-82.

It is well known that computing shortest paths over a network is an important task in many network and transportation related analyses. Choosing an adequate algorithm from the numerous algorithms reported in the literature is a critical step in many applications involving real road networks. In a recent study, a set of three shortest path algorithms that run fastest on real road networks has been identified. These three algorithms are: 1) the graph growth algorithm implemented with two queues, 2) the Dijkstra algorithm implemented with approximate buckets, and 3) the Dijkstra algorithm implemented with double buckets. As a sequel to that study, this paper reviews and summarizes these three algorithms, and demonstrates the data structures and procedures related to the algorithms. This paper should be particularly useful to researchers and practitioners in transportation, GIS, operations research and management sciences.

Zhan, F. Benjamin and C. E. Noon. 1998. "Shortest Path Algorithms: An Evaluation using Real Road Networks". *Transportation Science, Vol. 32, No. 1*, February 1998. p. 65-73.

Ziliaskopoulos, Athanasios K. 1996. *A Linear Programming Model for the Single Destination System Optimum Dynamic Traffic. Northwestern University*

Recently, Daganzo introduced the cell transmission model-a simple approach for modeling highway traffic flow consistent with the hydrodynamic model. In this paper, we use the cell transmission model to formulate the single destination System Optimum Dynamic Traffic Assignment (SO DTA) problem as a Linear Program (LP). We demonstrate that the model can obtain insights into the DTA problem and we address various related issues, such as the concept of marginal travel time in a dynamic network and system optimum necessary and sufficient conditions. The model is limited to one destination and although it can account for traffic realities as they are captured by the cell transmission model, it is not presented as an operational model for actual applications. The main objective of the paper is to demonstrate that the DTA problem can be modeled as an LP, which allows the vast existing literature on LP to be used to better understand and compute DTA. A numerical example illustrates the simplicity and applicability of the proposed approach.

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Annotated Bibliography – Freight Planning

1983. *Trucking and intermodal freight issues*. Corp Author(s): National Research Council (U.S.).; Transportation Research Board. Washington, D.C., Transportation Research Board National Research Council National Academy of Sciences.

1986. "Report of joint conference, Eno Foundation board of directors and board of consultants, October 23 and 24, 1985." *Transportation Quarterly 40(5):* 126.

Devoted to two panels, "Transportation's new look--the challenges ahead" and "Intermodal freight transportation"; with a summary of the discussion.

1996. *Intermodal freight transportation : projects and planning issues : report to congressional committees*, U.S. General Accounting Office.

1997. "Indiana Rail-, Truck-Freight Service to be subsidiary of Norfolk Southern". *Knight-Ridder/Tribune Business News*: p609.

1999. House Joint Resolution No. 704: *Requesting the Secretary of Transportation to study the desirability and feasibility of establishing additional inland ports*.

1999. "At the short end of the intermodal stick". *Journal of Commerce*: 6.

The problem is real. Though statistics are sketchy, one sample of intermodal truckers' inspection records found violations in more than 20 percent of the containers or chassis. It should be noted that violations were found in a similar percentage of intermodal tractors.4. Productivity. Intermodal truckers haven't gained productivity like ocean and rail carriers that have ever-larger equipment and companies. Intermodal truckers are small businesses. Virtually no intermodal trucking is performed by publicly held companies with ready access to investment capital. Most intermodal drivers are independent contractors. That approach reduces costs, but also discourages loyalty. It's easy to understand why angry drivers feel their personal needs are inconsistent with those of carriers.5. Leverage. Billion-dollar ocean carriers have the upper hand because they can band together in rate negotiations with individual truckers whose revenue barely reaches the millions. Given these situations, it's understandable why intermodal truckers, and drivers, are restless.

2001. *Congestion in the United States transportation system* : hearings before the Committee on Transportation and Infrastructure, House of Representatives, One Hundred Seventh Congress, first session, May 22, 23, and 24, 2001. Committee on Transportation and Infrastructure., Washington : U.S. G.P.O. : For sale by the Supt. of Docs., U.S. G.P.O. [Congressional Sales Office], 2001 [i.e. 2002].

2002. "Trucking Briefs." *Traffic World*: 1.

2003. "Proposals on I-81 in $6 billion range two plans call for tolls to help fund the project". *Richmond Times-Dispatch*.

2003. *TEA-21 reauthorization: freight issues, joint hearing*. Committee on Commerce, Science, and Transportation. Subcommittee on Surface Transportation and Merchant Marine. Washington : U.S, G.P.O. : For sale by the Supt. of Docs., U.S. G.P.O., [Congressional Sales Office],: iv, 145 p.

2004. "Intermodal record powers U.S. rail freight". *Journal of Commerce*: 1.

In total, 15 reporting U.S. and Canadian roads in 2003 moved 20.2 million carloads, up 0.3 percent, and 12.1 million trailers and containers, up 6.5 percent compared with 2002.

Abacoumkin, C. and A. Ballis. 2004. "Development of an expert system for the evaluation of conventional and innovative technologies in the intermodal transport area." *European Journal of Operational Research 152(2):* 410-419.

The context of this paper concerns the structure of an expert system based modeling tool that was developed and used within the framework of a recent European research project. The objective of the expert system is to produce alternative "technically sound" terminal designs, based on a number of user-defined parameters (cargo volume, loading unit mixture, layout characteristics, operating conditions, etc.) and equipment selections (conventional or innovative transshipment systems, rail access systems, identification, location and positioning devices, semi-automatic control, information systems, etc.). Each of the above "technological bricks" is identified by its "compatibility", "performance" and "cost" attributes. The "compatibility" and "performance" attributes-through an interactive interface-enable the development of technically sound terminal designs while the "performance" attributes are also used for the calculation of the equipment service cycle. A simulation module converts the equipment service cycle into train service time, as well as into truck service and dwell times, which are then compared to specific quality of service criteria. The cost of the non-rejected designs is calculated (using the "cost" attributes of all involved elements) and together with the draft terminal layout, the area equipment and personnel requirements, form part of the expert system output. (C) 2003 Elsevier B.V. All rights reserved. [References: 16]

Abbott, J. E. 1993. "World freight technology, '93." *Sterling Publications International Ltd.; 1993* 246p.

Head of title: The annual review of land, sea and air freight handling systems. Contents grouped under the headings: Containers and ancillaries; Port developments; Container and other freight handling equipment; Rail and intermodal freight; Computers in transport; Air freight. Freight transport; Motor transport; Air transport; Rail freight; Containerization (freight); Ports; Shipment of goods; Technological innovations; Shipping: Information processing systems.

Ahn, S. and I. S. o. A. T. Automation. 1997. *ITS applications on I-81 corridor in Virginia*.

Allen, B. J. V., R. Dale. 1986. "The Logistics of Rail-Barge Transportation Involving Non-Integrated Firms: A Purchasing Case Study." *Logistics and Transportation Review 22(1):* 69.

A case study is presented of an evaluation of a proposed rail-barge movement of coal for a Midwestern utility to replace an existing all-rail movement. Attention is focused on the actions involved in developing a large integrated transportation movement using nonintegrated transportation firms. Of special importance is the uncertainty associated with future market conditions and the importance of environmental regulations regarding the types of coal that can be used by the utility. The results illustrate that: 1. when a substantial capital investment is necessary, the risks associated with a change in transportation arrangements tend to favor the status quo, 2. rail service advantages that have important but difficult to measure economic effects tend to favor the use of all-rail transportation, 3. only a few rail-barge transportation options were available, and 4. transaction costs associated with rail-barge transportation are perceived to be insignificant by the utility's management.

Anonymous. 1997. "Location technology gives trucking firms the competitive edge." *Fleet Equipment 23(7):* 71.

Coastal Connection, an intermodal trucking company servicing Southern California, installed an automated vehicle location system offered by Teletrac Inc. The system allows Coastal's dispatchers to locate one or all of Coastal Connection's vehicles instantly and accurately on a highly sophisticated computer map of the region.

Anonymous. 2000. "Intermodal container traffic continues to rise." *Transportation & Distribution 41(10):* 12.

Anonymous. 2002. 2001 "Container traffic up". *Logisticstoday. 43*: p20.

Anonymous. 2002. "Staying on track." *Logistics Management 42(7):* 39.

Former Surface Transportation Board head Linda Morgan believes that the railroad industry should keep three words in mind: growth, cost, and-perhaps most importantly-service. To compete with trucks, service has got to be reliable and consistent. Railroads have indeed become more aware of the importance of service, to the point that some carriers are offering money-back guarantees if they fail to meet specific targets. Improved intermodal service may be the railroads' best hope for growth. The potential is definitely there: intermodal transportation set a record last year with nearly 9.4 million originating trailer and container units, up from 8.9 million in 2001. The rail industry has its share of controversies, too. First and foremost is the dwindling number of major railroads, which has raised questions about whether the federal government needs to foster more competition. Another is the issue of open access, which allows customers moving freight along one rail line to choose an alternate provider or route.

Anonymous. 2002. "Rail giants introduce coast-to-coast guaranteed service." *Transportation & Distribution 43(6)*: 19.

The Burlington Northern and Santa Fe Railway Co. and Norfold Southern Railway Co. have introduced coast-to-coast guaranteed intermodal service between Southern California and the Northeast.

Anonymous. 2002. "Moving product to Mexico." *Transportation & Distribution 43(9):* 14.
Honda has selected MexiModal to move time-sensitive parts between its production complex in Marysville, OH, and Guadalajara, Mexico. BAX Global, which services the main business areas of Mexico City, has expanded its BAXSavel service to include time-definite, door to door delivery with its single provider service, cross-border customs compliance, and Web based tracking.

Anonymous. 2003. "Pacer adds two to Mexico-US intermodal services." *Transportation & Distribution 44(4):* 19.

Anonymous. 2004. "Can intermodal mix with Amtrak in the Northeast Corridor? NS says yes." *Trains 64(2):* 13.

Apffel, C. 1996. *Freight components in Louisiana's statewide intermodal transportation plan*.

Arkansas State Highway and Transportation Department Planning and Research Division. 2002. *Freight component: Arkansas' statewide long-range intermodal transportation plan.*

This report, an assessment of Arkansas' freight transportation system, is divided into four sections: (I) Arkansas' Existing Freight Transportation System; (II) Major Freight Corridors and Intermodal Freight Facilities; (III) Market Areas and Shipping Patterns; and (IV) Freight Transportation Issues, Funding Options, and Development Strategies. The two primary objectives of the study were to identify key factors for developing Arkansas' freight transportation modes and intermodal services, and to determine the most pressing issues facing the freight system.

Arnold, P., D. Peeters, et al. "Modelling a rail/road intermodal transportation system." *Transportation Research Part E: Logistics and Transportation Review In Press*, Corrected Proof.

This paper deals with the problem of optimally locating rail/road terminals for freight transport. A linear 0-1 program is formulated and solved by a heuristic approach. The model is applied to the rail/road transportation system in the Iberian Peninsula. Five planning scenarios are considered. It is shown that modal shares are very sensitive to the cost of rail and to that of track gauge changes at the Spanish border. Conversely, the location of the terminals has little or no impact on the market shares of the combined traffic, but location changes in the Peninsula generate consequences on the entire European transportation system.

Arnold, P. and I. Thomas. 1999. "An attempt at modelling the optimal location of transshipment points in a multimodal system." *Espace Geographique 28(3):* 193-204.

Multimodality can be a competitive alternative for the transport of people or goods. An important factor in this competitiveness is the location of transshipment points, i.e. the junctions between different transport modes or networks. This paper discusses this issue from the angle of location theory. The location of transshipment points is defined as a distinct issue involving the optimal location of facilities for transfers from one network to another with the objective of

reducing total transport costs. These costs are defined as the sum of the transshipment costs and the cost(s) associated with the transport mode(s) operating on each network; these latter costs are a function of the distance covered on each network and of the volumes transported. An analytical solution is proposed and discussed. An example of application to freight transport in Belgium illustrates its relevance. [Journal Article; 29 Refs; In French; Summary in English and French].

Ashtakala, B. and A. S. N. Murthy. 1993. "Sequential models to determine intercity commodity transportation demand." *Transportation Research Part A-Policy & Practice 27(5):* 373-382.

The objective of this study is to determine the demand for commodity transportation using the conventional sequential modelling approach. In this study, the amounts of productions and consumptions of commodities at various locations were obtained from a commodity flow survey (shipper and consignee type) conducted by Alberta Transportation, Edmonton, in 1977 and 1978. Optimized gravity model for distribution and Log-linear and Logit models for modal split were developed from the above survey data. These models are discussed in this paper. The above three stages of modelling process yield the demand for commodities between origins and destinations in the province of Alberta. Demands for commodities (flows) are represented graphically in the form of commodity flow diagrams (CFD) between the population centers (origins and destinations). They also show the demand for commodities between origins and destinations by different modes, truck and rail. The CFDs for a few selected centers are shown to indicate the pattern of commodity flows across the province. They indicate that truck transport dominates the movement of all commodities. The modelling procedures and the results shown in this paper are applicable for transportation planning. [References: 14].

Babcock, M. W. G., H. Wade. 1989. "Changing Determinants Of Truck-Rail Market Shares." *Logistics and Transportation Review 25(3):* 251.

Rail market share models are developed for both the pre and post deregulation eras. Analysis indicates that rail-truck market shares in the pre-deregulation period are a function of relative modal rates, interest rates, and relative modal service. However, this formulation breaks down in the post 1980 period. Analysis indicates that post deregulation time dummy variables accounted for little impact on rail-truck market shares in 1981 and 1982 but the effect steadily increased in the most markets between 1983 and 1986. This could be due to lagged response to major transportation policy changes including the Motor Carrier Act of 1980, the Staggers Rail Act of 1980, and the Surface Transportation Assistance Act of 1982.

Ballis, A. and J. Golias. 2004. "Towards the improvement of a combined transport chain performance." *European Journal of Operational Research 152(2):* 420-436.

Within the framework of the promotion of the environmental friendly modes, the European Commission has launched a number of research projects aiming at evaluating technical and organizational innovations that can improve the performance of the freight transport operations in the rail sector. The scope of this paper is to present a modelling approach focusing on the comparative evaluation of conventional and advanced rail-road terminal equipment. The set of models used, consists of an expert system for the terminal design, a model simulating terminal operations and a macro-model implementing rail operating forms and assigning freight flows in the transport network. This approach stems from the fact that the time savings due to efficient terminal transshipment can be used effectively only in combination with advanced rail operating forms. (C) 2003 Elsevier B.V. All rights reserved. [References: 29].

Barami, B. and J. A. V. N. T. S. Center. 2000. *Partnership to promote enhanced freight movement at ports and intermodal terminals a strategic plan*. Cambridge, Mass., The Office.

Barton, J. E. 1999. *Developing a proposal for a multi-user intermodal freight terminal as a public-private partnership : lessons learned about public and private perspectives, timing, and roles*.

Battelle Team. 1995. *Comprehensive Truck Size and Weight (TS&W) Study. Phase 1-Synthesis. Working Paper 9: The Effects of TS&W Regulations on Truck Travel and Mode Share*. U.S. DOT Comprehensive Truck Size & Weight Study, Phase I, Paper 9, Federal Highway Administration, U.S. Department of Transportation.

The paper discusses the ways size and weight policy affects vehicle usage and modal diversion and areas that require further analysis. The end of the paper also includes a bibliography of related papers.

The intention of this working paper is to provide researchers and policy analysts with as much information about estimating the effects of potential policy changes on usage of alternative truck configurations and on modal diversions as it is practical to assemble within a limited period of time. The first section of this paper contains an extended discussion of the ways in which size and weight policy affects vehicle usage and modal diversion. The second section provides a brief discussion of several areas requiring more investigation. The concluding section contains a bibliography of material relating to issues addressed in this report. Topics covered include: the effect of changes in truck size and weight regulations on vehicle configurations currently used for different hauls; the effect of those regulations on diversion between rail and truck; effect on ton-miles transported by truck; and effect on truck vehicle miles.

___.. Truck Size and Weight Modelling Workshop. U.S. Department of Transportation Comprehensive Truck Size and Weight Study Report No.3.

Beargie, T. 2001. "DOT seeks fix for intermodal connectors." *American Shipper 43(2):* p. 16-17. Subtitle: Agency launches drive to improve U.S. highway connections to ports, airports and intermodal freight transfer facilities.

Bel, G. 1997. "Changes in travel time across modes and its impact on the demand for inter-urban rail travel." *Transportation Research. Part e, Logistics & Transportation Review 33:* 43.

Analysis of the demand for inter-urban rail travel has received little attention in contrast to the large number of studies on urban travel demand. The studies on inter-urban rail demand usually emphasize the effects of monetary costs. Occasionally, changes in rail travel time are considered. However, the central aspect in our study is the impact of changes in road travel time on the demand for rail. This paper specifies and empirically estimates an explanatory model to evaluate the impact of travel time changes on inter-urban rail demand. The change in rail passenger traffic between two periods on various routes is compared to the change in travel times on these routes. That is, it is a model estimated on the change in cross-section traffic volumes between the two periods. The empirical analysis confirms the explanatory power of changes in the intermodal structure of travel times, and shows the need to introduce the impart of these changes when studying the demand for inter-urban travel.

Berwick, M. 2001. Intermodal highway/rail/container transportation and north Dakota. Fargo, ND, Mountain-Plains Consortium.

The report discusses a survey of North Dakota businesses' outbound/inbound transportation that was conducted to identify containers being shipped by truck/rail intermodal into and from the state. Results showed that the Southeast portion of the state represented some 61% of all traffic. The study provides a snapshot of truck/rail container intermodal shipping into and out of North Dakota. It reveals the benefits of intermodal transportation including lower overall transportation costs, increased economic productivity and efficiency, reduced congestion and a burden on over-stressed highway infrastructure, higher returns from public and private infrastructure investments, reduced energy consumption, and increased safety.

Berwick, M. D., U. G. P. T. Institute., et al. 2001. *North Dakota strategic freight analysis*. Fargo, N.D., Upper Great Plains Transportation Institute, North Dakota State University.

Beuthe, M., B. Jourquin, et al. 2001. "Freight transportation demand elasticities: a geographic multimodal transportation network analysis." *Transportation Research Part E: Logistics and Transportation Review 37(4):* 253-266.

Bianco, L., D. Campisi, et al. 1995. "Which regions really benefit from rail-truck substitution - empirical evidence for Italy." Papers in *Regional Science 74(1):* 41-62.

Recent papers show a renewed interest in the analysis of trade-offs and of substitution effects in freight transport between truck and rail modes in order to reduce air and noise pollution as well as oil consumption. The inter-modal substitution effects are of particular interest in the Italian peninsula where geographical and geological factors create a natural impedance to the movement of goods between regions. In this paper, we analyze the current situation in Italy, evaluate the possibility of a consistent switch to the rail system and compute the relevant substitution and demand elasticities. Regions and productive sectors that benefit from an increased efficiency in transportation are identified. [References: 22].

Boardman, B. M., EM. 1999. *Intermodal cost analysis software user's manual*: 36p.

This document presents installation procedures and operating instructions for intermodal transportation analysis software. The software enables the user to determine the least cost combination of transportation modes or the shortest throughput route between a given shipment origin and destination. The user may define both the origin and destination as well as the shipping network that is analyzed. The software accommodates truck, rail, barge and air transportation. The software is described in more detail in two technical reports available from the Mack-Blackwell Transportation Center (MBTC) at the University of Arkansas.

Boile, M. P. and J. G. Gaspard. 2002. "A combined passenger/freight intermodal transportation system." *Transportation Quarterly 56(2):* 7-13.

Bonney, J. 2004. "An interesting year ahead". *Journal of Commerce*: 1.

Intermodal chassis. Shipping lines in the Ocean Carrier Equipment Management Association have been discussing wider use of chassis pools in which carriers share equipment. Look for

movement on that front. Action also is likely this year on an industry effort, brokered by the Intermodal Association of North America, to address chassis maintenance, repair and liability issues.

Bontekoning, Y. M. 2000. *The importance of new-generation freight terminals for intermodal transport*.

Bontekoning, Y. M., C. Macharis, et al. 2004. "Is a new applied transportation research field emerging?--A review of intermodal rail-truck freight transport literature." *Transportation Research Part A: Policy and Practice 38(1):* 1-34.

Intermodal freight transport has developed into a significant sector of the transport industry in its own right. This development has been followed by an increase in intermodal freight transportation research. We contend that a new transportation research application field is emerging; and that, while still in a pre-paradigmatic phase, it is now time to move on to a more mature independent research field. An independent research field can be justified because intermodal transport is a complex system that has characteristics which distinguishes it from other transport systems. We have reviewed 92 publications in order to identify the characteristics of the intermodal research community and scientific knowledge base. This paper will discuss aspects of this research, assessing the status quo and seeking directions for the future. To conclude, we will propose an intermodal research agenda which can direct the intermodal research field towards a period of "normal science".

Bookbinder, J. H. and N. S. Fox. 1998. "Intermodal routing of Canada-Mexico shipments under NAFTA." *Transportation Research Part E: Logistics and Transportation Review 34(4):* 289-303.

Boske, L. B. and L. B. J. S. o. P. Affairs. 1999. *Case studies of multimodal/intermodal transportation planning methods, funding programs, and projects*. [Austin], Lyndon B. Johnson School of Public Affairs, University of Texas at Austin.

Boyce, C. 2003. "Roadmap to Peace?" *Traffic World*: 1.

The Association of American Railroads and the American Trucking Associations agreed to support the status quo on truck size and weight regulations in effect since Congress passed the Intermodal Surface Transportation Efficiency Act in 1991. In the short term, the agreement means little because no one expects anything more than a 1- or 2-year extension of the Transportation Equity Act for the 21st Century from this Congress. Shippers' advocates such as the National Industrial Transportation League see the truce as a positive step.

Boyer, K. D. 1975. *The price sensitivity of shippers' mode of transport selection and the inter-modal allocation of freight traffic*, University of Michigan.: vii, 166 leaves.

Brander, J. R. G. and F. R. Wilson. 2001. *Regional intermodal freight transport flows and projections*.

Brogan, J. J. 2001. *Establishing a foundation for statewide freight planning*, University of Virginia: xi, 227 p.

Brogan, J. J., S. C. Brich, et al. 2001. *Application of a Statewide Intermodal Freight Planning Methodology. Vtrc* ; 02-R5. Charlottesville, Va. Springfield, VA, Virginia Transportation Research Council: 60.

Anticipating the need for Virginia to comply with the new freight planning guidelines outlined by ISTEA and TEA-21, the Virginia Transportation Research Council in 1998 developed a Statewide Intermodal Freight Transportation Planning Methodology which provided a standard framework for identifying problems and evaluating alternative improvements to Virginia's freight transportation infrastructure. The first step in the methodology was to inventory the system. This study completed that step.

Burton, M. 2003. *Improving the efficiency of truck/rail intermodal transportation*.

The vast majority of manufactured commodities moving in international trade are shipped in ocean-going containers. Thus, except for locations relatively near seaports, regions that wish to engage in emerging global markets must rely on rail-truck intermodal facilities. The nearer manufacturers are to such facilities, the more competitive they are. Firms that are relatively far from intermodal facilities find it difficult to complete in international markets. With the possible exception of West Virginia's northern and eastern panhandles, most areas of West Virginia are more than 130 miles from the nearest rail-truck intermodal facility. The same is true for eastern Kentucky and southern Ohio. This lack of proximity adds approximately $450 - $650 to each container shipped to or from the region. As a result, the volume of such shipments is relatively small. If the region is to become a meaningful participant in international markets for manufactured goods, the lack of access to intermodal terminals must be addressed.

However, because the rail lines that traverse the region cannot accommodate double-stack intermodal railroad equipment, remedying the lack of facilities is challenging. Freight containers are shipped most efficiently when they are moved in equipment that allows containers to be stacked two high (double-stacked). Double stacking allows many quasi-fixed train costs to be spread over a nearly doubled cargo capacity. This substantially reduces the per-ton cost of container movements. Generally, doublestacks require a minimum top-of-rail clearance of 20'3". Within this context, the West Virginia Department of Transportation, in conjunction with a number of partners, has engaged in an analysis that explores double-stack container movements. This report summarizes the preliminary findings of this investigation and provides a set of policy recommendations.

Caldwell, H. *North American Freight Flows and Trends*. O. o. F. M. a. O. United States. Federal Highway Administration.

The slides present FHWA Freight Productivity Program and schedule for Federal reauthorization; discuss the Freight Analytical Framework, NAFTA and Niagara freight flow estimates, and trends; and examine data and forecast applications to support Niagara awareness.

Cambridge, J., U. S. F. H. A. O. o. P. Development., et al. 1993. *Inventory of existing trade, traffic, and visitor flow data sources*. [Washington, D.C.], Federal Highway Administration.

Cambridge Systematics. 1995. *Characteristics and Changes in Freight Transportation Demand: A Guidebook for Planners and Policy Analysts*.

This guidebook is intended to be used as a reference document to assist transportation planners and others in conducting a variety of different types of analyses involving freight demand. References are provided to other documents for more details on procedures and data sources.

Cambridge Systematics, C. C. Leeper, Inc., et al. 1996. *Forecasting Freight Transportation Demand: A guidebook for planners and policy analysts*. National Cooperative Highway Research Program Project 8-30. Washington, D.C.

Campisi, D. and M. Gastaldi. 1996. "Environmental protection, economic efficiency and intermodal competition in freight transport." *Transportation Research 4C(6):* p. 391-406.

The awareness of the consequences of a further rise in transport for the environment has not only been a matter of concern for scientific researchers but also for planners and policymakers. In fact, the environment is now an ever present factor in the new political agenda and issues of excessive traffic congestion and global atmospheric pollution are increasingly attracting administrators' attention. One of the most important scenarios proposed for the protection of the environment, taking into account the adverse effects of traffic, is the redistribution of freight transport demand. In this paper the Italian situation has been tested, evidencing productive sectors and regions really benefiting from a more effective redistribution of trade flows among existing links on the freight network. This pattern is estimated by evaluating substitution elasticities before and after the introduction of a pollution tax. Numerical simulations, in terms of reduction of pollution emissions and transportation costs, are also provided.

Casey, J. E., E. Rhein, T; S. Branscum, G. Stefflre, J. Hertwig. 2000. *Intermodal freight transportation report card: Private sector perspective*. Global Intermodal Freight: State of Readiness for the 21st Century, Long Beach, California.

The private sector perspective on the intermodal freight transportation report card is examined in these presentations. Progress and challenges are addressed from the perspectives of the shipper, the ocean carrier, railroads, motor carriers, and intermodal system planning.

Center of Urban Transportation Research (CUTR) at the University of South Florida. 2002. "Analysis of Freight Movement Mode Choice Factors". F. D. o. T. R. P. a. *Safety:* 79p.

CUTR's efforts entailed a survey of available and relevant publications, reports and studies, an examination of the industry sectors where mode shift from road to rail might be most likely to occur, an investigation into the mode choice factors considered by shippers, and an overview of potential activities and policy direction to achieve an optimal split between road and rail movement of goods.

Chatterjee, A. 2002. "Security issues involving intermodal freight transportation and terminals." *Transportation Security Papers 2002*: p1-11.

Though passenger transportation generally receives more safety and security attention than freight transportation, it is quite important that freight transportation not be ignored. This paper investigates the security and safety risks to freight transportation, with special attention given to terrorist related security issues on intermodal freight transportation. The paper covers accidents, cargo theft, and acts of terrorism.

Chatterjee, A., UNC Institute for Transportation Research and Education, et al. 1995. *Intermodal freight transportation and highway safety*. Raleigh, NC, University of North Carolina, Institute for Transportation Research and Education.

Chimini, L., H. Caldwell, et al. 2000. *NHS intermodal freight connectors a report to Congress*. [Washington, D.C.], Federal Highway Administration, Office of Freight Management and Operations.

Chow, G. 1997. "Review of North American Commercial Transport Data Collection and Modelling Experience". Transport Data Centre and N. D. o. *Transport*: 119p + Appendices.

Clarke, D. B. 1996. *Intermodal freight transportation and highway safety*.

CNNfn. 2000. *Turning I-81 into easier drive, VDOT touts roadway helpers*. CNNfn industry watch [online].

Information and safety systems on Interstate 81 in Virginia's Shenandoah Valley.

Conference, N. A. o. S. T. O. 1997. *Intermodal freight planning in New England : the Port of Boston economic development plan and the New England transportation initiative*.

Conrad, K. 2000. "Competition in transport models and the provision of infrastructure services." *Journal of Transport Economics & Policy 34(Part 3):* 333-358.

The purpose of this paper is to model competition in freight transport and to work out the role of government in providing infrastructure for the competitors. Freight transport could in principle be provided by the firm itself by using firm-owned trucks, or transport services could be out-sourced by purchasing these services from rail and/or truck transport firms. We link production in the rest of the economy to transport demand, provided by two competing modes of transport. Given infrastructure, a fuel tax, and the stock of vehicles, we first derive the conditional demand functions of the economy for truck and rail services. The two transport firms know these demand functions and compete in prices. We then propose a transport policy that chooses two types of infrastructure, highways and the railway system, and a fuel tax in order to maximize welfare. The economic aspects for an optimal provision of the two types of infrastructure can be expressed by a set of unknown elasticities that measure the impact of infrastructure services on price and quantity variables in transport industries. With time-series data for the German economy we measure these impacts on prices in the rail and truck industries, on the volume of transport, on congestion, and on the utilization of the stock of transport equipment. [References: 6]

Coogan, M. A., S. C. Campbell, et al. 1995. *Innovative Practices for Multimodal Planning for Freight and Passengers: Project Bibliography*.

Cook, P. D., S. Das, A. Aeppli, and C. Martland. 1999. *Key Factors in Road-Rail Mode Choice in India: Applying the Logistic Cost Approach*. Proceedings of the 1999 Winter Simulation Conference.

There have been major changes in the share of road and rail traffic in India as the economy and the population has grown and become more urbanized. This paper summarizes the key factors for mode choice in freight transport that were found in India in a recent survey based on the Logistics Cost Model of shipper behavior. Both the relative importance of these factors and customer rating of satisfaction is presented.

Cottrill, K. 2001. "The long haul." *Journal of Planning Literature 15(3).*

If the U.S. economy continues on its current growth path as expected, the challenge facing planners and the freight industry is how to build an infrastructure capable of accommodating more freight traffic without encroaching on local communities. Most of the overseas trade flowing into and out of the United States passes through the nation's ports. One source indicates that 95 percent of all U.S. seas trade by weight and 75 percent by volume are carried by ocean-going vessels. On land, to cut costs, freight shippers and carriers are placing more emphasis of reducing their inventories. Such a task requires precise, highly reliable delivery services that are closely synchronized with manufacturing and distribution processes. Each transportation mode must keep delays and traffic bottlenecks to a minimum to meet the stringent delivery deadlines imposed by their customers.

Cross, G. 2000. *Travel Shenandoah: Lessons learned in a public/private ATIS Partnership*. ITS America. Meeting (10th). Revolutionary thinking, real results: ITS 2000, Washington, D.C.. ITS America.

Travel Shenandoah is a public/private partnership to provide timely accurate and useful traffic, travel conditions, traveler services tourist destinations and emergency service information for the Shenandoah Valley of Virginia. The ATIS was developed to address two specific areas: to minimize traffic problems caused by the widening of Interstate 81 which runs through the Valley and to improve the provision of traveler information for residents, visitors, tourists private and business travelers and motor freight carriers. The Shenandoah Valley ATIS will provide travelers with six classifications of information: travel alerts; traffic and travel conditions; traveler services; tourism, attractions and events; emergency services and route guidance. This information will be available to users on an "on-demand" basis through landline, cellular and PDC telephones, the worldwide web, cable television, radio and changeable roadside advisory signs and though subscription based technologies such as pagers, voice mail and fax.

Darche, M. 2002. *Trends in container transport : the modal split.*

de Jong, G., W. W. Hugh Gunn, and J. Widell , et al. 2002. *Study on Ideas on a New National Freight Model System for Sweden.* Prepared for the SAMGODS Group: 60p.

This study is intended to provide most recent and very best concepts that provide coherent and innovative framework suitable for policy oriented analyses and modeling for freight transport in a Sweden.

Delaware Valley Regional Planning Commission. 1995. *Intermodal freight plan*. Philadelphia, Pa., Delaware Valley Regional Planning Commission.

___. 2001. *National highway system connectors to freight facilities in the Delaware Valley region.*

Delaware Valley Regional Planning Commission (DVRPC) conducted a study of important roadway connections between the National Highway System and 12 key intermodal freight terminals to assist the planning needs of the Delaware Valley Goods Movement Task Force. The analytical work includes an inventory and assessment of physical and traffic operating conditions along the connectors (contained in the Appendix). Recommendations to improve deficiencies

along the network are also contained in Table 4 in the main report. The candidate improvement program identifies cost estimates and potential funding sources to implement the improvements, and truck trip generation estimates are provided as activity indicators for establishing priorities. Through the work, 67 individual projects have been identified representing approximately $163 million in improvement needs for the connector network.

The scope of the recommendations include conducting additional studies, improving signing, providing auxiliary lanes and/or new traffic signalization at intersections, completing/reconfiguring interchanges and constructing new access roadways. Many of the improvement recommendations are already contained in existing financing programs, while many of the smaller scale projects can be undertaken through existing maintenance programs. The work was conducted through DVRPC's Intermodal Management System (IMS) Planning Program. The IMS was one of the six management systems created by the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991, and is carried on through the auspices of the region's current long range plan.

Denisis, A. and M. I. o. T. D. o. O. Engineering. 2002. *Improving performance of intermodal terminals through automation and rail-for-truck modal switch.* Massachusetts Institute of Technology, Dept. of Ocean Engineering: 97 p.

Dewey, J. F., D. Denslow, et al. 2002. "The Response o i am going to go..... i don't want to ... but i can't $$ afford itf Railroad and Truck Freight Shipments to Optimal Excess Capacity Subsidies and Externality Taxes: An Empirical Study of Florida's Surface Freight Transportation Market". Report for Florida Department of Transportation. U. o. F. B. *Bureau of Economic and Business Research*: 47p.

Florida's public highways are congested. At the same time there is excess capacity on private railroads. Further, the social costs of moving a ton-mile of freight-including costs from air pollution, accidents, congestion, and wear on the nation's transportation system-are lower by rail than by truck for many types of freight movements. Given this situation, should the state design policies to increase utilization of the state's railroads? Would a policy that subsidizes freight shipment by railroad, and taxes the generation of harmful externalities, be beneficial to residents of the state? This report examines whether such policies can be economically justified.

BEBR's efforts entailed a consideration in economic terms of the justification for policies designed to alter the mode split from a traffic management, social cost and infrastructure utilization perspective. The level of subsidies and taxes necessary to achieve a shift are explored, and the potential consequences of such policies are reviewed. This report is a complimentary study of Analysis of freight Movement Mode Choice Factors conducted by the Center of Urban Transportation Research at the University of South Florida.

DiBenedetto, B. 2004. "Port of Portland revises transportation plan". *Journal of Commerce*: 1.

The Columbia Intermodal Corridor is a high density road and rail route in north and northeast Portland that carries more than 25,000 vehicles and 35 trains a day, the port said. The main east-west route serves Portland International Airport and the Rivergate Industrial District. The corridor is home to about 96 percent of Oregon's and southwest Washington's freight industries.

Donelly, R., N. M. S. H. a. T. D. O. o. B. Programs., et al. 1993. *Regional data bases and working paper on regional computerized data base*. [Washington, D.C.], Federal Highway Administration.

Donnelly, R., U. S. F. H. A. O. o. P. Development., et al. 1993. *Working paper on the role of government in trade and transportation between the U.S. and Mexico*. [Washington, D.C.], Federal Highway Administration.

Duin, R. v. 2002. *Intermodal freight transport*.

___. 2003. "Intermodal freight transport. Innovations in Freight Transport (Advances in Transport)". E. Taniguchi and R. G. Thompson. Southampton, Boston, *WIT Press*: pp 79-99.

In the last century the terms of accessibility and livability have become major issues in the development of a sustainable society. One of the important policy strategies in order to meet the elements of a sustainable society is the modal shift of road transport to more environmentally-friendly modes like railroad, coastal and barge transport. To compete with road transport, these transport modes are multi-modal set-up as intermodal transportation services with pick-up and delivery serviced by trucks. The general logistical concept for intermodal transportation handling is as follows: a carrier picks up an empty container from an empty dept by truck, leads the container at the shipper's location and brings the container to the nearest terminal.

The terminal operator receives this container, stacks the container temporarily and transships the container on the scheduled train or barge service. For fixed departure-times, a train or barge with fixed capacity departs for a long distance trip to another terminal. The container is temporarily stacked and a carrier arranges the final delivery to the customer. Other transport modes, like air and pipelines, can also be part of an intermodal transport system but these modes normally apply to different kinds of load units. This paper focuses on intermodal transportation services that have survived competition in business practice or have good potential to be accepted as serious alternative intermodal transport services.

Eatough, C. J., S. C. Brich, et al.1998. "A Methodology for Statewide Intermodal Freight Transportation Planning". *Virginia Transportation Research Council: 53*.

The study contained a methodology for statewide freight transportation planning with emphasis on identifying and prioritizing infrastructure needs to improve the intermodal freight transportation system. It is designed to provide the framework for state DOTs and MPOs to meet the freight transportation planning requirements as mandated by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and The Transportation Equity Act for the 21st Century.

The researchers accomplished this by interpreting the results of a literature search on the legislation, participant roles, and analytical methodologies to formulate the steps of the method and demonstrating how each step is performed. The process is based on the interaction between inputs from stakeholders and a technical analysis that provide decision support information. A case study demonstrates how the technical tasks for the system inventory and data forecasting are accomplished. The study shows that a standard but flexible freight planning methodology can help remove impediments to efficient goods transportation. Future developments such as

geographic information system data, improved freight flow data, and established system inventories are shown to facilitate the recommended process.

___. 2000. *A statewide intermodal freight transportation planning methodology.*

Ebeling, C. W. 2003. "Riding the intermodal rails." *Logistics Today 44(8): 26(6).*

Emmett, E. M. 1999. "Shippers sharpen focus on trucking, rail issues." *Transport Topics,(3336)*: p. 20-21.

Eno Transportation Foundation. 2003. *Intermodal freight transport in Europe and the United States*. A report of the fifth EU-US forum on intermodal freight: 78p.

This forum continues an informal, international exchange between leaders in government and private companies that began in 1997 with assistance of the European Union and the United States Department of Transportation. The separate agencies, companies, or industry associations as well as many individuals can, by meeting together help create a fuller system-wide understanding so that these individual actions, when taken together, contribute to a more efficient, more continuous and effective intermodal network. The following four priorities have been identified for this forum: strategic development of plans to alleviate specific bottlenecks, including consideration of operational improvements; increased public private cooperation to help all parties work in areas of mutual interest; creation of competitive structures that more fully reflect social concerns and that encourage greater coordination of processes and procedures; and, after September 11, 2001, analysis of risks and setting of priorities to deal with them to provide improved security.

Erickson, C. L., L. R. Grenzeback, et al. 1999. *Challenges and opportunities for an ITS/intermodal freight program : final report*. Washington, D.C., U.S. Dept. of Transportation, Federal Highway Administration.

Erickson, T. F. J. 2001. "Urban freight economics: A new rail paradigm for large lots." *Transportation Journal 40(3):* 5.

The generalization that trucks are more efficient for short-haul freight than railcars does not pertain where shipment size and complementary traffic levels are sufficiently large. In particular; there appear to be enormous opportunities for the competitive movement of truckload- and larger-sized lots by rail within urban areas, which have a sufficient concentration of freight activity to justify minimum right-of-way maintenance and reliable switching service on industrial branch lines. The recognition of this urban rail opportunity, in an age of escalating road degradation and congestion, would have far-reaching implications for regulators, urban planners, and rail management, all of whom have heretofore assumed that railroads' urban future lies only in disgorging trucks onto the urban road network from intermodal terminals.

European Commission. 2001. *Freight Intermodality*. Luxembourg, Belgium, Office for Official Publications of the European Communities.

The rapid growth in the road sector is taking away benefits of the vital contribution freight transport makes to the economy and society. The transport research program has targeted a range of solutions in freight transport. This brochure discusses research that will enhance door-

to-door services based on intermodal transport, and identify other topics considered. Some of the key areas of immediate action towards the realization of intermodal freight transport in Europe include: pursuing the strategy on trans-European networks and nodes; harmonizing regulations and competition rules in support of a single market in transport; eliminating obstacles to intermodality; and implementing the information society in the transport sector.

___. "Innovative rail intermodal service - IRIS." 128p.

The IRIS (Innovative Rail Intermodal Services) project follows the overall objective to demonstrate the commercial, operational and technical feasibility of enhancing intermodal freight transport on short and medium distances and to derive aspects which make this kind of transport a success. Three demonstration projects, characterized by different technical, organizational and administrative elements were implemented, demonstrated and evaluated in detail. An overview is given of the three demonstrations and an outline is provided of their contribution to the project results.

European Commission. Directorate-General Transport, PLS Consult, et al. 2000. *FREIA : towards the networking of European freight villages*. Luxembourg [Lanham, MD, Office for Official Publications of the European Communities ; Distributed in USA by Bernan Associates.

European Conference of Ministers of Transport. 2002. *Key issues for transport beyond 2000* : introductory reports and summary of discussions : 15th International Symposium on Theory and Practice in Transport Economics, Thessaloniki, 7-9 June 2000. Paris, France, European Conference of Ministers of Transport.

European Conference of Ministers of Transport, E. R. C. 1993. *Possibilities and limitations of combined transport*: report of the ninety-first Round Table on Transport Economics, held in Paris on 24th-25th October 1991. Organization for Economic Co-operation and Development; 1993, Organization for Economic Co-operation and Development: 128p.

Prospects for intermodal freight transport via road and rail in Germany, France, and the Netherlands.

Evers, P. T. 1994. "The occurrence of statistical economies of scale in intermodal transportation." *Transportation Journal 33(4):* 51.

A study is presented to empirically examine the extent to which statistical economies of scale are available to service-oriented companies - specifically, intermodal railroad-truck transportation firms. The obvious problem in applying inventory theory to service settings is that inventory is not carried by service-oriented companies. Four intermodal terminals in the US were visited during the spring of 1992 in order to collect data and observe the operating characteristics of the individual terminals. The findings suggest that, by combining adjacent intermodal terminals, railroads can reduce their capital investment in trackage and parking lots. The research suggests that investment reductions can be divided into 2 components: 1. reductions due to improved utilization, and 2. reductions due to pooled uncertainty. The occurrence of statistical economies of scale intermodal terminal consolidations was documented.

Evers, P. T. and C. J. Johnson. 2000. "Performance perceptions, satisfaction, and intention: The intermodal shipper's perspective." *Transportation Journal 40(2):* 27.

This article proposes a hypothesized model of intermodal railroad-truck usage and tests it at the carrier level. Empirical results indicate that a shipper's future usage of a railroad's intermodal service is affected by the shipper's satisfaction with, and ability to replace, the carrier. In turn, shipper satisfaction is, according to the analysis, influenced by a shipper's overall perception of the railroad's intermodal service. It is also established that these overall performance perceptions are driven by shipper perceptions of communication, quality of customer service, consistent delivery, transit times, and competitive rates. Implications of the investigation are given for railroad providers of intermodal service, and avenues of research are highlighted for future study.

Fang, Y. Y., R. Harrison, et al. 1996. *Forecasting freight traffic between the U.S. and Mexico*. Austin, Tex. [Springfield, Va., Center for Transportation Research, Bureau of Engineering Research, the University of Texas at Austin ; Available through the National Technical Information Service.

Faris, J. M. a. D. I. 1999. *Freight Modeling Techniques for Small and Medium-Sized Areas*. Sixth National Conference on Transportation Planning for Small and Medium-Sized Communities; Session #4.

This paper presents a practical and low cost modeling technique to include freight demand and truck movements in the development of long range transportation plans. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the new Transportation Equity Act for the 21st Century (TEA21) requires that States and Metropolitan Planning Organization (MPOs) consider urban freight in their long-range plans, transportation improvement programs, and annual work elements. However, in the last rounds of MPO long-range plan update certification reviews by the Federal Highway Administration (FHWA), one of the negative themes was the lack of freight and goods movement analysis within the current plans. This lack of analysis has occurred because most States and MPO's have little experience in freight planning, current and historical data on truck movements are limited, and most of the old freight models are extremely complicated. In September 1996 the U.S. Department of Transportation released the final report on the Quick Response Freight Manual through the Travel Model Improvement Program.

This manual provides the transportation modeler with simple techniques and transferable parameters which can be used to develop commercial truck movements within a conventional four-step planning model. This paper combines the techniques presented in the Quick Response Freight Manual and a simple four-step TranPlan travel demand model to develop, assign and analyze commercial truck trips in a small to medium urban area. Using the simple techniques and transferable parameters, the model could be developed with a limited amount of actual truck data. In this model, truck trips are broken into three types: four-tire; single unit; and, combination. By keeping the truck trips and the auto driver trips in separate purposes, the modeler can pre-assign or assign the truck trips (all, four-tire, single unit, and combination) to a regular network or special truck network under a full equilibrium process.

Federal Highway Administration. 2000. *Comprehensive truck size and weight study*. Volumes I, II, III, and IV: v.p.

This report presents results of a comprehensive examination of issues surrounding current Federal truck size and weight (TS&W) limits and potential impacts of changes to those limits. The report is provided in four volumes. Volume I, Summary Report, synthesizes the findings

presented in Volume II and Volume III. Volume II, Background and Issues, summarizes the information developed during the course of the study in the following areas: (1) TS&W regulations; (2) motor carrier operations and industry structure; (3) truck-rail competition; (4) shipper concerns; (5) highway safety and traffic operations; (6) highway infrastructure; and (7) enforcement. Volume III, Scenario Analysis, presents a broad assessment of the impacts that could be expected as a result of changes in TS&W limits. Volume IV, Guide to Documentation, presents a listing of the technical reports where methodological details related to analytical aspects of the study may be found.

___.. 2002. "Freight information real-time system for transport (FIRST)". *Freight News*: 2.

FIRST is an Internet-based, real-time network that integrates many resources into a single, easy-to-use Web site on cargo and port information. Designed by the intermodal freight industry, in cooperation with public sector partners, FIRST uses the Internet as a platform to data in a variety of formats to facilitate the safe, efficient, secure, and seamless movement of freight through the Port of New York and New Jersey. The FIRST Web site - http://www.firstnynj.com - provides real-time information on cargo status to ocean carriers, exporters, importers, foreign freight forwarders, customs brokers, terminal operators, and rail and trucking services. A trucking company, for example, can use the system to find out the status of a cargo container waiting to be picked up at the port. By verifying that the container is at the terminal and has been released for pickup, the trucker can avoid multiple telephone calls to the terminal and prevent unnecessary trips to the port.

___. "Freight information highway and cargo visibility Prototype". *Freight News*. Washington, D.C.: 2p.

A typical intermodal shipment traverses many miles and changes hands many times. During its journey, information about a shipment is often minimal and its visibility outside of the time that it's under the direct control of any one party is negligible. This lack of information leads to inefficiencies in freight transport. The Intermodal Freight Technology Working Group has been working with the intermodal industry, the U.S. Department of Transportation, and ITS America to develop and test applicable ITS technologies. Under the guidance of this public-private partnership, a team consisting of American Presidents Line, PAR Logistics Management Systems, Union Pacific, and Transcentric are now deploying the Freight Information Highway and Cargo Tracking prototype national system. The system is expected to integrate an advanced third-generation chassis tracking system with Internet-based intermodal freight logistics applications to provide end-to-end cargo visibility. One of the project's long-term goals is to provide information on the status and location of an asset over its serviceable life.

Ferreira, L. and J. Sigut. 1993. *Measuring the performance of intermodal freight terminals*.

___.1995. *Modelling intermodal freight terminal operations*.

Field, M. 2002. "Highway intermodal freight transportation: a policy and administration challenge for the new millennium." *Review of Policy Research 19(2):* pp 33-50.

This paper presents an overview of factors influencing highway intermodal freight transportation planning and policy in the U.S. The work gives examples of state and local initiatives to manage or balance the increasing highway transportation of freight with decreasing system capacity. Key

trends in commerce affecting intermodal freight generation are also identified. The paper concludes with a discussion of issues facing intermodal freight transportation planning and policymaking at the millennium.

Foran, P. 2002. "The next level: To get there, TFM, Ferromex and Ferrosur must remain more-with-less mode while achieving top-line growth." *Progressive Railroading 45(1):* pp 23-30.

Mexico's three largest freight railroads, Transportacion Ferroviaria Mexicana S.A. (TFM), Ferrocarril Mexicano S.A. de C.V. (Ferromex) and Ferrosur S.A. de C.V. eye the next step in privatization now that they have installed new procedures, streamlined some operations and captured the most promising business opportunities. They discuss their next-level strategies. TFM is aiming at the intermodal truck-to-train business, tighter operations and leaner budgets, more reliable schedules and shorter transit times. Ferromex is turning more attention to customer satisfaction with increasing on-time performance from 54% to 80% and more aggressive marketing. Ferrosur spent most of its first three years repairing infrastructure, and now the investment is starting to pay off. It is experiencing double digit growth and is expanding to link up with ferries and other vessels.

Fowkes, A. N., CA; G. Tweddle. 2002. "Investigating the market for inter-modal freight technologies. In: Transport Logistics." *Classics in Transport Analysis(5):* pp 217-228.

One of the main objectives of this paper is to assess the application of new intermodal freight technology that is under development for use in the U.K. 50 firms participated in the survey, the aim of which was to estimate the value manufacturers place on quality of service attributes in the transport of their goods. In addition to the quantitative results gained from the use of computer gaming techniques, qualitative information was collected regarding both the individual firms and the sector of industry of which they form a part. The results indicate that the current scope of intermodal services within Great Britain is quite limited. When the Channel Tunnel is opened, however, the picture is expected to change.

Gallagher, J. (2002). "Piecing it together." *Traffic World 266(45):* 25.

In its quest to build upon its motto of being more than truckload, Schneider National is ready to expand over its entire network an innovative intermodal marketing program it launched with Burlington Northern Santa Fe Railway last year. The service, called TruckRail Express, combines long-haul trucking with rail to create an intermodal move that is much heavier on the highway component than is typical for traditional intermodal. By leveraging its own fleet of 53-foot trailers and its own drayage services for the program, Schneider has been able to maintain a competitive advantage over other IMCs and other truckload carriers.

___. "Intermodal boxcars." *Traffic World 266(36):* 23.

When Hub Group Inc. asked wine distributor Lauber Imports Ltd. to consider a new intermodal service that utilizes boxcars instead of containers and trailers to move product, Lauber Imports President Mark Lauber was skeptical. But Hub Group said it could address his concerns, and, over a year later, Lauber is satisfied. Hub's intermodal carload revenue increased from $4 million in 1999 to $9.7 million in 2000, and then jumped to $18.9 million in 2001. A key to the success of the initiative is its ability to benefit from an intermodal infrastructure already in place.

___.2003. "Rail's intermodal future: intermodal could replace king coal in 2004 if the railroads can improve and maintain service.(Rail & Intermodal)." *Traffic World 267(51):* p24(2).

___. "Rails wooing FedEx: FedEx use of rail shows how hard railroads will push to compete for premium service. Rail & Intermodal." *Traffic World 267(47): 31(2).*

Gallamore, R. E. 1998. *State of the art of intermodal freight transport in the United States*.

Garber, N. J., H. Wang, et al. 2002. "Estimating the Supply and Demand for Commercial Heavy Truck Parking on Interstate Highways". *Virginia Transportation Research Council:* 61.

The increasing number of trucks traveling on Virginia highways has led to a growing demand for public rest areas and private truck stops. This study developed a methodology to determine the supply and demand for commercial heavy truck parking using I-81 in Virginia as a case study. In this study, supply was defined as the number of parking spaces available for large truck parking, and demand at a given time was defined as the sum of the parking accumulation and the illegal parking. Extensive data on the characteristics of large truck parking including parking duration and accumulation for different times of day were obtained. Data were obtained at 14 public rest areas and 29 private truck stops. Detailed information was also obtained on the characteristics of each truck stop and rest area, including the location; number and types of parking spaces; and availability of other facilities, such as restaurants and showers. Two types of questionnaire surveys were conducted. The first involved truck drivers, and the second involved truck stop managers/owners. The data collected were used to develop models to describe the relationship between parking accumulation and independent variables such as traffic volume on the highway, truck percentage, parking duration, and the distance of a truck stop from the interstate. The models developed were then used to estimate demand in 10 and 20 years. Any shortfall in supply with respect to the estimated demand was then determined for each truck stop and the entire highway.

The results indicated that the existing maximum demand is 2,947 parking spaces, which exceeds the supply by 309 spaces. This deficiency will increase to 1,193 and 1,463 spaces in 2010 and 2020, respectively, if the number of parking spaces for large trucks does not increase.

___.. *Estimating the supply and demand for commercial heavy truck parking on interstate highways : a case study of I-81 in Virginia*. Charlottesville, Va. [Springfield, VA, Virginia Transportation Research Council ; Available from the National Technical Information Service].

Gertz, C. 2003. "Lessons from a landmark US policy for transportation, land use and air quality, and implications for policy changes in other countries." *International Social Science Journal 55(2):* 307-+.

Normally, discussion about more sustainable mobility concentrates on the travel behavior of individuals, but the transportation system is also very much influenced by the behavior of institutions. This paper looks into changes in transportation planning and financing mechanisms initiated by the US Intermodal Surface Transportation Efficiency Act, introduced in 1991, and the Transportation Equity Act for the 21(st) Century, introduced in 1997. In spite of their limitations, these legislative provisions, driven by strong advocacy coalitions, have had a significant impact on US transport policy. They indicate lessons for other countries both in terms of the political process and in terms of interactions between levels of policy making. A top-down approach at

the Federal level can be useful to enhance a nationwide bottom-up planning process at the local and regional level. The ability to induce reform even in an unbalanced and unsustainable transport system with high car ownership, extreme development of car-oriented infrastructure, and high car use is an indication of more general potential for change. [References: 11].

Golob, T. F. and C. R. Amelia. 2002. "Impacts of highway congestion on freight operations: perceptions of trucking industry managers." *Journal of Planning Literature 16(3):* 397-477.

To better understand how road congestion adversely affects trucking operations, the authors surveyed approximately 1,200 managers of all types of trucking companies operating in California. More than eighty percent of these managers consider traffic congestion on freeways and surface streets to be either a somewhat serious or critically serious problem for their business. A structural equations model is estimated on these data to determine how five aspects of the congestion problem differ across sectors of the trucking industry. The five aspects are slow average speeds, unreliable travel times, increased driver frustration and morale, higher fuel and maintenance costs, and higher costs of accidents and insurance. The model also simultaneously estimates how these five aspects combine to predict the perceived overall magnitude of the problem. Overall, congestion is perceived to be a more serious problem by managers of trucking companies engaged in intermodal operations, particularly private and for-hire trucking companies serving airports and private companies serving rail terminals. Companies specializing in refrigerated transport also perceive congestion to be a more serious overall problem, as do private companies engaged in LTL operations. The most problematic aspect of congestion is unreliable travel times, followed by driver frustration and morale, and then by slow average speeds. Unreliable travel times are a significantly more serious problem for intermodal air operations. Driver frustration and morale attributable to congestion is perceived to be more of a problem by managers of long-haul carriers and tanker operations. Slow average speeds are also more of a concern for airport and refrigerated operations.

Goodloe, J. C., S. C. Brich, et al. 1996. *Development of a GIS freight transportation planning database* : final report. University Park, Pa., Mid-Atlantic Universities Transportation Center.

Group, O. f. E. C.-o. a. D. I. T. A. 2001. *Intermodal freight transport : Institutional aspects*. Paris, Organisation for Economic Co-operation and Development.

Guelat, J., M. Florian, et al. 1990. "A multimode multiproduct network assignment model for strategic planning of freight flows." *Transportation Science 24(1):* 25-39.

Hall, R. W. 1993. "Design for local area freight networks." *Transportation Research Part B: Methodological 27(2):* 79-95.

Local area freight networks (LANs) are used to collect and distribute freight within metropolitan regions. This paper classifies LAN topologies, then shows how the optimal topology for a common carrier depends on demand characteristics. A link cost function is developed that incorporates a linear and an integer term, the latter representing excess cost due to incomplete utilization of vehicle capacity. Continuous space models are used to approximate transportation distance. In addition, the model accounts for sorting and fixed costs at terminals. The star topology is found to be most attractive when a large proportion of shipments are external (i.e. originate or are destined outside the region), when many pickup and delivery routes are needed

to distribute freight and when shipments are small. The best examples of systems with these characteristics are postal services. The complete topology is most attractive when shipments are large and primarily internal, as in many less-than-truckload (LTL) trucking companies.

Harper, D. V. and P. T. Evers. 1993. "Competitive issues in intermodal railroad-truck service." *Transportation Journal 32(3):* 31.

US intermodal railroad (IRT) service is where one or more motor carriers provide the short-haul pickup and delivery service part of the trip and one or more railroads provide the long-haul or line-haul part. IRT combines the door-to-door convenience of trucks with the high-volume, long-haul economies of railroads. For IRT to be a viable alternative, it must be available to shippers and receivers, the quality and cost of IRT service must be competitive with other modes, and IRT service must be accepted and used by shippers. In a recent study, the results indicated that the overwhelming reason for using IRT was cost. However, availability and suitability of the service were important reasons as well. Comparing user perceptions of IRT and railroads, only one aspect of IRT service was rated lower that railroad service - suitability for shipment sizes.

Harrison, R., T. D. o. T. O. o. R. a. T. Transfer., et al. 1997. *Transportation issues and the U.S.-Mexico free trade agreement*. Austin, Tex. [Springfield, Va., Center for Transportation Research, Bureau of Engineering Research, the University of Texas at Austin ; Available through the National Technical Information Service.

Hauser, R. J. 1986. "Competitive Forces in the U.S. Inland Grain Transport Industry: A Regional Perspective." *Logistics and Transportation Review 22(2):* 158.

An empirical analysis is presented of interregional and intertemporal characteristics of US grain transportation rates from various regions by various modes to various export points. Representative transport rates for grain shipments from each crop-reporting district to relevant ports are obtained. Transport modes considered are direct rail, rail-barge, direct truck, and truck-barge. Port destinations include the East Coast, the West Coast, the Gulf, and the Great Lakes ports at Duluth, Chicago, Toledo, and Saginaw. The analysis covers the period September 1978-March 1983, before and after the 1980 Staggers Act. Rate levels tended to rise during the pre-Staggers period and to fall thereafter. Competition is found to arise from alternate destinations as well as alternate origins. Rate relationships among alternate routes and modes appear to vary over time; this implies that regional optimizing models should look carefully when estimating rate relationships for optimal location and routing decisions.

Hess, S. 2002. "Trucking guide provides reader with big picture." *Transport Topics(3512):* 15.

Hesse, M. 2002. *Transport and logistics in city regions : driving forces for counter urbanization?*

Hickey, K. 2001. "Road safety." *Traffic World 265(10):* 27.

Operation Respond Institute has a new member: W. W. Roland Trucking Co., part of The Roland Group. Operation Respond works with the railroad and trucking industries to prevent and contain serious accidents by providing information on hazardous materials traveling by train or truck.

HLB Decision Economics Inc. 1999. *Public Policy Impacts on Freight Productivity*. F. H. Administration: 126p.

The purpose of this report is to provide an annotated bibliography of the literature profile synthesizing existing research efforts that investigate public policy impacts on productivity. The annotated bibliography serves as a basis for the computer database. The report is presented in three chapters. The first chapter provides an introduction. Chapter 2 provides answers, emerging from the literature review, to questions about public policy impacts on productivity. Chapter 2 also introduces the format of the annotated bibliography and Chapter 3 concludes this report by providing a summary of findings. The main findings are as follows: Highway investments between 1950 and 1973 had a significant positive impact on trucking and economy-wide productivity; After 1970 the benefits of additional highway investment declined and were close to normal; The decline in both public and private investment has contributed to the slowdown in productivity; Changes in highway network investment lead to larger changes in productivity growth in vehicle intensive industries; An increase in highway capital leads to a reduction in demand for labor and materials and an increase in demand for private capital; and An effective transportation network delivers benefits beyond and above the direct benefits from improved transportation.

Hoel, L. and J. L. Peek. 1999. "A Simulation Analysis of Traffic Flow Elements for Restricted Truck Lanes on Interstate Highways in Virginia:. *Virginia Transportation Research Council*: 30.

In recent years, increases in truck traffic on Virginia's highways have raised issues concerning safety and capacity on interstates such as I-81 and I-95. Lane restrictions represent a strategy that is intended to reduce conflicts between trucks and cars and facilitate traffic flow. Field experiments to determine the effects on existing traffic under lane restrictions for an interstate freeway segment are usually not feasible, and an alternative approach was selected. In this study, the simulation model FRESIM was used to estimate various traffic flow elements. The purpose of this study was to analyze changes in traffic flow elements (density, lane changes per vehicle, and speed differential) under conditions of restricted and unrestricted truck lane configurations.

Prior to application of the simulation model to actual sites in Virginia, a scenario analysis was completed. The scenario analysis tested the variability of each traffic flow element considering the following variables: traffic volume, percentage of trucks, percentage of total volume by lane, presence or absence of lane restrictions, and grade. A statistical paired-sample t test was used to determine significant differences in the values of the three traffic flow elements when lane restrictions were applied. An analysis was also completed for three case studies in Virginia, located on I-81 near Buchanan, Christiansburg, and Wytheville. Two types of restrictions were tested: restricting trucks from the left lane and restricting trucks from the right lane.

From the results obtained in this study several conclusions were drawn: (1) restricting trucks from the left lane with steep grades causes an increase in speed differential and may decrease density and the number of lane changes, (2) restricting trucks from the right lane causes an increase in the number of lane changes, and (3) site characteristics dictate the effects of truck lane restrictions. Based on the results of this study, it is recommended that (1) trucks be restricted from the left lane when grades are 4 percent or greater and (2) trucks not be restricted from the right lane. The study results did not support removal of truck lane restrictions in Virginia.

Hoel, L. and J. Vidunas. 1997. "Exclusive lanes for trucks and passenger vehicles on interstate highways: an economic evaluation". *Virginia Transportation Research Council*: 3.

EVFS facilitates the calculation of BCR and NPW by applying prediction models. The reliability of the results is a function of the accuracy of the model and the quality of the data supplied to the program. Based on our extensive review and experience applying the model to a wide variety of conditions, we determined that EVFS is a useful analytical tool. A number of factors contribute to the feasibility of exclusive lanes. Although no factor predominates, EVFS gives more weight to traffic volume, vehicle mix percentage, crash rates, and maintenance and construction costs than other factors. The strengths of EVFS are its ability to analyze a number of alternatives for a variety of conditions, its ease of use, and its low cost. The weaknesses of EVFS are its inability to differentiate among lanes (i.e., inside, middle, outside) to which restrictions are applied and its unsuitability for analyzing exclusive lane alternatives in which a barrier is used to separate types of vehicles.

Holguín-Veras, J. 1999. "New Jersey's Links to the 21st Century: Maximizing the Impact of Infrastructure Investment". *Working Paper No. 2. Discussion of Alternative Modeling Frameworks*. United States Department of Transportation and the New Jersey Department of Transportation.: 13p.

This paper discusses the alternative modeling frameworks and identifies some of the key issues of the modeling components of the New Jersey's Links to the 21st Century project. It reviews the a wide range of modeling options with emphasis on the scope, level of specification (network and zoning), modeling options and computer tools, and data needs.

Holguín-Veras, J., G. F. List, et al. 2001. "An Assessment of Methodological Alternatives for a Regional Freight Model in the NYMTC Region". *New York Metropolitan Transportation Council (NYMTC):* 181p.

This report assesses the different freight transportation modeling methodologies. It begins with a definition of the scope of the regional freight model, followed by a discussion of the main freight transportation issues in the NYMTC region, and the potential role of the regional freight model. The main methodological alternatives are discussed next. This includes a brief description of the different models and a preliminary assessment of: (a) data requirements, (b) staff requirements; (c) computing power required; (d) adequacy to NYMTC's conditions; (e) practicality; and (f) conceptual validity. The final section presents a summary of the key findings of this project.

Hyland, T. 2002. "Louisville leads the way in logistics." *Transportation & Distribution 43(5):* 38.

The Logistics Quotient - a joint project of Transportation & Distribution and Expansion Management magazines - ranks Louisville, KY, second in the nation (behind Savannah, GA) for logistics-friendliness. Louisville' central location - within 500 miles of half of the US population - and diverse transportation infrastructure, make it an ideal place from which to operate a distribution center. The area boasts an impressive intermodal system as well. The region is served by 92 motor carriers, including most major freight companies, and has an extensive rail and yard network.

ICF Consulting and HLB Decision-Economics. 2002. "Economic Effects of Transportation: The Freight Story". *AECOM:* 24p.

This report describes the linkages between freight transportation and the economy. It is written with a broad audience in mind—an audience that is comprised predominantly of noneconomists. It draws on the technical concepts that have been constructed under the Freight Benefit-Cost Analysis (BCA) Study that is being sponsored by the Federal Highway Administration (FHWA)—see the adjacent exhibit. Improvements in freight carriage can be expected to have important economic effects. Lower costs or better service, or both, in freight movement have a positive effect on all firms engaged in the production, distribution, trade and/or retail sale of physical goods. Reducing the per mile cost of goods carriage means that any production or distribution facility can serve a wider market area, with potential gains from scale efficiencies. It also means a factory can draw supplies from a wider area with potential gains in terms of the cost and/or quality of parts and materials coming to the factory. Managers of businesses are paying ever closer attention to efficiency in goods movement and tighter control of inventory and the whole supply chain.

Logistics costs comprise transportation costs, costs of owning and operating warehouses, ordering costs, and carrying costs of inventory (principally interest and insurance). In recent years, trucking costs have been falling and reliability has been improving. Businesses have tended to respond by buying more transportation and using it to reduce the other components of logistics costs (e.g., through fewer warehouses or lower inventories). As we shall see, the tendency of managers to respond this way to lower costs and/or improved quality of freight transportation is a fundamental source of the economic benefits stemming from improvements in the freight transportation system. This report describes how an efficient and reliable freight transportation system helps to generate improvements in economic productivity.

Using findings from FHWA's Freight BCA Study, the underlying linkages between freight transport and the economy are reviewed first. Then, the types of factors that drive the efficiency and reliability of freight transportation are discussed. Emphasis is placed on events that have led to significant improvements in truck and rail transport—events that have provided the foundation for the benefits that can be generated via business reorganization. Finally, the detrimental effects of worsening congestion on the productivity of the freight system are reviewed. The speed and reliability of the freight system can be expected to worsen as vehicle traffic grows and congestion increases. Such a development could force shippers and carriers into costly redesign and restructuring of their systems with higher logistics costs and a consequent drop in productivity. Improvement in the performance of the freight system, with concomitant gains in national productivity, will require significant gains in the battle against congestion.

ICF Consulting, HLB Decision-Economics, et al. 2001. "Freight Benefit/Cost Study Capturing the Full benefits of Freight Transportation Improvements: A Non-Technical Review of Linkages and the Benefit-Cost Analysis Framework". *Federal Highway Administration Office of Freight Management and Operations:* 30.

ICF Consulting, H. D. E., Louis Berger Group. 2001. "Freight Benefit/Cost Study White Paper: Benefit-Cost Analysis of Highway Improvements in Relation to Freight Transportation: Microeconomic Framework". *FHWA's Freight BCA Study, Federal Highway Administration Office of Freight Management and Operations:* 77.

This study develops the micro-economic framework within which to measure the freight-related economic benefits and costs of transportation improvements. A key objective is to ensure that the Benefit-Cost Analysis framework recognizes the gains in economic welfare (efficiency) that follow from the propensity of industry to adopt productivity-enhancing "advanced logistics" in response to transportation infrastructure improvements. Whether the conventional Benefit-Cost Analysis framework already recognizes these so-called "reorganization" effects has been debated for some time. This paper seeks to put the matter to rest. This technical paper is presented in five sections. Section 2 gives an overview of industrial organization in relation to freight logistics. Section 3 outlines previous efforts to expand the micro-economic foundations of Benefit-Cost Analysis so as to capture the effects of industry reorganization. Section 4 builds on past efforts to develop the complete framework. Section 5 concludes with a discussion of related measurement issues and information requirements.

___."Freight Benefit/Cost Study Compilation of the Literature:. *Federal Highway Administration Office of Freight Management and Operations:* 73.

Iskander, W. H., M. Jaraiedi, et al. 1996. *Traffic volume projection in West Virginia and the I-81 Corridor*. Morgantown, WV [Springfield, VA, West Virginia University, Harley O. Staggers National Transportation Center ; Available through the National Technical Information Service.

ITS America. 2002. "Homeland security and ITS: using intelligent transportation systems to improve and support homeland security. Supplement to the National ITS Program Plan: A ten-year vision". *ITS America:* 36p.

This is a supplement to a document published in January 2002, entitled, "National ITS Program Plan: A Ten-Year Vision". The new theme of homeland security incorporates current status of the 10 year plan; needed research, institutional and program actions; benefits and challenges of the plan. One of the visions of ITS (Intelligent Transportation Systems) is that transportation systems in the future will be operated and managed in a way that provides end-to-end, seamless intermodal passenger transportation regardless of passenger age, location or disability; and end-to-end, seamless intermodal freight transportation as well. Goals for the transportation system include energy efficiency and environmental friendliness, transportation safety and security, optimal mobility and access, and economic soundness.

Jack Faucett Associates Inc. 1996. *Assessment of the Effects of Proposed Locomotive Regulations on Goods Transport Modes and Locomotive Emissions.* California Air Resources Board.

___. 1997. *California Freight Energy Demand Model Update*, California Energy Commission.

___. 1999. *Development of Destination, Mode, and Model Choice Options for Freight*. Washington, D.C., U.S. Department of Transportation Research and Special Programs Administration: 66p + Appendices.

The project will produce: Destination Choice Module, Mode Choice Scenario Analyzer, Procedures for Truck Network Assignment.

Jensen, M. W., M; R. Sanchez, A. Newton, C. Mitchell, and M. Hallenbeck. 2003. *WSDOT intermodal data linkages freight ITS operational test evaluation final report part 2: Freight ITS traffic data evaluation*: 66p.

In mid-1999, in response to the U.S. Department of Transportation's request for participation in the Intelligent Transportation Systems (ITS) Intermodal Freight Field Operational Test (FOT) Program, the Washington State Department of Transportation (WSDOT) entered into a partnership with public and private organizations to test and evaluate the following two freight traffic data ITS projects as part of its overall "Intermodal Data Linkages ITS Operational Test": (1) Freight ITS Congestion Management System. This test included an examination of a queue detection system and variable message sign on I-5 approaching the Port of Tacoma, as well as an Internet-based camera system installed at three port terminal roadway approaches at the Port of Seattle to monitor gateway and access road queues. (2) Freight ITS Data Collection. This test looked at vehicle transponders and wireless Global Positioning System (GPS) devices as tools for detailed data collection of regional freight traffic flows. These two tests were conducted in tandem with 17 public and private sector participants. Science Applications International Corporation served as the "Independent Evaluator" for this test.

Additionally, the Washington State Transportation Center (TRAC) served as the primary research team for the examination of the use of GPS devices and transponders to support freight traffic data collection. The results of these assessments, along with corresponding conclusions and recommendations, are detailed in this report. Two key conclusions are summarized as follows: (1) The three Port of Seattle cameras experienced approximately 2,000 hits on each camera in July of 2002. These three cameras have become an integrated component of the overall traffic management system in the greater Seattle region. (2) Despite significant data analysis challenges, the use of real-time GPS and transponder data collected from trucks and state systems does show promise as a means for metropolitan planning organizations to collect regional freight transportation data; however, further research and system tests will be needed to develop appropriate methods and tools.

Jiang, F. and C. C. P. Johnson. 1999. "Freight Demand Characteristics and Mode Choice: An Analysis of the Results of Modeling with Disaggregate Revealed Preference Data." *Journal of Transportation and Statistics 2(2)*: p149-158.

Considerably less research has been done on modeling freight demand with disaggregate discrete models than on modeling passenger demand. The principal reason for this imbalance is the lack of freight demand data. Freight demand characteristics are expensive to obtain and are sometimes confidential. This paper analyzes the freight demand characteristics that drive modal choice by means of a large-scale, national, disaggregate revealed preference database for shippers in France in 1988, using a nested logit. Particular attention is given to private transportation (own account transportation) and combined public and private transportation. After aggregation and validation of discrete choice models, the influence of demand characteristics on freight modal choice is analyzed. The maximum probability of choosing public road transportation takes place at approximately 700 kilometers, while that of choosing rail transportation take place at 1,300 kilometers.

Joe, B. and Reebie Associates. 2001. *Traffic Diversion: Highway to Rail Intermodal: U.S. Experience & Potential*. Conference on Freight Trends & Market Advantage. Cambridge, MA.: 26 slides.

Johnston, M. L. and S. Marshall. 1993. "Shipper perceptions of intermodal equipment." *Transportation Journal 33(1)*: 21.

Perceptions of intermodal shippers toward trailer-on-flatcar (TOFC), RoadRailer, and container intermodal rail equipment are examined. Six characteristics of equipment use are studied. These are: 1. cubic capacity, 2. gross weight capacity, 3. ease of loading and unloading, 4. protection of lading, 5. cleanliness, and 6. flexibility. The results indicate that shipper perceptions of present intermodal equipment is mixed, but some general impressions can be assessed. Currently, there is no single type of equipment that predominates for shipper favor. TOFC trailers are perceived high for cubic and weight capacity and flexibility between modes, but low for protection of lading and cleanliness. Containers are perceived high for ease of loading and unloading, protection of the lading, and cleanliness, but low for flexibility. RoadRailer trailers are perceived high for modal flexibility and cleanliness, but low for capacity. Containers appear to be the best investment for railroad equipment purchases.

Jourquin, B. and M. Beuthe. 1996. "Transportation policy analysis with a geographic information system: The virtual network of freight transportation in Europe." *Transportation Research Part C: Emerging Technologies 4(6):* 359-371.

This paper presents a multi-modal freight transportation model based on a digitized geographic network. A systematic analysis and decomposition of all the transport operations i.e. moving, loading and unloading, transshipping and transiting, leads to the development of a virtual network where each virtual link corresponds to a specific operation, and all transportation modes and means are inter-linked. Software, called NODUS, automatically generates the virtual network so that the model can be conveniently applied to large networks. The analytical structure of the links notation makes it easy to attach specific cost functions to each virtual link. The model is applied to the trans-European freight network of roads, railways and inland waterways for the transportation of wood. Cost functions are built up for each operation by each mode/means combination. A detailed point-to-point origin-destination matrix, calibrated on Eurostat statistics, is generated by a Monte-Carlo technique. Then, the total transportation cost is minimized with respect to the choices of routes, modes and means. This provides estimations of transportation services demands as well as modal splits, to the extent that the two hypotheses of demand based on generalized cost minimization and market contestability are accepted. A sensitivity analysis on the relative road cost is made, which provides measures of arc-elasticities.

Juang, Y. 2003. *Challenges for multimode transport in international logistics part: A case of Taiwanese ports*. 5th International Conference on Marine Technology, Szczecin, Poland, WIT.

This paper proposes an intermodal container cargo transport service that includes as its objectives economies of scale, operational efficiencies, and financial arrangement. The focus is on a short term objective to approach the long term vision by establishing a port logistics system and a global logistics management mode. The paper discusses the strategy for the intermodal freight transport system, comparing with the interior and exterior environmental situation for the intermodal development in international logistics park. Also described is the strategic planning methodology that adopted the Analytic Hierarchy Process method from the comparative point of view with container ports that use maritime intermodal facilities.

Kaori, M. and A. Takamasa. 2001. *Construction of Modal Choice Model with a Descriptive Utility Function using Fuzzy Reasoning*.: 6p.

It is important in travel behavior analysis to construct precise discrete choice models. Stochastic models based on the random utility theory such as logit models and fuzzy reasoning models can be combined in order to create advanced models for the estimation of travel behavior as hybrid models. Particularly, logit models with fuzzy logic utility functions have been proposed. It is known that the utility function described with fuzzy inference rules can reflect human decision with vagueness on the logit models. Multinominal fuzzy logit models are applied to a modal choice problem in this study. In particular, the fuzzy inference rules and parameters of membership functions are determined using Genetic Algorithm.

Kasturia, S. 1995. *An econometric study of intermodal competition: The case of German transportation*. Northwestern University: 149 p.

This dissertation analyzes some issues in intermodal competition in German transportation. The focus is on the determination of the rate structure in transportation industries in Germany, in particular railroad and trucking. Using current empirical industrial organization modeling techniques, the author develops an econometric model, calculates price-cost markups, and tests for the level of competition in the trucking and railroad industries in the freight and passenger markets. The results suggest that prices for motor carriers in Germany appear to be close to marginal costs. Thus, unlike one popular belief in Germany, there may not be much to be gained from further deregulating the industry. We also find the railroad industry prices to be close to marginal cost in the passenger market, but above marginal cost in the freight market. This could have important implications for this industry in analyzing the potential implications of privatization.

Kaufman, L. H. 2001. "Mexico: Land of opportunity." *Railway Age 202(2):* 40.

Cross-border rail traffic between the US and Mexico is growing at double-digit rates as Canada, the US, and Mexico integrate their economies under NAFTA. Automobiles and auto parts are by far the biggest category of cross-border traffic. Following autos and parts, southbound grain is the biggest traffic category, followed by beer northbound, steel in both directions, cement, soda ash moving southbound to be made into glass, scrap paper, coke, sand, and clay. Union Pacific leads the US railroads doing business with Mexico, which accounted for one-third of its growth in 1999. With revenue of around $900 million, UP's market share ranges from 75% to 80%, depending on how much grain Mexico imports.

___. "Move it cold, move it fast." *Railway Age 202(1):* 53.

Rail executives who market reefer service estimate the industry still carries only about 5% of the potential business that requires protective services. Trucks get the rest. But some are calling it a growth market. One railroad already is receiving new reefers, the first large order for new mechanical refrigerator boxcars in years, and another is seriously considering buying cars. Burlington Northern Santa Fe Corp. is optimistic about its intermodal Ice Cold Express operation, which originally operated between California and Chicago and more recently was extended to Toronto in an interline agreement with Canadian National.

Kim, C. G., T. 2000. *The potential for modal shift: Contestable truck traffic. Bridging the Gaps*. Canadian Transportation Research Board Forum, Proceedings of the 35th Annual Conference, Charlottetown, Prince Edward Island, Canada.

This paper provides an overview of a modal shift analysis done by Transport Canada in 1998 in support of the deliberations of the Transportation Climate Change Table. Previous work on modal shift has tended to focus either on specific shipments using detailed data, or on a larger scale, using aggregated publicly available data. The objective of this work was to develop a tool to assess the potential for modal shift from truck to rail, producing a complete picture of national and transborder transportation, and at a level of detail made possible by carrier data available.

Knatz, G. H., A; C. Cutshall, T. Wakeman, III. 2000. *Environmental Issues. Global Intermodal Freight: State of Readiness for the 21st Century*. Long Beach, California.

This conference panel session focuses on environmental issues, in particular what the transportation industry may face in the future. G. Knatz provides an overview. A. Hendrix highlights three major issues: air emissions from all modes and the impact on air quality; the need for technologies to reduce noise, particularly from trucks, rail, and at the localized level from airplanes; and water-quality controls. C. Cutshall focuses on what has become a hodgepodge of laws and regulations associated with the permitting process that confronts transportation projects. T. Wakeman discusses the challenges faced by the port community in getting approval for and undertaking dredging projects.

Komor, P. 1995. "Reducing energy use in US freight transport." *Transport Policy 2(2):* 119-128.

The movement of freight consumes about 6.2 EJ of energy annually, and accounts for about 19% of US oil consumption. Environmental concerns, notably urban air quality and global climate change, have increased attention on fossil fuel use and ways to reduce it. The freight sector has been largely overlooked, although there are numerous opportunities for reductions in energy use in this sector. Although trucks carry less than one-third of all freight (as measured by tonne-km), they account for over 80% of freight energy use - and their energy use is likely to continue to grow rapidly. Options to reduce freight truck energy use include improving technical energy efficiency through improved technology and operations; and shifting freight to other, more energy efficient modes. Demonstration runs of heavy trucks combining commercially available technologies, careful driving, and optimal driving conditions have obtained impressive energy efficiencies - 50-70% above that of the current fleet. If all heavy trucks achieved this level of energy efficiency, oil consumption could be reduced by about 1.0 EJ. Although real-world operating conditions would likely yield reduced energy efficiencies, these results do suggest the potential for a considerable energy saving from greater use of commercially available technologies.

For long-haul movements, trains are often more energy efficient than trucks. However the two modes differ in many other ways as well - trucks are often faster and more flexible, while trains are often less expensive. The recent growth in intermodal movements ties the two modes together, making use of each mode's strengths. At present trains and trucks do compete in some long-haul markets, and additional savings of up to 0.2-0.5 EJ may be possible by shifting more long-haul freight from trucks to trains.

Policy options to promote reduced energy use in freight transport include energy taxes, regulations such as performance mandates and improved speed limit enforcement, changes in Federal procurement and R&D, early retirement programs, and promotion of intermodal movements. In many cases reduced energy use can reduce costs and thereby improve the freight

system overall; however some policy options to reduce energy use - such as reductions in speed limits - may adversely affect other goals (in this case, speed of delivery); policy decisions must recognize these trade-offs.

Konings, J. W. 1996. "Integrated centers for the transshipment, storage, collection and distribution of goods." *Transport Policy 3(1/2):* 3-11.

In many circumstances intermodal transport is not competitive to direct road haulage. Intermodal transport is often less cost-effective, more time-consuming and less reliable than road transport. The necessary handling and the initial and final road section in an intermodal transport chain play an important role in this respect. Cost savings and quality improvements in the handling systems at container terminals as well as in the initial and final road section are therefore vital instruments for enhancing the competitiveness of intermodal transport. The concept of 'integrated centers for the transshipment, storage, collection and distribution of goods', presented in this article, integrates these policy instruments. The integrated centre is characterized by the spatial and functional integration of container handling, storage plus businesses having intensive container transport. The key element of the centre is the centre's own internal transport system. This paper outlines where, and under what conditions, these integrated centres could be best developed. Finally, the possibilities for developing such a centre at the Rotterdam Maasvlakte area are more fully discussed.

Kozan, E. 2000. "Optimizing container transfers at multimodal terminals." *Mathematical and Computer Modelling 31(10-12):* 235-243.
The use of containers have greatly reduced handling operations at ports and at all other transfer points, thus increasing the efficiency and speed of transportation. This was done in an attempt to cut down the cost of maritime transport, mainly by reducing cargo handling and costs, and ships' time in port by speeding up handling operations. This paper discusses the major factors influencing the transfer efficiency of seaport container terminals. A network model is designed to analyze container progress in the system and applied to a seaport container terminal. The model presented here can be seen as a decision support system in the context of investment appraisal of multimodal container terminals.

Kozan, E. and P. Preston. 1999. "Genetic algorithms to schedule container transfers at multimodal terminals." *International Transactions in Operational Research 6(3):* 311-329.

Kreutzberger, E. 2003. "Impact of innovative technical concepts for load unit exchange on the design of intermodal freight networks." *Transportation Research Record(1820).*

The best and most promising intermodal freight rail and barge networks, given new opportunities for designing networks, are identified. These opportunities have arisen because of numerous attempts at the end of the 20th century to introduce innovations in intermodal transport rapidly and to achieve a quality leap--a substantial improvement in the quality-cost ratio. The total effect had the appearance of an innovation wave. Most visible in Europe were hardware expressions such as new types of terminals, trains, barges, and storage and transport systems. Despite the low speed of implementation, achievement of a new level of effectiveness and efficiency of load unit exchange at nodes and link operations is expected. That would imply new conditions for network design. Thus, less promising networks could be improved, and some existing models would be superseded.

An important aspect of this reorientation is the choice of bundling concepts by train and barge operators. Beginning with the expectation of new opportunities, an analysis will be done of networks innovative in the method of bundling flows and by realizing short load unit exchange times at nodes. The focus will be on the relationship between important bundling characteristics--network volumes, transport frequencies, scale of transport, and network layout. A typology of bundling concepts, mathematical formulation of bundling effects and, for rail transport, results of performance and cost calculations are presented. One result is that, given one daily service on each transport relationship, hub-and-spoke concepts have the lowest main modality costs for networks with medium-sized flows, and line concepts have the lowest for networks with small flows.

___. *Impact of innovative technical concepts for load unit exchange on the design of intermodal freight networks*.

Lahsene, S. 2001. "New economy, new vision for transportation: Prominent role for intermodal freight?" *TR News(216):* p. 9-11.

Electronic commerce (e-commerce) is a business process improvement--but the high-tech system still depends on transportation to move goods from a point of origin to a place of higher value. The far-flung intermodal supply chains linked to this economy demand a prominent role for truck, air, rail, and waterborne freight. This article concludes, however, that without a strategy for the transportation system to support the changes in technology and business operations, the United States will lose vital economic opportunities.

LaLonde, B. J. 1997. *Intermodal freight requirements*.

Lambert, B. 2002. "Freight Transportation Profile—Virginia: Freight Analysis Framework". *Freight News:* 2.

Lantz, B. M., North Dakota State University., et al. 2000. *An evaluation of the impacts of ITS/CVO technologies on safety and the associated benefits throughout the supply chain. Phase I, A review of literature and case study analysis*. Fargo, N.D., North Dakota State University.

Lantz, B. M. C. A. N. D. S. U., I. Upper Great Plains Transportation, et al. 2000. *An evaluation of the impacts of ITS/CVO technologies on safety and the associated benefits throughout the supply chain. Phase I, A review of literature and case study analysis*. Fargo, N.D., North Dakota State University.

Lau, S. W. 1995. *Truck Travel Surveys: A review of the literature and state-of-the-art*. P. S. Metropolitan Transportation Commission: xvii, 80p, appendices.

This paper presents the literature on conducting truck travel surveys in the U.S. and abroad. It includes past experiences, as well as current practices in conducting truck surveys. The primary purpose of this paper is to present compiled information on truck surveys and truck travel demand forecasting experiences to the MTC to help evaluate the need for new truck/freight planning tools. The paper reports truck/freight survey experiences from Councils of Government, MPOs, for which MTC is one, and other state and regional transportation planning agencies, both inside and outside of the country. The paper des not attempt to review literature

on freight mode-choice surveys and/or modeling efforts (competition between rail and truck, for example)

Lewis, I., J. Semeijn, et al. 2001. "Issues and initiatives surrounding rail freight transportation in Europe." *Transportation Journal 41(2-3):* 23-31.

This article reviews the current issues and initiatives related to rail freight transportation in Europe. Since the liberalization of transportation in the European Union (EU), rail freight transportation systems have not been as successfully integrated as passenger rail networks, or airline, motor carriage, or inland waterway systems. As a result, EU policy and directives are attempting to promote and develop increased use of rail freight and intermodal services to overcome the environmental and congestion problems caused by the disproportionate use of motor carriage in the EU. The over-reliance on trucking has become even more critical as the EU expands towards Eastern Europe. Key initiatives such as the Trans-European Transport Network (TEN), Pan-European Corridors (PAN), Transport Infrastructure Needs Assessment (TINA), and Pilot Actions for Combined Transport (PACT) are discussed. Finally, suggestions are offered that would enable EU rail freight carriers to provide more competitive services on. a Pan-European scale. [References: 40]

Long, D. 2003. *International logistics : global supply chain management*. Norwell, Mass., Kluwer Academic Publishers.

Lowe, D. 2002. "Combined road-rail: What future?" *Logistics and Transport Focus 4(9):* 40.

The take-up of road-rail intermodalism has been slow and there is an undoubted continuing reluctance among freight shippers to divert traffic from established systems, where a road vehicle takes a load through from initial loading to final destination, to a system where the local collection and delivery element only is by lorry while the long-haul leg of the journey becomes rail-borne. Combined road-rail is seen, in many quarters, to be the alternative transport mode that has the greater respect for the environment and best exploits the complementary qualities of road and rail. The economic benefits of road-rail combined transport result from the fact that the expensive element of the road operation, namely the tractive unit and the driver, is kept fully utilized on short-haul, road-borne collections and deliveries, for which it is ideally suited and sufficiently flexible to go anywhere at any time to suit individual requirements. The essence of efficient combined road-rail transport lies in the use of standard loading units. Intermodalism is being spurred on by legislation and by its ability to beat traffic jams, lorry bans and goods vehicle drivers' hour's restrictions and shortages.

Macharis, C. and Y. M. Bontekoning. 2004. "Opportunities for OR in intermodal freight transport research: A review." *European Journal of Operational Research 153(2):* 400-416.

Intermodal transport reflects the combination of at least two modes of transport in a single transport chain, without a change of container for the goods, with most of the route traveled by rail, inland waterway or ocean-going vessel, and with the shortest possible initial and final journeys by road. Operational Research has focused mostly on transport problems of uni-modal transport modes. We argue that intermodal freight transportation research is emerging as a new transportation research application field, that it still is in a pre-paradigmatic phase, and that it needs a different type of models than those applicated to uni-modal transport. In this paper a

review is given of the operational research models that are currently used in this emerging field and the modelling problems, which need to be addressed. (C) 2003 Elsevier B.V. All rights reserved. [References: 47]

Mahoney, J. H. 1985. *Intermodal freight transportation, Eno Found for Transportation.*

The various combinations of motor, rail, water, air, and pipeline transport; issue of government regulation and deregulation; U.S., chiefly.

Mason, M. 2004. "Virginians Speak Out Against Toll Plans". *Harrisonburg Daily News-Record*.

McGinnis, M. A. 1990. *The relative importance of cost and service in freight transportation choice : before and after deregulation.*

McGuckin, N. C., Ed. 2000. "Intermodal truck traffic: Description and results of a survey in Chicago." *ITE Journal 70(12):* p. 38-41.

The intermodal truck survey was conducted in the Chicago, Illinois, area in the fall of 1996. The survey was designed to obtain characteristics of a sample of trucks and the trips made by those trucks, which travel to the surveyed intermodal facilities. Ten rail yards--five older urban facilities and five newer state-of-the-practice suburban facilities--were surveyed to determine the amount of truck trips attracted to each site in an average 24-hour weekday. Information was obtained by intercepting drivers arriving at a sample of intermodal sites and conducting a short interview about the origin of the trip that brought him to the intermodal yard and the destination of the next trip. A total of 2,213 interviews were obtained during the survey period. The vast majority of vehicles entering the sties were tractor-trailers. Over 64% arrived at the site carrying cargo, with an average cargo weight of 22,500 lbs. Only 8.2% of all trucks were classified as operating drayage--trips that move between intermodal facilities. On average, there were just over 12 truck trips per regular and contract employee in 24 hours. There was consistent activity during the business day, with an early afternoon peak.

McMahon, C. J. 2001. "The issues and challenges facing America's maritime and intermodal transportation system in the early 21st century." *Logistics Spectrum 35(1):* 24.

The future strength and vitality of the US is contingent on maintaining the best intermodal transportation system in the world, but the economic, strategic, and environmental challenges facing the transportation industry are enormous. Modal issues in the US air, highway, rail freight, and inland waterway systems are discussed, and some economic reasons for an American-flag merchant marine are considered.

McVey, M. J. B., C. Phillip, R. N. Wisner. 2000. *Brazil's soybean transportation system: A comparison with the U.S. system*. Proceedings of the 42nd Annual Meeting of the Transportation Research Forum, Annapolis, Maryland.

Several agribusiness firms and organizations are lobbying to have 600-foot locks on Upper Mississippi River dams extended to 1,200-feet. A major reason cited to support lock extensions is that Brazil is rapidly increasing its soybean production and improving its transportation system. These groups argue that Brazil will capture U.S. soybean export markets unless the Upper

Mississippi River locks are extended to 1,200-feet to offset Brazil's declining transportation costs. This paper examines the recent and expected changes in Brazil soybean production and transportation systems. It compares the cost of producing and transporting soybeans from Mata Grosso, Brazil with those form Iowa. The paper concludes that Upper Mississippi River lock extension will not solve the problem of competition from Brazil.

Mercer Management Consulting Inc. 1995. *Task 2C Report: Evaluation of Key Methodologies*. Interregional Goods Movement Study. S. C. A. o. Governments.

Task 2C was added to the Interregional Goods Movement Study to permit extensive review of three methodologies that are critical to study success:

- Modal Shift Methodology
- Port Diversion Methodology
- Economic Impact Methodology

This report provides an extensive discussion of all three topics and provides, in the case of modal shift and port diversion, findings and recommendations. In the case of economic impact, it provides a detailed explanation of the methodology proposed.
Methodological evaluations were based on the models or methodologies, and their documentation that could be located in an intensive literature search, supplemented by personal knowledge of researchers in the field.

Appendix A gives details on modal choice methodologies considered, and Appendix B gives further information on the recommended choice methodology

Middlemiss, J. 1998. "Training wheels are off Canadian intermodal business". (Special Report: Transportation). *The Financial Post*: p.R15(1).

Miller, J. S., V. D. o. Transportation., et al. 2003. *Expected changes in transportation demand in Virginia by 2025*. Charlottesville, Va. [Springfield, VA, Virginia Transportation Research Council ; Available through the National Technical Information Service.

Miller, K. 2002. "North America's international trade corridor." *Logisticstoday 43(1):* p. S2(10).

Morabito, R. and S. Morales. 1998. "A simple and effective recursive procedure for the manufacturer's pallet loading problem." *Journal of the Operational Research Society 49(8):* 819-828.

In this paper we present a simple and effective heuristic to solve the problem of packing the maximum number of rectangles of sizes (l, w) and (w, l) into a larger rectangle (L, W) without overlapping. This problem appears in the loading of identical boxes on pallets, namely the manufacturer's pallet loading (MPL), as well as in package design and truck or rail car loading. Although apparently easy to be optimally solved, the MPL is claimed to be NP-complete and several authors have proposed approximate methods to deal with it. The procedure described in the present paper can be seen as a refinement of Bischoff and Dowsland's heuristic and can easily be implemented on a microcomputer. Using moderate computational resources, the procedure was able to find the optimal solution of 99.9% of more than 20 000 examples analyzed.
[References: 27]

Morlok, E. K. and L. N. Spasovic. 1994. *Redesigning rail-truck intermodal drayage operations for enhanced service and cost performance*.

Muller, G. 1999. *Intermodal freight transportation*. Washington, D.C., Eno Transportation Foundation : Intermodal Association of North America.

Muller, G., J. H. Mahoney, et al. 1995. *Intermodal freight transportation*. Greenbelt, MD Landsdowne, VA, Intermodal Association of North America ; Eno Transportation Foundation.

Munuzuri, J., J. Racero, et al. 2002. *Parking search modelling in freight transport and private traffic simulation.*

Murray, T. 2002. *Wrong train running? : carload pays the freight; intermodal gets the green light*.

National Association of Regional Councils, United States. Dept. of Transportation, et al. 1985. *Linking goods movement and economic development : a case study analysis* : final report. Washington, D.C., U.S. Dept. of Transportation and Economic Development Administration, U.S. Dept. of Commerce : Distributed in cooperation with Technology Sharing Program, Office of the Secretary of Transportation.

National Research Council. 1983. *Rail-truck intermodal transportation research, 1982*. Washington, D.C., Transportation Research Board, National Research Council, National Academy of Sciences.

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National Research Council and National Conference on the Intermodal Freight Terminal of the Future. 1996. *Intermodal freight terminal of the future*. Washington, D.C., Transportation Research Board, National Research Council. Proceedings of the 1994 National Conference on the Intermodal Freight Terminal of the Future.

National Research Council, National Cooperative Highway Research Program, et al. 1997. *A guidebook for forecasting freight transportation demand*. Washington, D.C., National Academy Press.

National Research Council, United States. Defense Advanced Research Projects Agency, et al. 2001. *Global intermodel freight : state of readiness for the 21st century* : report of a conference, February 23-26, 2000, Long Beach, California. Washington, D.C., National Academy Press.

National Research Council (U.S.). Transportation Research Board. 1983. *Trucking and intermodal freight issues*. Washington, D.C., Transportation Research Board, National Research Council, National Academy of Sciences.

___.Transportation Research Board. 1998. *Policy options for intermodal freight transportation*. Washington, D.C., National Academy Press.

Newbourne, M. 2002. *Intermodal transport by land in the United States: A guide to intermodal trucking*.

This book provides a functional tool for those interested in the land- and sea-based trucking side of intermodal transport. It is broadly structured to educate on the subject of the trucking industry, and endeavors to provide a solid historical background of the role of surface transport in intermodal freight movement.

How things (products, goods, etc.) get from place to place is a mystery that this book unravels as relates to freight that moves between modes. From Railroad to Truck, Steamship to Railroad or Truck and so forth. This type freight movement is called INTERMODAL TRANSPORTATION and this book, and its accompanying CD spell out the various Categories (Railroads, Steamship Lines, Trucking, Equipment, etc) and then sub-divide each into the Sections or components that makes it work in concert with the other Categories. How Rails work with Truckers, is one example.

Blended in with the operational aspects of how intermodal work is done is a history of the past 40 years of the business as seen through the eyes of the Author, and experienced by him as a trucker, railroader, governmental and industrial employee. The work is educational in the sense that students, teachers, participants in the freight business, or those who enjoy transport history niches will be benefited.

Nierat, P. 1997. "Market area of rail-truck terminals: Pertinence of the spatial theory." *Transportation Research Part A: Policy and Practice 31(2):* 109-127.

The comparison of transport modes cannot neglect space or location. Road and rail networks differ greatly from each other in the number of access points: the choice of one mode over another thus depends on shippers' location in relation to these points. For freight, a spatial theory allows us to compare road and rail-truck intermodal transport. By tracing the market area of rail terminals, the theory defines the zones for which each mode is the most competitive. It shows which factors guarantee profitability for intermodal transport. The market area of a number of existing terminals was set up by questioning carriers. The results confirm our theoretical conclusions, notably the effect that the location relative to the terminal, the rail line-haul direction, and the length of the rail line-haul have on the size of the intermodal rail terminal's market area.

___. 2002. *A geometry of uncertainty: Cost and time in intermodal freight competition*. European Transport Conference Proceedings, Homerton College, Cambridge, England.

The objective of this paper is to determine, what is the best choice to carry a volume of goods between two points? This question does not have a single answer. It depends on, among other things, who answers the question, the volume and nature of the goods, the location of the origin and destination, the hour, and the transportation techniques available. However, it is clear that a motor carrier and the people living along the route do not agree. It is less easy to understand that two carriers or two shippers having exactly the same cargo may use different mode choices even though they have the same selection criteria. The paper discusses a cost comparison between all road and intermodal rail-road door to door services. It shows that one carrier may use intermodal when another carrier may use all road because of the fact that the first carrier has enough clients in the terminal market area and he has a return freight when the second carrier does not. But cost

is not the only selection criteria. Freight transportation choice relies on other factors: availability, suitability, time, and quality of service. This paper attempts to answer the question, is it possible to take these parameters into account in the theory of market areas? It uses two selection criteria, time and cost, and presents a case study.

Nijkamp, P. 1994. "Roads toward environmentally sustainable transport." *Transportation Research Part A: Policy and Practice 28(4):* 261-271.

This paper explores roads toward environmentally sustainable transport, with particular emphasis on the bottlenecks preventing the achievement of policy objectives of reconciling the economic interests of the transport sector with environmental constraints. Several arguments substantiated by empirical evidence from various countries are put forward to demonstrate that current megatrends in transport are at odds with a sustainable development and lead to high social costs. A variety of policy strategies is discussed to improve the current threatening situation.

Nozick, L. K. and E. K. Morlok. 1997. "A model for medium-term operations planning in an intermodal rail-truck service." *Transportation Research 31A(2):* p. 91-107.

This paper describes a model developed for medium-term operations planning in an intermodal rail-truck system. It was motivated by the need to redesign such systems to produce (I) more reliable service, (2) multiple service classes, and (3) better equipment and facility utilization. The model is an integer linear program, which is computationally difficult to solve. A heuristic procedure was developed which provides excellent solutions, generally within 1% of the known optimal solution to the relaxed (non-integer) problem. Thus the model and heuristic could be used on large networks. Uses of the model and possible extensions are briefly discussed.

Organisation for Economic Co-operation and Development. 2002. *Benchmarking intermodal freight transport*. [Paris], OECD.

___.*Benchmarking intermodal freight transport*. [Paris], OECD.

Organisation for Economic Co-operation and Development. Intermodal Freight Transport Advisory Group. 2001. *Intermodal freight transport : institutional aspects*. Paris, OECD.

Ozment, J. 2001. *Demand for intermodal transportation in Arkansas*, University of Arkansas, Fayetteville Mack-Blackwell Transportation Study Center: 38p.

Intermodal transportation offers many benefits to shippers and society in general, and intermodal movements have grown rapidly over the past 20 years, however, it still represents a very small portion of the total freight market. Thus, the benefits to the shippers and society are not being fully realized. Many shippers who use truck transportation assume that service times of intermodal movements would prohibit their use of it, and shippers who use rail service often assume that transportation costs of intermodal would prohibit its use; however, few shippers actually base their mode selection on total cost. The purpose of this study is to examine the role that intermodal transportation plays in today's logistics environment and to assess its potential for further growth and adoption by examining the potential for intermodal service based on total logistics costs. Based on data provided in the DOT's 1997 Commodity Flow Survey, a selection of products of different values were used as examples to assess the total cost of movements between

hypothetical origins and destinations. The result of the total cost of these movements provide insight into their potential impact of shifting freight from truck to truck-rail intermodal.

Parsons Brinkerhoff Quade and Douglas Inc. 2000. Final Report: *VIRGINIA INTERMODAL FEASIBILITY STUDY*. Norfolk, Virginia, Virginia Department of Transportation: 62.

As per Virginia House Resolution No. 704, both the House and Senate of the Commonwealth have concurred that the Secretary of Transportation be requested to study the desirability and feasibility of establishing additional intermodal transfer facilities. This study will help determine the possibility of reducing heavy truck traffic on long-haul highways in the Commonwealth, particularly Interstates 81 and I-95 by improving/constructing intermodal transfer facilities. This report analyzes long-haul truck traffic using Virginia highways. The data provides Virginia legislators with an overview of freight operations in the Commonwealth. This inventory should assist the Legislature in any future considerations with regard to funding intermodal transfer facilities in the Commonwealth. In addition, this study should provide understanding of out-of-state facilities having the largest impact on the Commonwealth's interstate and primary highway systems.

The analysis also provides insight into scheduled intermodal improvements. As a general rule, there are a few characteristics that make rail a viable alternative to freight trucking. For rail travel to be competitive with trucks, the distance between origin and destination should be greater than 500 miles. The most viable freight commodities for rail intermodal diversion are dry van container goods. Intermodal transfer facilities need to be available at the origin and destination. Additionally, the rail service needs to meet both production timing and market needs. Certain characteristics of the production facility make transition from long-haul trucking to rail intermodal transportation more likely. The volume of existing truck traffic should be, at a minimum, 25,000 containers a year. The trends for the producer should exhibit growth, or at least maintenance of current production. Similarly, the market location (freight destination) should possess certain characteristics for rail intermodal diversion to be viable. For instance, the market should be located in a large metropolitan area. The forecast for the market should reflect growth in population, employment and income. Major coastal ports often have one or more intermodal facilities. External factors also play a major role influencing mode choice and freight volume. In general, economic factors, such as the Federal Reserve discount rate, subsides to freight carriers, petroleum/energy prices, federal legislative initiatives and international trade agreements impact the production of goods and the means by which they are transported.

Peacock, K. L. and M. J. Demetsky. 2003. *RESEARCH NEEDS FOR DEVELOPING A COMMODITY-DRIVEN FREIGHT MODELING APPROACH*. Charlottesville, Virginia, Virginia Transportation Research Council: 32.

It is well known that better freight forecasting models and data are needed, but the literature does not clearly indicate which components of the modeling methodology are most in need of improvement, which is a critical need in an era of limited research budgets. This effort sought to identify those components using a logistics-driven approach as a starting point. The research began by examining other states responses to freight planning legislation. A survey was sent to 47 states to determine the types of freight planning and freight modeling that occur and to understand the current data available and data needs. Research was conducted to gather information on how the supply chain functions and how logistics decisions regarding supply

chain management are made. Sample supply chains were created for a variety of commodities, and mode choice was related to the behavioral aspects of the supply chains logistics system. Once the mode was determined, the route assignment could be determined based on the accessible freight infrastructure.

It was found that not all elements of the freight modeling methodology are equally weak: indeed, trip attraction components for the production of raw materials and the dissemination of these materials from the manufacturing plant, whether to the consumer (in a traditional push system) or to a just-in-time distribution center (in the newer pull system) are adequately developed in practice. However, it is critical that future research address the following needs, listed in order of descending priority: (1) the mode choice component for delineating travel by air, truck, rail, water, or a combination thereof; (2) trip attraction equations for intermodal facilities that are used when manufacturing plants outsource key components rather than creating all components in-house, and (3) trip attraction equations for representing the flow of goods from distribution centers to the consumer.

Pendyala, R. M., F. D. o. T. R. Center., et al. 2002. *Urban highway freight modeling including intermodal connectors for Florida freight modeling data and networks*. Tallahassee, FL, Florida Dept. of Transportation Research Center: 1 CD-ROM.

With the emphasis on Florida, the research project reviews freight transportation modeling methods on urban freight transportation modeling practice. Freight transportation model development issues on the freight trip generation, trip distribution, modal choice, and assignment steps of the modeling process, as well as the data sources for truck modeling are identified. A freight transportation modeling system is designed to recognize intermodal connectivity, multimodal choices, and commodity and truck types. The last chapter addresses the statistical and econometric issues associated with development, specification, and estimation of urban freight transportation models from aggregate freight transportation data sets.

Petre, M. K., U. S. D. o. T. R. a. S. P. Administration., et al. 1999. *Finding synergy in intermodal operations with truck and rail*. [Fayetteville, Ark., University of Arkansas, Mack-Blackwell National Rural Transportation Study Center.

Plant, J. 2002. "Railroad policy and intermodalism: Policy choices after deregulation." *The Review of Policy Research 19(2):* p13-32.

This paper examines the role played by railroads in intermodal freight transportation and the framework of public policies around which intermodal freight movement has evolved. Intermodalism emerged because of technological, organizational, and public policy developments that contributed to its rapid growth. Deregulation of the rail industry since 1980 has led to significant restructuring through mergers and direct contracts between railroads and customers. As intermodal shipments become more important to the overall transport system in the U.S., attention will need to be given to ways in which intermodal concerns are addressed in surface transportation programs.

Plowman, E. G. and American University Washington D.C. Transportation and Logistics Research Center. 1969. *Coordinated transportation: problems and requirements*. Cambridge, Md.,, Cornell Maritime Press.

___.. *Coordinated transportation: problems and requirements*. Cambridge, Md., Cornell Maritime Press.

Priemus, H. 1999. "On modes, nodes and networks: Technological and spatial conditions for a breakthrough towards multimodal terminals and networks of freight transport in Europe." *Transportation Planning and Technology 23(2):* 83-103.

The market share of trucks in European freight transport is still growing. Avoiding road congestion and other environmental reasons makes a modal shift towards barge, train and pipes necessary. This shift entails much more than the substitution of truck kilometers by train or ship kilometers. First, trains and ships do not usually provide door-to-door transport services. A transshipment of freight is necessary to create intermodal logistic chains. Second, transshipment usually entails high costs and loss of time. There are, however, encouraging developments: strategically located multimodal terminals can efficiently transship freight from one mode to another, operating 24 h a day. This transshipment can be implemented in an automated, robotized manner. Such technological innovations provide terminals with a promising future. Third, freight flows may be too thin to guarantee a satisfactory loading efficiency. The solution can be found by rearranging logistic chains to bundle freight and achieve thicker freight flows. This contribution describes - from a Dutch perspective - current problems of multimodality in European freight transport and some promising developments concerning terminals and networks. A technological and organizational breakthrough towards multimodality in freight transport is anticipated. This implies a change in the spatial configuration of freight flows and multimodal terminals along with the optimal choice of a combination of modes. This paper indicates an optimalization problem on a European scale, aiming at the minimization of private costs and a reduction of environmental costs. [Journal Article; 23 Refs; In English; Summary in English]

Railroads., A. o. A. 1981. *Who pays to move America's freight?* Washington, D.C., The Association.

Reebie Associates, The Woodside Consulting Group, et al. 2003. *The Northeast - Southeast - Midwest Corridor Marketing Study*. Stamford: 66.

Reed, R. 2003. *I-81 environmental study gets fast track. The first phase should take 18 months, one-third the time normally required*. Roanoke Times.

___.*Utilize railway, study on I-81 says*. Roanoke Times. Roanoke: 3.

___.. *Boucher wants decision on I-81: He seeks commitment to separate truck lanes*. Roanoke Times, The. Roanoke: 3.

The legislation to distribute federal funds for highway construction for the next five years is being drafted.

Regan, A. C. and R. A. Garrido. 2002. *Modeling Freight Demand and Shipper Behavior: State of the Art, Future Directions*.

The paper reviews research regarding freight demand and shipper behavior modeling. Various approaches to freight demand modeling are analyzed and their advantages/disadvantages discussed. These models are categorized according to their data requirement and geographical

scope (aggregate, disaggregate, international, intercity (interregional), and urban). Later in the paper, research regarding the shipper behavior modeling is analyzed and emerging issues and opportunities are discussed.

Reggiani, A. and Regional Science Association. World Conference. 1998. *Accessibility, trade, and locational behaviour*. Aldershot, Hants, England ; Brookfield, Vt., Ashgate.

Reiskin, J. S. 2002. "Making the truck-rail connection pay off." *Transport Topics(3512):* 1.

___. "Stackable containers grab market share from trailers." *Transport Topics(3512):* 13.

Ribeiro, R. A., A. M. D. Moreira, et al. 2003. "A fuzzy evaluation model: A case for intermodal terminals in Europe." *Applied Decision Support With Soft Computing 124:* 218-234.

Richardson, H. L. 2002. "Rail service on the right track-finally." *Transportation & Distribution 43(5):* 50.

Few would claim rail service to be bug-free, but service improvements promised in the wake of the merger fever of several years ago are finally materializing. For example, Burlington Northern and Santa Fe Railway launched a guaranteed intermodal service in May 2000. At UP, new partnerships and improved services followed high capital investment. As an industry, railroads continue to focus on capturing more freight from the highway. Recently developed service products are considerably more competitive than those of just a few years ago.

Roop, S. S. C. A. T., T. Dept. of, et al. 1996. *Intermodal freight movements in South Texas : transportation challenges and emerging research needs : a research study*. College Station, Tex. Texas Transportation Institute, Texas A&M University System, [Springfield Va.

Ross, L. M. 1994. "Interstate regionalism: The I-81 QUADCO example." *Economic Development Review 12(1):* p70(2).
Along a 75-mile stretch if Interstate 81 (I-81) running from Chambersburg, Pennsylvania to Winchester Virginia, and including Hagerstown, Maryland, and Martinsburg, West Virginia, economic development is in the midst of evolutionary change. The 4 counties in the 4 states have formed an alliance known as I-81 QUADCO. The theory behind QUADCO is that while there is a natural element of competition between the counties, cooperation only makes sense, because it will ultimately benefit each county individually and collectively. QUADCO is concerned not only with attracting new companies to the area, but also to establishing the importance of industry retention. Environmental, regulatory, labor, and community issues are all part of the QUADCO agenda. The overriding concern faced by QUADCO is not necessarily creating economic growth, but managing growth in a manner that not only retains but also enhances the regional quality of life.

Saricks, C. T., MM. 1999. *State-level accident rates of surface freight transportation. A Reexamination*.

State level accident rates for truck, rail and barge transportation have been updated for mid-1990s shipping conditions. The updated accident, fatality, and injury rates reflect multiyear data for interstate registered highway carriers, American Association of Railroads member carriers, and coastal and internal waterway barge traffic. Adjustments have been made to account for the share of highway combination-truck traffic actually attributable to interstate registered carriers and for

duplicated or otherwise inaccurate or unusable entries in the public use accident data files applied. State-to-state variation in rates, reflecting recent developments in freight flows, the possible effect of speed limit changes on highway rates, and the stability of rates over time are discussed. Carrier specific information was used to confirm the general accuracy of the computed rates for highway shipments.

Schafer, B. 1993. "Piggyback and Containers: A History of Rail Intermodal on America's Steel Highway." *Transportation Journal 33(2):* 55-56.

A book review of Piggyback and Containers: A History of Rail Intermodal on America's Steel Highway by David J. DeBoer is presented.

Schulz, J. D. 2003. "Roadmap to TEA-3." *Traffic World:* 1.

The American Trucking Associations (ATA) and the Association of American Railroads (AAR) agreed to support continuation of existing federal statutory provisions concerning truck sizes and weights that initially were passed by Congress in the Intermodal Surface Transportation Equity Act in 1991. ATA and AAR believe that this agreement will position the trucking and rail industries to meet the future needs of their customers. The groups noted that shippers' freight is expected to result in a doubling in demand for freight transportation in the next 20 years.

Science Applications International Corporation and Federal Highway Administration. 2002. *A combined report for freight information real-time system for transport (first)*. Part A - Final evaluation plan, Part B- detailed test plans: 44p.

Industry and government are concerned about the capacity of existing ports and terminals - and the associated highways, rail lines, and waterways that serve them - to handle steadily increasing volumes of intermodal traffic, especially containerized freight. Today's intermodal freight system is not equipped to handle the growth it is experiencing. For the Port Authority of New York/New Jersey, the most acute problem occurs on landside access to terminals. With very little room for land and facility expansion, the private terminals at the Port Authority's Marine Terminals are struggling with the ever-increasing flow of trucks into their terminals to unload and load container ships. To respond to this situation, the Port Authority is looking to leverage information technologies and intelligent transportation systems (ITS) to improve the efficiencies of Port operations. The Freight Information Real-time System for Transport (FIRST) Demonstration Project is being developed and funded in part as an attempt to develop some unique solutions to these problems.

The FIRST system is focused on testing new concepts for the following three elements: improving landside transportation access to ports, enhancing information sharing among intermodal freight service providers, and reducing the air pollution caused by truck congestion at intermodal marine terminals. FIRST is an Internet-based, real-time network that integrates numerous resources into a single, easy-to-use web site for access to cargo and Port information needs. Part A of this document was developed to serve as a planning and guidance document from which a successful evaluation effort will be implemented. Part B provides more detailed guidance for performing associated tests and measurements while conducting three specific evaluation studies.

Shafran, I. S.-W., A. 2003. *Financing and improving land access to U.S. Intermodal cargo hubs*. NCHRP national cooperative highway research program report ; 497. Washington, DC, Transportation Research Board of the National Academies: 162p.

This report presents guidance on the most effective strategies for financing improvements to cargo hub and intermodal freight facilities. These strategies focus on existing and emerging funding sources and on developing partnerships between government agencies, cargo hub operators and users, and local communities. After preparing an inventory of cargo hub improvements projects across the United States, the research team selected 12 projects as case studies for in-depth analysis. Appendixes to the report include detailed information on each case study, the full inventory of major cargo hub access improvement projects, and a listing of relevant federal and selected state funding sources and mechanisms. The report should be particularly valuable to planners and senior decision-makers in government and the private sector who are faced with a growing challenge to maintain or improve access to cargo hub facilities that are growing rapidly in size, quantity and importance.

Shashikumar, N. and G. L. Schatz. 2000. "The impact of US regulatory changes on international intermodal movements." *Transportation Journal 40(1):* 5-14.

Liner service ocean carriers were the initiators and developers of containerized intermodal water-rail and truck-rail freight movements. Land-based earners were followers in the development of such movements. This subordinate role resulted in part from regulatory, barriers and in part from managerial myopia. Enactment of the Ocean Shipping Reform Act of 1998 (OSRA) has further reduced regulatory barriers to the provision of international intermodal freight movements, and has set the stage for different forms of relationships between carriers in the different modes and between shippers and ocean carriers. A comprehensive survey of ocean container operators, exporters and importers, and freight forwarders and NVOCCs produced a number of findings about the possible future course of such relationships. In general, ocean carriers were more positive about the expected outcomes than were shippers. The survey revealed continuing shipper antagonism and distrust of carriers. Nevertheless, the changes wrought by OSRA have the potential for facilitating long-term partnerships among all parties involved in international intermodal movements. movements. [References: 31]

Small, K. A. and C. Winston. 1999. *The Demand for Transportation: Models and Applications.* Brookings Institution Press.

This comprehensive survey of transportation economic policy pays homage to a classic work, Techniques of Transportation Planning, by renowned transportation scholar John R. Meyer. With contributions from leading economists in the field, it includes added emphasis on policy developments and analysis. The book covers the basic analytic methods used in transportation economics and policy analysis; focuses on the automobile, as both the mainstay of American transportation and the source of some of its most serious difficulties; covers key issues of urban public transportation; and analyzes the impact of regulation and deregulation on the U.S. airline, railroad, and trucking industries.

Southworth, F. and B. E. Peterson. 2000. "Intermodal and international freight network modeling*1." *Transportation Research Part C: Emerging Technologies 8(1-6):* 147-166.

The authors describe the development and application of a single, integrated digital representation of a multimodal and transcontinental freight transportation network. The network was constructed to support the simulation of some five million origin to destination freight shipments reported as part of the 1997 United States Commodity Flow Survey. The paper focuses on the routing of the tens of thousands of intermodal freight movements reported in this survey. Routings involve different combinations of truck, rail and water transportation. Geographic information systems (GIS) technology was invaluable in the cost-effective construction and maintenance of this network and in the subsequent validation of mode sequences and route selections. However, computationally efficient routing of intermodal freight shipments was found to be most efficiently accomplished outside the GIS. Selection of appropriate intermodal routes required procedures for linking freight origins and destinations to the transportation network, procedures for modeling intermodal terminal transfers and inter-carrier interlining practices, and a procedure for generating multimodal impedance functions to reflect the relative costs of alternative, survey reported mode sequences.

Sparkman, D. 2001. "Will truck traffic return to the railroads?" *Transportation & Distribution 42(6):* 39.

Enthusiasm for intermodal transportation drained away during the widespread rail service failures in the wake of the mergers of Burlington Northern and Santa Fe, Union Pacific and Southern Pacific, and the split up of Conrail between CSX and Norfolk Southern. In spite of intermodal's big stumble from grace, the railroads may have a shot at regaining the confidence of shippers and carriers if they are willing to make a serious commitment to service quality. While no one expects an intermodal shipment to move 1,000 miles as quickly as it would if handled by truck, shippers have long complained that the real problem is not that rail service is slow, it is that you never know when the freight will show up at the final destination. Technological advances will wring enough inefficiencies out of intermodal to persuade the railroads to devote more of their resources to its growth.

Stagl, J. "Back to the future: To carry intermodal forward, tomorrow's innovators will need to rely on past pioneers' lessons while sharpening new skills." *Progressive Railroading 44(9):* 2p.
Intermodal freight transportation developed with innovative thinking when it was invented nearly 50 years ago. This article presents a look at the risks and challenges facing today's executives responsible for broadening its reach again.

Stagl, J. 2001. "Setting the pace: Schneider national's double digit growth, customer focus prod railroads to shift into intermodal overdrive." *Progressive Railroading 44(6):* p. 29-32.

The trucking company Schneider National's intermodal truck-train business rose 20% in 2000. Two main alliances are a 53-foot container service with Union Pacific Railroad and Norfolk Southern Railway, and TruckRail, a trailer service with BNSF and CSX Transportation. Extensive training and retention of staff, technology upgrades for tracking systems and advanced logistics are part of the formula.

Standifer, G. W., CM. 2000. *Development of a geographic information systems (GIS) model for intermodal freight.*

The purpose of this report is to demonstrate usage of Geographical Information Systems (GIS) for analyzing intermodal freight networks. A complete GIS network, focused on the state of Texas, is developed and used to examine impacts of price, time, location, and policy on shipper routing.

This process begins with an exploration of existing GIS applications, and state of the practice within the intermodal freight industry. This information provides a framework for building a technically feasible and relevant application. Data acquisition and processing techniques for both geographic and attribute data are considered. Relevant processes for creation of a GIS network and data conflation are identified and demonstrated. These techniques are used to create a network modeling the complex interactions and transfer rules amongst modes. Finally, several case studies are developed using the completed network to exhibit the power of GIS applied to intermodal freight. The report concludes with a summary, and observations to assist others attempting to build upon these results.

Stewart, R. D., W. D. o. Transportation., et al. 2003. *Twin ports intermodal freight terminal study: evaluation of shipper requirements and potential cargo required to establish a rail-truck-marine intermodal terminal in the twin ports of Superior, Wisconsin and Duluth, Minnesota*. Madison, Wis., Midwest Regional University Transportation Center, University of Wisconsin-Madison: 160p.

This study examines the potential for an intermodal freight terminal in the metropolitan area of Duluth, Minnesota and Superior, Wisconsin (Twin Ports). The geographic regions in the U.S. and Canada are assessed for potential intermodal cargo. Operating intermodal terminals in comparable statistical metropolitan areas are examined and key success factors derived. Major shippers in the region are surveyed to determine freight volume, shipper requirements, and destinations of inbound and outbound freight. Intermodal Marketing Companies and other third party providers are surveyed. Reebie [Transearch (Registered Trademark)] freight flow data between sixty-six Business Economic Areas (BEAs) and the Twin Ports are analyzed for freight volume by mode, destinations, lanes and load balance. The establishment of a Roll-On/Roll-Off (RO-RO) marine service with Thunder Bay, Ontario is examined as a feeder for an intermodal terminal. Operating rail yards in the Twin Ports are cataloged and evaluated as potential intermodal terminals. An overall determination of the Twin Ports' suitability as an intermodal terminal is presented.

Still, M. 2003. *Glimpse of rail study reinforces I-81 congestion view*. Bristol Herald Courier. Bristol: 2.

___..2004. *Two I-81 proposals criticized during public forum*. Bristol Herald Courier. Bristol: 2.

Strauss-Wieder, A. 2003. "Integrating freight facilities and operations with community goals." *NCHRP Synthesis of Highway Practice(320):* 66p.

This synthesis report will be of interest to freight and transportation agencies, economic development departments, metropolitan planning and other community sector organizations, as well as elected officials. It covers water, truck, rail, and air freight facilities and operations. Although the report does not include pipelines, several of the issues and practices discussed are relevant to pipeline facilities and operations. The document identifies practices that have been or are being used by the private-sector freight companies and public transportation agencies in siting their facilities, modifying their operations, and managing their community relations. "Good neighbor initiatives" and balancing practices employed by metropolitan planning and economic development organizations, local governments, and others are also recognized. The synthesis contains information culled from survey responses from state transportation agencies and planning organizations. This information is combined with that from interviews with selected respondents and extensive, iterative Internet-based searches and follow-up discussions.

Szylowicz, J. S. 2003. "Decision-making, intermodal transportation, and sustainable mobility: towards a new paradigm." *International Social Science Journal 55(2):* 185-+.

Contemporary transportation systems and policies are discussed in terms of their relationship to sustainable development. The current situation is generally characterized by policies that favor motorization and violate fundamental elements of sustainability. Accordingly, a new vision of sustainable transportation is required, one that incorporates intermodalism for both passengers and freight. Creating a sustainable intermodal system necessitates overcoming many obstacles and can be achieved only with appropriate policy and decision-making systems that incorporate genuine public participation. However, existing decision-making processes and public involvement mechanisms are inadequate. New approaches need to be developed and implemented if the new transportation paradigm is to be realized. [References: 47]

Taniguchi, E. and R. G. Thompson. 2003. *Innovations in freight transport*. Southampton, Boston, WIT Press.

Tavasszy, L. A., C. Groothedde, et al. 2000. *Aggregate Models of Spatial Logistics - Improving the Behavioral Content of Freight Transport Models*. Paper prepared for the Third International Meeting for Research in Logistics (IMRL) conference., Trois-Rivières, Québec, Canada.

The paper presents research on the modeling of freight transport flows within the Netherlands. Models that are innovative, combining traditional aggregate models of freight transportation, the normative models of firm-level logistics processes, and system dynamics, are introduced. The report is intended to provide a more comprehensive and flexible models that aids public policy analysis on freight transportation.

Teske, P. E., S. Best, et al. 1995. *Deregulating freight transportation : delivering the goods*. Washington, D.C., AEI Press.

Thompson, R. G. and R. v. Duin. 2002. *Vehicle routing and scheduling*.

Transportation Research Board. 2000. *Global intermodal freight: State of readiness for the 21st century*. Global Intermodal Freight: State of Readiness for the 21st Century, Long Beach, California.

Following the model of previous Transportation Research Board (TRB) intermodal conferences, this conference provided a forum for discussion and information-sharing on the issues and developments affecting intermodal freight transportation planning and operations. The conference brought together more than 200 leaders and experts in intermodal freight transportation from the private sector, all levels of government, and the military. The goal was to take a collective look at how far the nation has come and at what remains to be done toward realizing the vision set forth in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The discussions and findings from this conference provide useful input to the framers of the next surface transportation reauthorization scheduled for 2004. Included in the proceedings are conference presentations and the following appendices: (A) Intermodal Freight Transportation Report Card; (B) Summary of U.S. Department of Transportation Actions on Recommendations of the National Commission on Intermodal Transportation; (C) Conference Exhibits and Posters; and (D) List of Conference Participants.

Tsai, J. F., E. K. Morlok, et al. 1994. *Optimal pricing of rail intermodal freight : models and tests*. University Park, PA, Pennsylvania Transportation Institute Mid-Atlantic Universities Transportation Center.

Intermodal service (rail-truck) has many positive features including energy and environmental advantages, and economies of density. However, intermodal service has attracted only a limited market share in most traffic lanes. This dissertation focuses on improving intermodal service by searching for its optimal price and level of service in competition with truck service. This problem has a number of features which distinguish it from typical pricing problems in other industries or services, because of the special technology and economies of' transportation in connection with headhauls and backhauls (usually unbalanced flows). Both demand side (shippers) and supply side (carriers) are taken into account, and equilibrium solutions are pursued by a mathematical programming approach. On the demand side, two mode choice methods are incorporated in the models, the minimum logistics cost approach and the logistic demand function approach. On the supply side, the highly competitive truck industry and the monopolistic intermodal industry are discussed.

Two models (Competition Model I and Competition Model II) for optimal price and level of service positioning of intermodal service in competition with truck service are developed for the one-commodity case as well as the multiple-commodity case. A program for solving Competition Model I by FORTRAN computer language is developed for the applications of the model. A Stackelberg leader-follower game is formulated in Competition Model II, and an example of a one-commodity model is discussed. Two case studies using the minimum logistics cost approach are introduced. One is the Portland-Los Angeles case with its sensitivity analysis. The other is a hypothesized freight flow with higher value of commodity for comparison with the Portland-Los Angeles case. Extensions to a trucking network in which an intermodal link is located are also discussed. Two approaches are introduced: a computational approach and a simplified approach. The relationship between truck empty repositioning cost and intermodal traffic volume is investigated.

Tsamboulas, D. A. and S. Kapros. 2003. *Freight village evaluation under uncertainty with public and private financing*.

Tye, W. B. and A. N. Kleit. 1993. "Pricing market access for regulated firms; Problems come before solutions: Comment; Reply." *Logistics and Transportation Review 29(1):* 39.

Regulators often determine that access to a bottleneck or essential facility must be available to competitors in order to achieve a successful transition to deregulation. The need for such access is assumed for the purpose of evaluating the economic properties of alternative pricing mechanisms. The standard of competition on equal terms would price rail competitive access to make ownership of an essential facility competitively neutral. Three other pricing methods are examined and shown not to have this desirable property. In a comment, Kleit claims that Tye's arguments seem based on weak foundations. He also says that Tye presents no evidence that price squeezes are an important problem. Given this, the burden is on Tye to show that a problem exists that requires a solution. Tye responded that the issue of competitive access in the rail industry is not simply an argument over the division of quasirents. The chief issue is whether intramodal competition is redundant or undesirable.

U.S. Census Bureau. 1999. *Hazardous Materials: 1997 Transportation Commodity Flow Survey*. 1997 Economic Census. U. S. C. Bureau.

United States. Dept of Energy. 1999. *Model documentation report: Transportation sector model of the national energy modeling system*: 360p.

___.2001. *House Document No. 23*: 360p.

The Transportation Sector Model incorporates an integrated modular design which is based upon economic, engineering, and demographic relationships that model transportation sector energy consumption at the nine Census Division level of detail. The Transportation Sector Model comprises the following components: light duty vehicles, light duty fleet vehicles, commercial light trucks, freight transportation (truck, rail, and marine), aircraft, miscellaneous transportation (military, mass transit, and recreational boats), and transportation emissions. The model provides sales estimates of 2 conventional and 14 alternative fuel light duty vehicles, and consumption estimates of 12 main fuels.

United States. Dept of Transportation. 2000. *NHS intermodal freight connectors: A report to Congress*. Section 1106(d) of the Transportation Equity Act for the 21st Century (TEA-21) directed the Secretary to conduct a review of the National Highway System (NHS) freight connectors that serve seaports, airports, and major intermodal terminals and report to Congress by June 9, 2000.

The Federal Highway Administration (FHWA) conducted this study with the following objectives: (1) evaluate the condition of NHS connectors to major freight intermodal terminals; (2) review improvements and investments made or programmed for these connectors; and (3) identify impediments and options to making improvements to the intermodal freight connectors. NHS freight connectors are the public roads leading to major intermodal terminals. This report discusses the study and its findings.

___.2002. The 2002 Intelligent Transportation Systems Projects Book.

The 2002 Intelligent Transportation Systems (ITS) Projects Book documents, catalogues, and describes ITS research projects, tests, and studies initiated through September 30, 2001. The current edition continues to categorize both legacy projects, originating under ISTEA, and those begun since the enactment of TEA-21, according to the restructured program organization. The restructured ITS Program focuses on two major areas: intelligent infrastructure and intelligent vehicles. In this report, projects identified as "other" were earmarked activities originating during the ISTEA period of authorization. Projects identified as "deployment/integration" reflect the restructuring of ITS program activities under TEA-21. Four chapters describe and catalogue the research projects, tests, and studies under the following four program areas: metropolitan ITS infrastructure, rural ITS infrastructure, commercial vehicles ITS infrastructure, and intelligent vehicle initiative. The remaining chapters describe projects and studies under other ITS program areas: intermodal freight; evaluation/program assessment; architecture, standards, and national compatibility planning; mainstreaming; and other related programs. Overall ITS offer technology based solutions to the challenges confronting the nation's surface transportation systems, while concurrently establishing the basis for dealing with future demands through a strategic intermodal view of transportation.

___. F. H. A. 2002. "Benefit-cost analysis of freight investments". *Freight News*.

___. 1997. *Intermodal Freight Symposium: Workbook*.

On September 30, 1996, the Federal Highway Administration's ITS Joint Program Office and the National Highway Institute hosted an lntermodal Freight Symposium. The symposium brought together public and private sector experts in fright movement and intelligent transportation systems to exchange information and explore emerging trends. The symposium covered a broad range of topics, including intermodal freight logistics, ITS freight applications, the federal role and key partnerships. Information presented at the Intermodal Freight Symposium has been collected in this Workbook. The Workbook is divided into three parts:

Part 1: Intermodal Freight Movement-the Big Picture. This material was presented by John Vickerman of Vickerman.Zachary.Miller (VZM)/TranSystems, and was originally developed for an NHI Training Course entitled "Landside Access for Intermodal Facilities."

Part 2: ITS Applications for Intermodal Freight. This material was also developed and presented by John Vickerman of VZM/TranSystems.

Part 3: Intelligent Transportation Systems and Intermodal Freight Transportation. This is a reprint of a report prepared by the Volpe National Transportation Systems Center in December, 1996. It covers information presented by Michael Onder and Harry Caldwell on the role of the public sector and the need for effective public/private partnerships.

United States. Dept. of Transportation. Office of the Secretary, United States. Federal Transit Administration, et al. 1996. *Quick response freight manual*. [Washington, D.C.], U.S. Dept. of Transportation.

United States. Federal Highway Administration and Cambridge Systematics. 1995. *Intermodal freight transportation final report*. Washington, D.C., Federal Highway Administration : Distributed in cooperation with Technology Sharing Program.

United States. General Accounting Office. 1996. *Intermodal freight transportation projects and planning issues : report to congressional committees*., Washington, D.C. (441 G St., NW, Room LM, Washington 20548) : U.S. General Accounting Office.

United States. General Accounting Office, United States. Congress. House, et al. 1993. *Intermodal freight transportation : combined rail-truck service offers public benefits, but challenges remain* : report to the Committee on Public Works and Transportation, House of Representatives. Washington, D.C. [Gaithersburg, Md.] (P.O. Box 6015, Gaithersburg 20884-6015), Gaithersburg MD (P.O. Box 6015 Gaithersburg 20877): 59 p.

US Department of Commerce, International Trade Administration, et al. 1999. *SMALL & MEDIUM SIZED EXPORTING SMALL & MEDIUM SIZED EXPORTING COMPANIES: A STATISTICAL PROFILE*: 28.

Van Schijndel, W.-J. and J. Dinwoodie. 2000. "Congestion and multimodal transport: a survey of cargo transport operators in the Netherlands." *Transport Policy 7(4):* 231-241.

Longer and more frequent traffic jams in the Netherlands are increasing the costs of transporting cargo. Tightly scheduled production systems rely on punctual materials movements, but are congestion-induced delays sufficient to stimulate freight mode switching from road to combined road-rail and road-water movements? A survey of Dutch transport companies revealed an estimated 10% of vehicle operating time spent in congested conditions. The perceived impact on transport operations, consumers and service characteristics are reported. Based on the survey findings, a vehicle cost simulation attributed 7% of transport costs to congestion, increasing the attractiveness of multimodal transport and other solutions.

Visser, J. G. S. N. 2002. *Underground freight transport systems*.

Voigtlaender, C., C. Barnhart, et al. 1995. *Intermodal freight operations*. Cambridge, Mass., Massachusetts Institute of Technology, Center for Transportation Studies.

Volpe National Transportation Systems Center. 1999. *Intermodal cargo transportation: Industry best security practices.*

Cargo related crimes, including cargo theft, insurance fraud, drug trafficking, and the transportation of illegal immigrants into the United States, have become serious criminal issues. This report represents the results of research, interviews and on-site evaluations conducted to identify the issues related to security of cargo terminals to theft, smuggling, and other illegal activities. It provides industry best security practices for eliminating, mitigating, and controlling identified concerns within the security framework of cargo transportation. The report is not organized by mode (truck, rail, maritime and pipeline) but provides an integrated discussion of all modes using cargo terminals with a special focus on intermodalism.

Wachs, M. 1998. *Transportation Models in the Policy-Making Process: Uses, Misuses, and Lessons for the Future.* Proceedings from a Symposium in the Problems of Transportation Analysis and Modeling in the World of Politics, Pacific Grove, California.

Wang, H. G., Nicholas J. 2003. *Estimation of the demand for commercial truck parking on interstate highways in Virginia*. N. I. I. R. Center.

The steady growth of commercial truck traveling on most Interstate and primary highways has resulted in increasing demand for both public rest areas and private truck stops in Virginia. In addition inadequate parking spaces for commercial trucks may be a contributing factor to drivers fatigue and the unsafe practices of parking commercial trucks on highway shoulders and interchange ramps. This study developed a methodology to determine the supply and demand for commercial truck parking along highway system. In this study, supply was defined as the number of parking spaces available for commercial truck parking, and demand was defined as the sum of the parking accumulation and the illegal parking at a given time. A two-phase research project on the Supply And Demand For Commercial Truck Parking Facilities in Virginia has been carried out to evaluate truck driver parking needs.

Phase one of this study developed a methodology to determine the supply and demand for commercial truck parking using Interstate-81 in Virginia as a case study. Phase two expanded the study to other Interstate and primary highways in Virginia, checked the applicability of the

parking demand model developed in phase one and developed new models for the other highways in Virginia. Extensive data on the characteristics of commercial truck parking including parking duration and accumulation for different times of day were obtained. Detailed information was also obtained on the characteristics of each truck stop and rest area, including the location, number and types of parking spaces, and availability of other amenities, such as restaurants and showers

Wang, X. and A. C. Regan. 2002. "Local truckload pickup and delivery with hard time window constraints." *Transportation Research Part B: Methodological 36(2):* 97-112.

This paper describes a solution method for a multiple traveling salesman problem with time window constraints (m-TSPTW). The method was developed for local truckload pickup and delivery problems such as those supporting rail or maritime intermodal operations but is suitable for application in other problems in which the number of tasks assigned to each server at any time is relatively small. We present a model and describe an iterative solution technique in which explicit time constraints are replaced by binary flow variables. At each iteration two versions of the problem, one over-constrained and the other under-constrained are solved. The solution to the over-constrained problem provides a feasible solution, while the optimality gap provided by the two solutions informs the decision of whether to continue searching or to implement the best solution found so far. A specific time window partitioning scheme is used to ensure that the cost of solutions found are monotonically non-increasing. The method developed is suitable for real-time or quasi real-time implementation.

Wiegmans, B. M., E; P. Nijkamp. 2002. "Intermodal freight terminals: an analysis of the terminal market. In: Transport Logistics." *Classics in Transport Analysis(5)*: p. 229-252.

The aim of this paper is to elaborate on the potential of new generation freight terminals along with bundling of freight flows. Identified are five competitive forces that apply to the intermodal terminal market: industry competitors; potential entrants; suppliers; buyers/shippers, and substitutes.

Wiegmans, B. W., P. Nijkamp, et al. 2001. *Intermodal freight terminals : marketing channels and telecommunication networks.*

Wilbur Smith Associates, I. "Virginia Statewide Transportation Model."

Williams, B. M., L. A. Hoel, et al. 1997. *Intermodal freight planning at the multi-state corridor level : state of the practice and future directions*. Charlottesville, VA [Springfield, VA, University of Virginia, School of Engineering and Applied Science ; Available through the National Technical Information Service.

Williams, I. 2002. *DfT Integrated Transport and Economic Appraisal: Review of Freight Modelling Inception Report*: 45p.

The study reviews current freight modelling techniques. After assessing the suitability of the options potentially available, the study makes recommendations on the most appropriate techniques for use in Great Britain. The review will include road, rail and other freight modes and the modelling of light goods vehicles.

___. *DfT Integrated Transport and Economic Appraisal Review of Freight Modelling: Report B2 – Review of Models in Continental Europe and Elsewhere*: 82p.

The study reviews current freight modeling techniques in the continental Europe and North America and assess its suitability for use in Great Britain.

Wilner, F. N. 1999. "Truck-rail war looms." *Traffic World 257(8):* p. 12-14.
Subtitle: ATA threatens to join forces with captive rail shippers if railroads don't back off truck size campaign.

Yamada, T. 2002. *Logistics terminals*.

Yan, S., D. Bernstein, et al. 1995. "Intermodal pricing using network flow techniques." *Transportation Research Part B: Methodological 29(3):* 171-180.

Traditional cost calculations do not accurately estimate the opportunity costs of using conveyances in intermodal operations, thus, results in many short-term pricing problems. The objective of this research is to develop a framework for estimating the opportunity costs of using conveyances in trailer-on-flatcar (TOFC) operations to assist carriers in improving their pricing strategies under highly competitive market conditions. The framework is based on a network model that simulates current operations in order to find the reduced costs and the opportunity costs of serving the loads. The network model is formulated as a linear network flow problem with side constraints. To find the reduced costs, a technique using Lagrangian Relaxation, a minimum cost algorithm, and a shortest path algorithm were developed in the research. We illustrate this model with a case study of a major north American railroad. The results show that opportunity costs do affect the accuracy of calculated system contributions for services. Moreover, the opportunity costs and system incremental costs (SICs) are unstable over time. To handle the instability we make use of a new risk-pricing approach.

Ybarra, S. J. 2001. *The potential for shifting Virginia's highway traffic to railroads*. Richmond, Commonwealth of Virginia: i-ii; 40.

Zhang, C. Q., J. Y. Liu, et al. 2003. "Storage space allocation in container terminals." *Transportation Research Part B-Methodological 37(10):* 883-903.

Container terminals are essential intermodal interfaces in the global transportation network. Efficient container handling at terminals is important in reducing transportation costs and keeping shipping schedules. In this paper, we study the storage space allocation problem in the storage yards of terminals. This problem is related to all the resources in terminal operations, including quay cranes, yard cranes, storage space, and internal trucks. We solve the problem using a rolling-horizon approach. For each planning horizon, the problem is decomposed into two levels and each level is formulated as a mathematical programming model. At the first level, the total number of containers to be placed in each storage block in each time period of the planning horizon is set to balance two types of workloads among blocks. The second level determines the number of containers associated with each vessel that constitutes the total number of containers in each block in each period, in order to minimize the total distance to transport the containers between their storage blocks and the vessel berthing locations. Numerical runs show

that with short computation time the method significantly reduces the workload imbalance in the yard, avoiding possible bottlenecks in terminal operations. [References: 16]

Ziliaskopoulos, A. K. W., S. Travis. 2000. *Modeling intermodal freight movements in the Chicago area*. Proceedings of the 42nd Annual Meeting of the Transportation Research Forum, Annapolis, Maryland.

This paper analyzes the intermodal operations in the Chicago area and the interaction of passenger vehicles and intermodal truck traffic. Current conditions within the region are discussed as well as issues related to the availability of data for the impact of intermodal truck traffic. A simulation-based traffic model is presented that accounts for the simultaneous routing of passenger and truck traffic in order to develop performance measures, so that more informed infrastructure improvements decisions can be made. The applicability of the model is demonstrated by running various improvement scenarios on a major part of the Chicago network.

Ziliaskopoulos, A. T., P. 2001. *Development of information on intermodal safety issues in Illinois*. I. T. R. Center: 134p.

The objective of this study was to identify safety and efficiency issues related to the intermodal truck movements in the Chicago area. The literature was comprehensively reviewed and all possible sources of information were identified, so that a clear and objective assessment of the status of the intermodal industry in Chicago could be provided, as well as the problems they face and the problems they are creating. It was not possible to get complete access to all databases, or conclusively answer questions, such as "Are intermodal trucks less safe than the non-intermodal trucks?" However, the reasons for that were identified and recommendations for remedying this shortcoming were provided.

The requirements of this study were exceeded by investigating sources of potential information not considered before (automatic vehicle location, yard gate information) as well as the development of innovative tools that can help engineers and planners to objectively evaluate future improvements on the street network. In addition, the global view was taken of looking at the problem at the system level. Truck drivers were surveyed in a cost effective way and both insights and objective data were obtained. Also, in the course of this research, communication was established with all involved stakeholders (trucking companies, drivers, Illinois Transportation Association, Chicago Area Transportation Study, rail companies, the police) who helped the team understand the problems better from their perspectives. The findings of this research are outlined with emphasis on the implementable recommendations.

Technical Appendices

APPENDIX A - FREIGHT SHIPPER/CARRIER SURVEY
APPENDIX B - TRUCK INTERCEPT SURVEY
APPENDIX C - SURVEY ORIGIN-DESTINATION & ENTRY-EXIT PAIRS
APPENDIX D - 2035 TRUCK TRIP FORECAST SUPPORT DATA
APPENDIX E - TRUCK TRIP TABLES SUPPORT DATA
APPENDIX F - RAIL DIVERSION MODEL SUPPORT DATA

APPENDIX A - FREIGHT SHIPPER/CARRIER SURVEY

INTERNET VERSION OF SHIPPER/CARRIER SURVEY

http://www.jfawest.com/I-81/Survey.html

I-81 CORRIDOR IMPROVEMENT STUDY

FREIGHT MOVEMENT SURVEY

Thank you for participating in the I-81 Freight Movement Survey. Your answers will help the Virginia Department of Transportation to evaluate improvement scenarios for I-81 as part of the Tier 1 environmental review.

This survey will take 5-7 minutes. We are especially interested in your comments about existing I-81 bottlenecks, etc. After you have completed this form, please click the "Submit" button at the bottom of the page.

About You

First Name: _____ Last Name: _____
Title: _____ Business Name: _____
Phone: _____ Email: _____

Facility

1. Location of facility:

City: _____
Zip Code: _____

2. Facility type: (Check one)

- ☐ Independent Operation *(company's only location)*
- ☐ Chain/Branch/Franchise *(one of company's many locations)*

3. How many people work at your facility? (Check one)

- ☐ 1-4
- ☐ 5-9
- ☐ 10-19
- ☐ 20-49
- ☐ 50-99
- ☐ 100 +

4. Nature of operation at facility: (Check all that apply)

- ☐ Farming/ Forestry/ Mining
- ☐ Manufacturing/Factory

- ☐ Construction
- ☐ Distribution Center/Warehouse/Wholesale
- ☐ Retail Sales
- ☐ Motor Carrier/Truck Operator
- ☐ Truck Rest Stop/ Food Service
- ☐ Truck Service/Fueling/ Repair & Maintenance
- ☐ Other (Please Specify)

5. Types of materials, products or equipment RECEIVED (inbound) at your facility:
(Check all that apply)

- ☐ Raw Agricultural & Animal Products *(i.e. crops, livestock, animal feed)*
- ☐ Food Products, Alcohol, & Tobacco *(i.e. meat, bakery products, dairy products, prepared foodstuffs)*
- ☐ Forestry, Wood, and Paper Products *(i.e., logs, lumber, paper) [EXCEPT furniture]*
- ☐ Chemicals & Chemical Products *(i.e., basic chemicals, fertilizers, pharmaceuticals)*
- ☐ Petroleum Products (Refined) *(i.e., plastics & rubber, gasoline, fuel oils)*
- ☐ Mining Materials (Raw Form) *(i.e., coal, sand, gravel, ores, crude petroleum, salt, clay)*
- ☐ Manufactured Metal & Mineral Products *(i.e. metal bars, rods, pipes, nails, screws; cement; concrete products, bricks; glass)*
- ☐ Other Manufactured Products or Equipment *(i.e. tools, electronics, furniture, machinery, textiles, vehicles, etc.)*
- ☐ Waste, Refuse, Recycling *(i.e. hazardous waste, trash, yard waste, recyclable products)*
- ☐ Other (Please Specify, *i.e. "courier parcels," "mixed freight"*)

6. Types of materials, products or equipment SHIPPED (outbound) from your facility:
(Check all that apply)

- ☐ Raw Agricultural & Animal Products *(i.e. crops, livestock, animal feed)*
- ☐ Food Products, Alcohol, & Tobacco *(i.e. meat, bakery products, dairy products, prepared foodstuffs)*
- ☐ Forestry, Wood, and Paper Products *(i.e., logs, lumber, paper) [EXCEPT furniture]*
- ☐ Chemicals & Chemical Products *(i.e., basic chemicals, fertilizers, pharmaceuticals)*
- ☐ Petroleum Products (Refined) *(i.e., plastics & rubber, gasoline, fuel oils)*
- ☐ Mining Materials (Raw Form) *(i.e., coal, sand, gravel, ores, crude petroleum, salt, clay)*
- ☐ Manufactured Metal & Mineral Products *(i.e. metal bars, rods, pipes, nails, screws; cement; concrete products, bricks; glass)*
- ☐ Other Manufactured Products or Equipment *(i.e. tools, electronics, furniture, machinery, textiles, vehicles, etc.)*
- ☐ Waste, Refuse, Recycling *(i.e. hazardous waste, trash, yard waste, recyclable products)*
- ☐ Other (Please Specify, *i.e. "courier parcels," "mixed freight"*)

Activity at Facility

7. Which type of activity best describes your business?

- ☐ Shipper/Receiver *(i.e., distributor, manufacturer)* **(Go to Question 8A)**
- ☐ Service Provider for Trucking *(i.e., rest stop, fuel, food)* **(Go to Question 8B)**
- ☐ Motor Carrier/ Truck Operator **(Go to Question 8C)**

8A. *[For Shipper/Receiver Facility only]*
On an average workday, how many trucks go in and out of your facility?

IN: **OUT:**

- ☐ 1-4
- ☐ 5-9
- ☐ 10-24
- ☐ 24-49
- ☐ 50-99
- ☐ 100+

- ☐ 1-4
- ☐ 5-9
- ☐ 10-24
- ☐ 24-49
- ☐ 50-99
- ☐ 100+

How many days do you operate in a week? (Check one)

- ☐ 1-4
- ☐ 5
- ☐ 6
- ☐ 7 **[continue at Question 9]**

8B. *[For Truck Service Provider Facility only]*
On an average workday, how many trucks do you serve?

- ☐ 1-4
- ☐ 5-9
- ☐ 10-24
- ☐ 24-49
- ☐ 50-99
- ☐ 100+

How many days do you operate in a week? (Check one)

- ☐ 1-4
- ☐ 5
- ☐ 6
- ☐ 7 **[continue at Question 9]**

8C. *[For Motor Carrier/Truck Operator Facility only]*
On an average workday, how many trucks do you operate?

- ☐ 1-4
- ☐ 5-9
- ☐ 10-24
- ☐ 24-49
- ☐ 50-99
- ☐ 100+

How many days do you operate in a week? (Check one)

- ☐ 1-4
- ☐ 5
- ☐ 6
- ☐ 7 **[continue at Question 9]**

9. How far do most trucks travel to and from your facility? (Check one)

- ☐ Local (within 50-mile radius)
- ☐ Long Distance (more than 50-mile radius)

10. Where do most trucks travel to and from your facility? (Check one)

- ☐ Inside Virginia
- ☐ Outside Virginia

11. Other than Virginia, what are the 3 most common ORIGIN states for materials, products, and

equipment received at your facility?

- ☐ Maryland
- ☐ Ohio
- ☐ Other: _____
- ☐ New York
- ☐ Pennsylvania
- ☐ Other: _____
- ☐ North Carolina
- ☐ Tennessee
- ☐ Other: _____

12. Other than Virginia, what are the 3 most common DESTINATION states for materials, products, and equipment shipped from your facility?

- ☐ Maryland
- ☐ Ohio
- ☐ Other: _____
- ☐ New York
- ☐ Pennsylvania
- ☐ Other: _____
- ☐ North Carolina
- ☐ Tennessee
- ☐ Other: _____

13. Do you have fluctuations in truck trips or activities during the day? (Check one)

☐ YES ☐ NO

If Yes, which times are your peak periods? (Check all that apply)

- ☐ 5 am - 10 am
- ☐ 10 am - 4 pm
- ☐ 4 pm - 7 pm
- ☐ 7 pm - 5 am

14. Do you have fluctuations in truck trips or activities during the year? (Check one)

☐ YES ☐ NO

If Yes, which months are your peak periods? (Check all that apply)

- ☐ **January** ☐ **February** ☐ **March** ☐ **April**
- ☐ **May** ☐ **June** ☐ **July** ☐ **August**
- ☐ **September** ☐ **October** ☐ **November** ☐ **December**

15. Do the trucks moving in and out of your facility use I-81?

- ☐ Yes, percentage of truck trips using I-81: _____ %
- ☐ No
- ☐ Don't Know

16. Does your facility use railroad transportation?

- ☐ Yes, percentage of freight volume using railroad transportation: _____ %
- ☐ No
- ☐ Don't Know

If you do not use railroad transportation, why not? (If you do use rail transportation, why?)

17. How can I-81 be improved to help your business?

18. Please identify any traffic problems related to I-81 truck movements (i.e., bottlenecks, congestion, safety).

Submit Reset

Thank you for your participation.

Questions or Comments:

Jack Faucett Associates (VDOT subcontractor)

4550 Montgomery Ave Suite 300 North

Bethesda, MD 20814

bezis@jfaucett.com

MAIL VERSION OF SHIPPER/CARRIER SURVEY

I-81 CORRIDOR IMPROVEMENT STUDY

FREIGHT MOVEMENT SURVEY

Dear Transportation/Logistics/Fleet Manager:

Virginia's stretch of Interstate 81 is vital to your business. Please help the Virginia Department of Transportation (VDOT) improve I-81 by completing this survey and faxing it to (301) 469-3001 or mailing it to the address on the last page.

In lieu of the paper survey, we strongly encourage you to complete the web version at ***http://www.jfawest.com/I-81/Survey.html***.

This survey will take 5-7 minutes. We are especially interested in your comments about existing I-81 bottlenecks, congestion, etc. Your answers will help VDOT evaluate improvement scenarios for I-81 as part of the Tier 1 environmental review. Responses will be kept anonymous and used solely for transportation planning purposes.

If you have questions about this survey, please contact Jason Bezis at bezis@jfaucett.com or at (925) 284-5998. For general inquiries about the I-81 environmental review, project manager Chris Collins can be reached at VDOT headquarters at (804) 225-4249.

About You

First Name: _____ Last Name: _____

Your Title/Position: _____

Phone Number: (_____)_____ E-mail Address: _____

Business Name: _____

Facility

1. Location of facility:

City: _____ Zip Code: _____

1

2. Facility type: (check one)

- ☐ Independent Operation (company's only location)
- ☐ Chain/Branch/Franchise (one of company's many locations)

3. How many people work at your facility? (check one)

- ☐ 1-4
- ☐ 5-9
- ☐ 10-19
- ☐ 20-49
- ☐ 50-99
- ☐ 100 +

4. Nature of operation at facility: (check all that apply)

- ☐ Farming/ Forestry/ Mining
- ☐ Manufacturing/Factory
- ☐ Construction
- ☐ Distribution Center/Warehouse/Wholesale
- ☐ Retail Sales
- ☐ Motor Carrier/Truck Operator
- ☐ Truck Rest Stop/ Food Service
- ☐ Truck Service/ Fueling/Repair & Maintenance
- ☐ Other: _____

5. Types of materials, products or equipment RECEIVED (inbound) at your facility:

- ☐ Raw Agricultural & Animal Products (i.e. crops, livestock, animal feed)
- ☐ Food Products, Alcohol, & Tobacco (i.e. meat, bakery products, dairy products, prepared foodstuffs)
- ☐ Forestry, Wood, and Paper Products (i.e., logs, lumber, paper) [EXCEPT furniture]
- ☐ Chemicals & Chemical Products (i.e., basic chemicals, fertilizers, pharmaceuticals)
- ☐ Petroleum Products (Refined) (i.e., plastics & rubber, gasoline, fuel oils)
- ☐ Mining Materials (Raw Form) (i.e., coal, sand, gravel, ores, crude petroleum, salt, clay)
- ☐ Manufactured Metal & Mineral Products (i.e. metal bars, rods, pipes, nails, screws; cement; concrete products, bricks; glass)
- ☐ Other Manufactured Products or Equipment (i.e. furniture, tools, electronics, cameras, clocks, machinery, textiles, vehicles, aircraft, boats etc.)
- ☐ Waste, Refuse, Recycling (i.e. hazardous waste, trash, yard waste, recyclable products)
- ☐ Miscellaneous (i.e. mail & courier parcels, mixed freight)
- ☐ Other: _____

6. Types of materials, products or equipment SHIPPED (outbound) from your facility:

- ☐ Raw Agricultural & Animal Products (i.e. crops, livestock, animal feed)
- ☐ Food Products, Alcohol, & Tobacco (i.e. meat, bakery products, dairy products, prepared foodstuffs)
- ☐ Forestry, Wood, and Paper Products (i.e., logs, lumber, paper) [EXCEPT furniture]
- ☐ Chemicals & Chemical Products (i.e., basic chemicals, fertilizers, pharmaceuticals)
- ☐ Petroleum Products (Refined) (i.e., plastics & rubber, gasoline, fuel oils)
- ☐ Mining Materials (Raw Form) (i.e., coal, sand, gravel, ores, crude petroleum, salt, clay)
- ☐ Manufactured Metal & Mineral Products (i.e. metal bars, rods, pipes, nails, screws; cement; concrete products, bricks; glass)
- ☐ Other Manufactured Products or Equipment (i.e. furniture, tools, electronics, cameras, clocks, machinery, textiles, vehicles, aircraft, boats etc.)
- ☐ Waste, Refuse, Recycling (i.e. hazardous waste, trash, yard waste, recyclable products)
- ☐ Miscellaneous (i.e. mail & courier parcels, mixed freight)
- ☐ Other: _____

Activity at Facility

7. On an average workday, how many trucks are coming in and out of your facility?

IN: (check one)	OUT: (check one)
☐ 1-4	☐ 1-4
☐ 5-9	☐ 5-9
☐ 10-24	☐ 10-24
☐ 24-49	☐ 24-49
☐ 50-99	☐ 50-99
☐ 100+	☐ 100+

8. How many days do you operate in a week? (check one)

- ☐ 1-4
- ☐ 5
- ☐ 6
- ☐ 7

9. How far do most trucks travel to and from your facility? (check one)

- ☐ Local (within 50-mile radius)
- ☐ Long Distance (more than 50-mile radius)

3

10. Where do most trucks travel to and from your facility? (check one)

☐ Inside Virginia
☐ Outside Virginia

11. Other than Virginia, what are the 3 most common ORIGIN states for materials, products, and equipment received at your facility?

☐ Maryland	☐ New York	☐ North Carolina
☐ Ohio	☐ Pennsylvania	☐ Tennessee
☐ Other:_____	☐ Other:_____	☐ Other:_____

12. Other than Virginia, what are the 3 most common DESTINATION states for materials, products, and equipment shipped from your facility?

☐ Maryland	☐ New York	☐ North Carolina
☐ Ohio	☐ Pennsylvania	☐ Tennessee
☐ Other:_____	☐ Other:_____	☐ Other:_____

13. Do you have fluctuations in truck trips or activities during the day?

☐ No
☐ Yes

If Yes, which times are your peak periods? (Check all that apply)

☐ 5am-10am	☐ 4pm-7pm
☐ 10am-4pm	☐ 7pm-5am

14. Do you have fluctuations in truck trips or activities during the year?

☐ No
☐ Yes

If Yes, which months are your peak periods? (Check all that apply)

☐ January	☐ May	☐ September
☐ February	☐ June	☐ October
☐ March	☐ July	☐ November
☐ April	☐ August	☐ December

15. Do the trucks moving in and out of your facility use I-81?

☐ Yes, percentage of truck trips using I-81: _____%
☐ No
☐ Don't Know

4

16. Does your facility use railroad transportation?
    ☐ Yes, percentage of freight volume using railroad transportation: _____%
    ☐ No
    ☐ Don't Know

    If you do not use railroad transportation, why not? (If you do use rail transportation, why?) If this space is not sufficient, please continue on back.

17. How can I-81 be improved to help your business? If this space is not sufficient, please continue on back.

18. Please identify any traffic problems related to I-81 truck movements (i.e., bottlenecks, congestion, safety). If this space is not sufficient, please continue on back.

Thank you for your participation.

When complete, please mail or fax to:

Jack Faucett Associates (VDOT subcontractor)

4550 Montgomery Avenue, Suite 300N

Bethesda, MD 20814

Phone: (925) 284-5998 (attn: Jason Bezis)

E-mail: bezis@jfaucett.com

Web survey: *http://www.jfawest.com/I-81/Survey.html*

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AMERICAN TRUCKING ASSOCIATIONS' WEBPAGE INVITING PARTICIPATION IN I-81 FREIGHT SURVEY

StateSIDE

Virginia: Input Needed For Interstate 81 Freight Survey

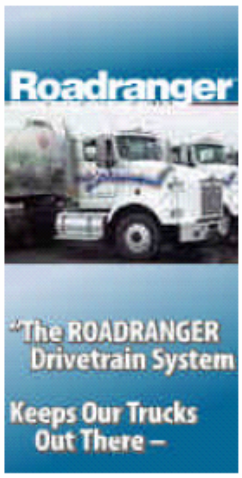
Available here is an important action alert regarding an Interstate 81 Freight Movement Survey and instructions on how to participate.

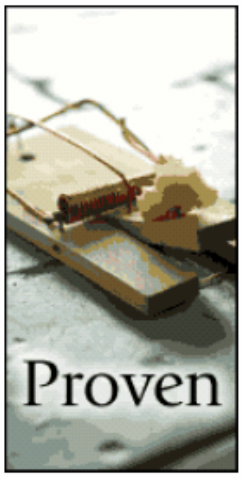
The results of this survey will be used to assess the impact of imposing tolls on I-81. Therefore we urge all members who use I-81 to complete and return this important survey to let the researchers know how tolls on I-81 will impact your business and customers.

The survey is in Word format. The action alert is in PDF (Adobe Acrobat reader) format. You will need Adobe Acrobat Reader (a free software program) installed on your computer in order to open and read the Action Alert.

If you do not have a current version of Acrobat Reader installed on your computer, it can be downloaded here. Once there, click on the yellow "Get Acrobat Reader" button and follow the instructions to download and install this program.

If you have problems downloading or opening the attachments please contact the VTA office and they will fax or mail them to you.





APPENDIX B - TRUCK INTERCEPT SURVEY

TRUCK INTERCEPT SURVEY INSTRUMENT

Interstate 81 Truck Survey

Virginia Department of Transportation **June 2004**

Truck type: (Check one)

☐ Single Unit
☐ Tractor Only (no trailer)
☐ Tractor + Single Trailer
☐ Tractor + Multiple Trailers

Total number of axles: (Check one)

☐ 2 ☐ 4 ☐ 6
☐ 3 ☐ 5 ☐ 7 or more

Is your truck empty? *(not carrying any products, tools, equipment, or materials)*

☐ Yes
☐ No

If your truck is loaded, what cargo are you carrying?
(e.g. "cattle," "logs," "processed foods," "chemicals," "empty container," "unknown")
(Estimate % of truck volume filled by each type of cargo)

_____ _____ %

_____ _____ %

_____ _____ %

_____ _____ %

Which direction are you headed on I-81? (Check one)

☐ Northbound
☐ Southbound

Where did you first enter I-81? (Check one)

☐ Outside of Virginia (first entered I-81 in TN, WV, MD, PA, or NY)
☐ From I-64
☐ From I-66
☐ From I-77
☐ From I-581
☐ Other: at Exit # _____ or Route Name in Virginia _____

Where will you finally exit I-81? (Check one)

☐ Outside of Virginia (will finally exit I-81 in TN, WV, MD, PA, or NY)
☐ At I-64
☐ At I-66
☐ At I-77
☐ At I-581
☐ Other: at Exit # _____ or Route Name in Virginia _____

1

Where is your home base/garage? *[where vehicle is usually parked when not on road]*

City: _____ State: _____

Where did you pick up this load? *[If empty, Where did you drop off your last load?]*

City: _____ State: _____

Type of facility where you picked up load:
☐ Farm/Forest/Mine ☐ Manufacturing Plant ☐ Distribution Center ☐ Other

Where will you drop off this load? *[If empty, Where will you pick up your next load?]*

City: _____ State: _____

Type of facility where you will drop off load:
☐ Farm/Forest/Mine ☐ Manufacturing Plant ☐ Distribution Center ☐ Other

How many times per month do you travel on I-81?

_____ times per month Northbound. _____ times per month Southbound.

Of these trips, how many times do you travel empty?

_____ times per month Northbound. _____ times per month Southbound.

Is this truck stop the only place where you're stopping inside Virginia?
☐ Yes ☐ No

If no, in order, list all your stops inside Virginia, including this location:
(Circle reasons for stop)

(1st) City: _____ Pick-Up Drop-Off Fuel/Food/Rest Other

(2nd) City: _____ Pick-Up Drop-Off Fuel/Food/Rest Other

(3rd) City: _____ Pick-Up Drop-Off Fuel/Food/Rest Other

(4th) City: _____ Pick-Up Drop-Off Fuel/Food/Rest Other

For this load, are you using any toll roads other than bridges or tunnels?
☐ Yes ☐ No

For this load, are you using alternative routes to avoid toll roads?
☐ Yes ☐ No

If I-81 were a toll road, would you use alternative routes?
☐ Yes – as an alternative, I would use _____
☐ No

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APPENDIX C - SURVEY ORIGIN-DESTINATION AND ENTRY-EXIT PAIRS

ORIGIN/DESTINATION PAIRS

OriginState	DestState	Total
AL	MA	1
	MD	1
	NJ	2
	NY	1
	PA	2
AR	MD & PA	1
	PA	2
CA	ME	1
CT	NC	2
	TN	1
DE	AL	1
	TN	1
	TX	1
FL	NJ	1
	KY	1
GA	MD	1
	ME	1
	NY	2
	PA	2
IL	WV	1
KS	PA & NJ	
LA	NY	1
	PA	1
MA	AZ	1
	LA	1
	MS	1
	NC	2
	TX	1
MD	AL	1
	MS	2
	NC	3
	TN	3
	TX	1
	(blank)	1
MS	CT	1
	NH	1
	NJ	1
	PA	1
NC	Canada	2
	CT	1
	MD	2
	NH	1
	NJ	4
	NY	3
	PA	5
	WV	1
NJ	CA	1
	FL	1
	GA	1
	IN	1
	SC	2
	TN	3
	TX	3
NY	AL	1
	NC	2
	TN	1
	TX	1
PA	AL	1
	CA	1
	FL	1
	GA	2
	NC	5
	SC	1
	TN	1
	TX	4
SC	Canada	1
	MD	1
	NY	1
	PA	1
TN	MA	2
	MD	2
	NJ	5
	PA	1
	PA, NH, ME	1
	VT	1
TX	DE	1
	MA	1
	NJ	1
	NY	1
	PA	1

ORIGIN-DESTINATION PAIRS

OriginState	DestState	Total
VA	AL	1
	CA	1
	Canada	2
	DE	1
	FL	1
	GA	2
	IL	1
	IN	1
	KS	1
	MD	3
	MI	2
	MN	
	NC	4
	NJ	1
	NY	1
	OH	3
	OK	1
	PA	3
	TN	2
	VT	1
	WV	2
	BLANK	3
WA	ME	1
WV	FL	1
	NC	1
BLANK	(blank)	3
Canada	AL	1
	TN	1
Grand Total		167

ENTRY/EXIT PAIRS

Entry Location	Exit Location	Number of Trucks
On I-81 at WV/VA Line	I-64	4
	I-66	1
	I-77	8
	On I-81 at TN/VA Line	36
	Other Interchanges within VA	4
	Roanoke Area	5
On I-81 at TN/VA Line	I-64	2
	I-66	10
	On I-81 at WV/VA Line	31
	Other Interchanges within VA	2
I-64	I-64	15
	I-66	3
	On I-81 at TN/VA Line	2
	On I-81 at WV/VA Line	2
	Other Interchanges within VA	4
	Roanoke Area	1
I-77	On I-81 at TN/VA Line	1
	On I-81 at WV/VA Line	21
	Other Interchanges within VA	3
I-66	I-64	2
	I-66	1
	I-77	2
	On I-81 at TN/VA Line	11
	On I-81 at WV/VA Line	1
	Other Interchanges within VA	3
	Roanoke Area	2
Roanoke Area	I-64	3
	I-66	1
	I-77	2
	On I-81 at WV/VA Line	9
	Other Interchanges within VA	4
Other Interchanges within VA	I-64	2
	I-77	2
	On I-81 at TN/VA Line	1
	On I-81 at WV/VA Line	3
	Other Interchanges within VA	9
	Roanoke Area	2
non 81	non 81	3
Unknown	Unknown	2
Grand Total		**220**

APPENDIX D - 2035 TRUCK TRIP FORECAST DATA

Summary Table of I-81 Count Station Final Data 2002, 2035

VDOT I-81 Count Station Identifiers			2002 Counts (000)			2035 Counts (000)			Percent Growth
Seq	Route	Name (Southern Terminus)	Single	Combo	Total	Single	Combo	Total	
1	North 81	Tennessee State Line	0.42	3.22	3.64	1.05	7.61	8.66	137.91%
2	North 81	SCL Bristol	0.42	3.22	3.64	1.05	7.61	8.66	137.99%
3	North 81	US 58, US 421	0.48	3.68	4.16	1.20	8.70	9.90	137.99%
4	North 81, 58	I-381	0.78	5.98	6.76	1.95	14.13	16.09	137.99%
5	North 81, 58	US 11, US 19	0.66	5.06	5.72	1.65	11.96	13.61	137.99%
6	North 81, 58	Old Airport Rd	0.66	5.06	5.72	1.65	11.96	13.61	137.99%
7	North 81, 58	NCL Bristol	0.66	5.06	5.72	1.65	11.96	13.61	137.99%
8	North 81, 58	FR-310, RT F-310	0.63	4.83	5.46	1.58	11.41	12.99	137.91%
9	North 81, 58	95-611	0.63	4.83	5.46	1.58	11.41	12.99	137.91%
10	North 81, 58	SR 140	0.60	4.60	5.20	1.50	10.87	12.37	137.91%
11	North 81, 58	SCL Abingdon	0.60	4.60	5.20	1.50	10.87	12.37	137.91%
12	North 81, 58	SR 175	0.72	5.52	6.24	1.80	13.04	14.85	137.91%
13	North 81, 58	NCL Abingdon	0.72	5.52	6.24	1.80	13.04	14.85	137.91%
14	North 81	US 11, US58	0.54	4.14	4.68	1.35	9.78	11.13	137.91%
15	North 81	95-704	0.54	4.14	4.68	1.35	9.78	11.13	137.91%
16	North 81	SR 80	0.51	3.91	4.42	1.28	9.24	10.52	137.91%
17	North 81	95-737	0.48	3.68	4.16	1.20	8.69	9.90	137.91%
18	North 81	SR 91	0.51	3.91	4.42	1.28	9.24	10.52	137.91%
19	North 81	US 11	0.42	3.22	3.64	1.05	7.61	8.66	137.91%
20	North 81	Washington, Smith County Line	0.42	3.22	3.64	1.05	7.61	8.66	138.04%
21	North 81	SCL Chilhowie	0.42	3.22	3.64	1.05	7.61	8.66	138.04%
22	North 81	SR 107	0.45	3.45	3.90	1.13	8.16	9.28	138.04%
23	North 81	NCL Chilhowie	0.45	3.45	3.90	1.13	8.16	9.28	138.04%
24	North 81	US 11; 86-645	0.45	3.45	3.90	1.13	8.16	9.28	138.04%
25	North 81	US 11	0.42	3.22	3.64	1.05	7.61	8.66	138.04%
26	North 81	86-730	0.45	3.45	3.90	1.13	8.16	9.28	138.04%
27	North 81	WCL Marion	0.45	3.45	3.90	1.13	8.16	9.28	138.04%
28	North 81	ECL Marion	0.45	3.45	3.90	1.13	8.16	9.28	138.04%
29	North 81	SCL Marion	0.45	3.45	3.90	1.13	8.16	9.28	138.04%
30	North 81	SR16	0.42	3.22	3.64	1.05	7.61	8.66	138.04%
31	North 81	NCL Marion	0.42	3.22	3.64	1.05	7.61	8.66	138.04%
32	North 81	RT F-10	0.42	3.22	3.64	1.05	7.61	8.66	138.04%
33	North 81	86-622	0.42	3.22	3.64	1.05	7.61	8.66	138.04%
34	North 81	86-683	0.36	2.76	3.12	0.90	6.52	7.43	138.04%

35	North 81	Smyth, Wythe County Line	0.36	2.76	3.12	0.90	6.52	7.43	138.02%
36	North 81	SR 90; 98-680	0.36	2.76	3.12	0.90	6.52	7.43	138.02%
37	North 81	US 11	0.39	2.99	3.38	0.98	7.07	8.05	138.02%
38	North 81	SCL Wytheville	0.39	2.99	3.38	0.98	7.07	8.05	138.02%
39	North 81, 52	US 21; US 52	0.39	2.99	3.38	0.98	7.07	8.05	138.02%
40	North 81, North 77, 52	I-77 Wytheville	0.66	6.82	7.48	1.65	16.12	17.78	137.64%
41	North 81, North 77, 11, 52	US 11	0.75	7.75	8.50	1.88	18.32	20.20	137.64%
42	North 81, North 77, 11, 52	NCL Wytheville	0.75	7.75	8.50	1.88	18.32	20.20	137.64%
43	North 81, North 77, 11, 52	F-42	0.72	7.44	8.16	1.80	17.59	19.39	137.64%
44	North 81, North 77, 11	US 52; SR 121	0.72	7.44	8.16	1.80	17.59	19.39	137.64%
45	North 81, 11	I-77 Fort Chiswell	0.54	5.22	5.76	1.35	12.34	13.69	137.72%
46	North 81, 11	98-619	0.54	5.22	5.76	1.35	12.34	13.69	137.72%
47	North 81, 11	98-618	0.54	5.22	5.76	1.35	12.34	13.69	137.72%
48	North 81, 11	Wythe, Pulaski County Line	0.54	5.22	5.76	1.35	12.33	13.68	137.52%
49	North 81	US 11	0.63	6.09	6.72	1.58	14.38	15.96	137.52%
50	North 81, 100	SR 100	0.63	6.09	6.72	1.58	14.38	15.96	137.52%
51	North 81, 100	RT F-47 S INT	0.51	4.93	5.44	1.28	11.64	12.92	137.52%
52	North 81, 100	SR 99	0.57	5.51	6.08	1.43	13.01	14.44	137.52%
53	North 81	SR 100	0.66	6.38	7.04	1.65	15.07	16.72	137.52%
54	North 81	77-660	0.66	6.38	7.04	1.65	15.07	16.72	137.52%
55	North 81	Pulaski, Montgomery County Line	0.66	6.38	7.04	1.65	15.08	16.73	137.70%
56	North 81	SR 232	0.51	4.93	5.44	1.28	11.65	12.93	137.70%
57	North 81	SR 177	0.60	5.80	6.40	1.50	13.71	15.21	137.70%
58	North 81	SR 8	0.63	6.09	6.72	1.58	14.39	15.97	137.70%
59	North 81	SCL Christiansburg	0.63	6.09	6.72	1.58	14.39	15.97	137.70%
60	North 81	US 11 US 460	0.72	6.96	7.68	1.80	16.45	18.26	137.70%
61	North 81	NCL Christiansburg	0.72	6.96	7.68	1.80	16.45	18.26	137.70%
62	North 81	60-603 Ironto	0.72	6.96	7.68	1.80	16.45	18.26	137.70%
63	North 81	Montgomery, Roanoke County Line	0.72	6.96	7.68	1.80	16.41	18.22	137.21%
64	North 81	80-647 Dow Hollow Rd	0.75	7.25	8.00	1.88	17.10	18.98	137.21%
65	North 81	SCL Salem	0.75	7.25	8.00	1.88	17.02	18.90	136.24%
66	North 81	SR 112 Wildwood Rd	0.93	8.99	9.92	2.33	21.10	23.44	136.24%
67	North 81	NCL Salem	0.93	8.99	9.92	2.33	21.10	23.44	136.24%
68	North 81	SR 311 Thompson Memorial Dr	0.90	8.70	9.60	2.26	20.52	22.77	137.21%
69	North 81	SR 419 Electric Rd	1.08	10.44	11.52	2.71	24.62	27.33	137.21%
70	North 81, 220	I-581	0.84	5.88	6.72	2.11	13.87	15.97	137.67%
71	North 81, 220	SR 115 Plantation RD	0.81	5.67	6.48	2.03	13.37	15.40	137.67%

72	North 81, 220	Roanoke , Botetourt County Line	0.81	5.67	6.48	2.03	13.40	15.43	138.05%
73	North 81	US 220	0.57	6.84	7.41	1.43	16.16	17.59	137.36%
74	North 81	11-640	0.48	5.76	6.24	1.20	13.61	14.81	137.36%
75	North 81	US 11 S	0.51	6.12	6.63	1.28	14.46	15.74	137.36%
76	North 81, 11	US 11 N	0.48	5.76	6.24	1.20	13.61	14.81	137.36%
77	North 81, 11	Botetourt, Rockbridge County Line	0.48	5.76	6.24	1.20	13.61	14.82	137.45%
78	North 81	US 11 S INT	0.45	5.40	5.85	1.13	12.76	13.89	137.45%
79	North 81	US 11 N INT	0.54	6.48	7.02	1.35	15.32	16.67	137.45%
80	North 81	US 60	0.40	6.60	7.00	1.00	15.60	16.60	137.17%
81	North 81, East 64	I-64	0.38	6.27	6.65	0.95	14.82	15.77	137.17%
82	North 81, East 64	US 11	0.38	6.27	6.65	0.95	14.82	15.77	137.17%
83	North 81, East 64	81-710	0.40	6.60	7.00	1.00	15.60	16.60	137.17%
84	North 81, East 64	81-606	0.42	6.93	7.35	1.05	16.38	17.43	137.17%
85	North 81, East 64	Rockbridge, Augusta County Line	0.42	6.93	7.35	1.05	16.38	17.43	137.17%
86	North 81, East 64	US 11	0.42	6.93	7.35	1.05	16.38	17.43	137.17%
87	North 81, East 64	07-654	0.48	7.92	8.40	1.20	18.72	19.92	137.17%
88	North 81, East 64	SR 262	0.52	8.58	9.10	1.30	20.28	21.58	137.17%
89	North 81	I-64	0.84	7.56	8.40	2.11	17.87	19.97	137.78%
90	North 81	US 250	0.78	7.02	7.80	1.95	16.59	18.55	137.78%
91	North 81	SR 275	0.72	6.48	7.20	1.80	15.32	17.12	137.78%
92	North 81	07-612	0.63	5.67	6.30	1.58	13.40	14.98	137.78%
93	North 81	SR 256	0.57	5.13	5.70	1.43	12.13	13.55	137.78%
94	North 81	Augusta, Rockingham County Line	0.57	5.13	5.70	1.43	12.13	13.56	137.81%
95	North 81	SR 257	0.69	6.21	6.90	1.73	14.68	16.41	137.81%
96	North 81	SCL Harrisonburg	0.69	6.21	6.90	1.73	14.67	16.40	137.67%
97	North 81	US 11	0.72	6.48	7.20	1.80	15.31	17.11	137.67%
98	North 81	82-659 Port Republic Road	0.75	6.75	7.50	1.88	15.95	17.82	137.67%
99	North 81	US 33	0.69	6.21	6.90	1.73	14.67	16.40	137.67%
100	North 81	NCL Harrisonburg	0.69	6.21	6.90	1.73	14.67	16.40	137.67%
101	North 81	US 11 S	0.66	5.94	6.60	1.65	14.04	15.70	137.81%
102	North 81	US 11 N	0.57	5.13	5.70	1.43	12.13	13.56	137.81%
103	North 81	Rockingham , Shenandoah County Line	0.57	5.13	5.70	1.43	12.13	13.56	137.88%
104	North 81	US 211	0.57	5.13	5.70	1.43	12.13	13.56	137.88%
105	North 81	SCL New Market	0.57	5.13	5.70	1.43	12.13	13.56	137.88%
106	North 81	NCL New Market	0.57	5.13	5.70	1.43	12.13	13.56	137.88%
107	North 81	85-730	0.51	4.59	5.10	1.28	10.85	12.13	137.88%
108	North 81	SR 292	0.63	5.67	6.30	1.58	13.41	14.99	137.88%

109	North 81	85-614	0.57	5.13	5.70	1.43	12.13	13.56	137.88%
110	North 81	SR 185	0.57	5.13	5.70	1.43	12.13	13.56	137.88%
111	North 81	SCL Woodstock	0.57	5.13	5.70	1.43	12.13	13.56	137.88%
112	North 81	SR 42	0.60	5.40	6.00	1.50	12.77	14.27	137.88%
113	North 81	NCL Woodstock	0.60	5.40	6.00	1.50	12.77	14.27	137.88%
114	North 81	85-651	0.60	5.40	6.00	1.50	12.77	14.27	137.88%
115	North 81	SR 55	0.60	5.40	6.00	1.50	12.77	14.27	137.88%
116	North 81	US 11	0.69	6.21	6.90	1.73	14.68	16.41	137.88%
117	North 81	Frederick County Maintenance Break	0.69	6.21	6.90	1.73	14.68	16.41	137.88%
118	North 81	Shenandoah, Warren County Line	0.69	6.21	6.90	1.73	14.68	16.41	137.80%
119		Dummy Station to match south	0.69	6.21	6.90	1.73	14.68	16.41	137.80%
119	North 81	I-66 Warren, Frederick County Line	0.88	4.62	5.50	2.21	10.92	13.13	138.73%
120	North 81	34-627	0.88	4.62	5.50	2.21	10.92	13.13	138.73%
121	North 81	SCL Stephens City	0.88	4.62	5.50	2.21	10.92	13.13	138.73%
122		Dummy Station to match south	0.88	4.62	5.50	2.21	10.92	13.13	138.73%
122	North 81	SR 277; NCL Stephens City	1.04	5.46	6.50	2.61	12.91	15.52	138.73%
123	North 81	SR 37	0.92	4.83	5.75	2.31	11.42	13.73	138.73%
124	North 81	US 50	1.12	5.88	7.00	2.81	13.90	16.71	138.73%
125	North 81	SCL Winchester	1.12	5.88	7.00	2.81	13.90	16.71	138.73%
126	North 81	NCL Winchester	1.12	5.88	7.00	2.81	13.90	16.71	138.73%
127	North 81	SR 7	1.08	5.67	6.75	2.71	13.41	16.11	138.73%
128	North 81	US 11	0.92	4.83	5.75	2.31	11.42	13.73	138.73%
129	North 81	34-672	0.92	4.83	5.75	2.31	11.42	13.73	138.73%
130	North 81	34-669	0.76	3.99	4.75	1.90	9.44	11.34	138.73%
		West Virginia State Line				-			
131	South 81	Tennessee State Line	0.48	3.20	3.68	1.20	8.03	9.23	150.92%
132	South 81	SCL Bristol	0.48	3.20	3.68	1.20	8.03	9.23	150.92%
133	South 81, 58	US 58, US 421	0.48	3.20	3.68	1.20	8.03	9.23	150.92%
134	South 81, 58	I-381	0.66	4.40	5.06	1.65	11.04	12.70	150.92%
135	South 81, 58	US 11, US 19	0.63	4.20	4.83	1.58	10.54	12.12	150.92%
136	South 81, 58	Old Airport Rd	0.81	5.40	6.21	2.03	13.55	15.58	150.92%
137	South 81, 58	NCL Bristol	0.81	5.40	6.21	2.03	13.55	15.58	150.92%
138	South 81, 58	RT F-310	0.54	3.60	4.14	1.35	9.03	10.39	150.92%
139	South 81, 58	95-611	0.66	4.40	5.06	1.65	11.04	12.70	150.92%
140	South 81, 58	SR 140	0.60	4.00	4.60	1.50	10.04	11.54	150.92%
141	South 81, 58	SCL Abingdon	0.60	4.00	4.60	1.50	10.04	11.54	150.92%
142	South 81, 58	SR 75	0.69	4.60	5.29	1.73	11.54	13.27	150.92%

143	South 81, 58	NCL Abingdon	0.69	4.60	5.29	1.73	11.54	13.27	150.92%
144	South 81	US 11, US 58	0.54	3.60	4.14	1.35	9.03	10.39	150.92%
145	South 81	95-704	0.57	3.80	4.37	1.43	9.54	10.97	150.92%
146	South 81	SR 80	0.57	3.80	4.37	1.43	9.54	10.97	150.92%
147	South 81	95-737	0.48	3.20	3.68	1.20	8.03	9.23	150.92%
148	South 81	SR 91	0.48	3.20	3.68	1.20	8.03	9.23	150.92%
149	South 81	US 11	0.51	3.40	3.91	1.28	8.53	9.81	150.92%
150	South 81	Washington, Smyth County Line	0.51	3.40	3.91	1.28	8.53	9.81	150.92%
151	South 81	SCL Chilhowie	0.51	3.40	3.91	1.28	8.53	9.81	150.92%
152	South 81	SR 107	0.45	3.00	3.45	1.13	7.53	8.66	150.92%
153	South 81	NCL Chilhowie	0.45	3.00	3.45	1.13	7.53	8.66	150.92%
154	South 81	US 11 S	0.48	3.20	3.68	1.20	8.03	9.23	150.92%
155	South 81	US 11 N	0.45	3.00	3.45	1.13	7.53	8.66	150.92%
156	South 81	86-730	0.48	3.20	3.68	1.20	8.03	9.23	150.92%
157	South 81	WCL Marion	0.48	3.20	3.68	1.20	8.03	9.23	150.92%
158	South 81	ECL Marion	0.48	3.20	3.68	1.20	8.03	9.23	150.92%
159	South 81	SCL Marion	0.48	3.20	3.68	1.20	8.03	9.23	150.92%
160	South 81	SR 16	0.51	3.40	3.91	1.28	8.53	9.81	150.92%
161	South 81	NCL Marion	0.51	3.40	3.91	1.28	8.53	9.81	150.92%
162	South 81	US 11	0.42	2.80	3.22	1.05	7.03	8.08	150.92%
163	South 81	86-622	0.42	2.80	3.22	1.05	7.03	8.08	150.92%
164	South 81	86-683	0.36	2.40	2.76	0.90	6.02	6.93	150.92%
165	South 81	Smyth, Wythe County Line	0.36	2.40	2.76	0.90	6.02	6.92	150.82%
166	South 81	SR 90; 98-680	0.36	2.40	2.76	0.90	6.02	6.92	150.82%
167	South 81	US 11	0.36	2.40	2.76	0.90	6.02	6.92	150.82%
168	South 81	SCL Wytheville	0.36	2.40	2.76	0.90	6.02	6.92	150.82%
169	South 81, 52	US 21; US 52	0.39	2.60	2.99	0.98	6.52	7.50	150.82%
170	South 81, North 77, 52	I-77 Wytheville	0.66	5.72	6.38	1.65	14.35	16.00	150.83%
171	South 81, North 77, 11, 52	US 11	0.75	6.50	7.25	1.88	16.31	18.19	150.83%
172	South 81, North 77, 11, 52	NCL Wytheville	0.75	6.50	7.25	1.88	16.31	18.19	150.83%
173	South 81, North 77, 11, 52	F-42	0.87	7.54	8.41	2.18	18.91	21.09	150.83%
174	South 81, North 77, 11	US 52; SR 121	0.75	6.50	7.25	1.88	16.31	18.19	150.83%
175	South 81, 11	I-77 Fort Chiswell	0.54	4.86	5.40	1.35	12.19	13.54	150.83%
176	South 81, 11	98-619	0.54	4.86	5.40	1.35	12.19	13.54	150.83%
177	South 81, 11	98-618	0.54	4.86	5.40	1.35	12.19	13.54	150.83%
178	South 81, 11	Wythe, Pulaski County Line	0.54	4.86	5.40	1.35	12.18	13.53	150.57%
179	South 81, 100	US 11	0.54	4.86	5.40	1.35	12.18	13.53	150.57%

180	NA	Dummy Station to match north	0.54	4.86	5.40	1.02	12.18	13.20	144.40%
180	South 81, 100	Connector Road F-327	0.54	4.86	5.40	1.35	12.18	13.53	150.57%
181	South 81, 100	SR 99	0.54	4.86	5.40	1.35	12.18	13.53	150.57%
182	South 81	SR 100	0.63	5.67	6.30	1.58	14.21	15.79	150.57%
183	South 81	77-660	0.63	5.67	6.30	1.58	14.21	15.79	150.57%
184	South 81	Pulaski, Montgomery County Line	0.63	5.67	6.30	1.58	14.21	15.79	150.57%
185	South 81	SR 232	0.54	4.86	5.40	1.35	12.18	13.53	150.57%
186	South 81	SR 177	0.60	5.40	6.00	1.50	13.53	15.03	150.57%
187	South 81	SR 8	0.66	5.94	6.60	1.65	14.88	16.54	150.57%
188	South 81	SCL Christiansburg	0.66	5.94	6.60	1.65	14.88	16.54	150.57%
189	South 81	US 11 US 460	0.69	6.21	6.90	1.73	15.56	17.29	150.57%
190	South 81	NCL Christiansburg	0.69	6.21	6.90	1.73	15.56	17.29	150.57%
191	South 81	60-603 Ironto	0.75	6.75	7.50	1.88	16.91	18.79	150.57%
192	South 81	Montgomery, Roanoke County Line	0.75	6.75	7.50	1.88	16.91	18.79	150.55%
193	South 81	80-647 Dow Hollow Rd	0.78	7.02	7.80	1.95	17.59	19.54	150.55%
194	South 81	SCL Salem	0.78	7.02	7.80	1.95	17.59	19.54	150.55%
195	South 81	SR 112 Wildwood Rd	0.99	8.91	9.90	2.48	22.32	24.80	150.55%
196	South 81	NCL Salem	0.99	8.91	9.90	2.48	22.32	24.80	150.55%
197	South 81	SR 311 Thompson Memorial Dr	0.99	8.91	9.90	2.48	22.32	24.80	150.55%
198	South 81	SR 419 Electric Rd	1.11	9.99	11.10	2.78	25.03	27.81	150.55%
199	South 81	I-581	0.81	5.13	5.94	2.03	12.85	14.88	150.56%
200	South 81, 220	SR 115 Plantation Rd	0.81	5.13	5.94	2.03	12.85	14.88	150.56%
201	South 81, 220	Roanoke , Botetourt County Line	0.81	5.13	5.94	2.03	12.85	14.88	150.57%
202	South 81	US 220	0.38	6.46	6.84	0.95	16.19	17.14	150.57%
203	South 81	11-640	0.38	6.46	6.84	0.95	16.19	17.14	150.57%
204	South 81	US 11	0.34	5.78	6.12	0.85	14.48	15.33	150.57%
205	South 81, 11	11-614	0.28	4.76	5.04	0.70	11.93	12.63	150.57%
206	South 81, 11	Botetourt, Rockbridge County Line	0.28	4.76	5.04	0.70	11.93	12.63	150.59%
207	South 81	US 11 S	0.32	5.44	5.76	0.80	13.63	14.43	150.59%
208	South 81	US 11 N	0.36	6.12	6.48	0.90	15.34	16.24	150.59%
209	South 81	US 60	0.36	6.12	6.48	0.90	15.34	16.24	150.59%
210	South 81, East 64	I-64	0.48	4.96	5.44	1.20	12.43	13.63	150.59%
211	South 81, East 64	US 11	0.60	6.20	6.80	1.50	15.54	17.04	150.59%
212	South 81, East 64	87-710	0.60	6.20	6.80	1.50	15.54	17.04	150.59%
213	South 81, East 64	81-606	0.60	6.20	6.80	1.50	15.54	17.04	150.59%
214	South 81, East 64	Rockbridge, Augusta County Line	0.60	6.20	6.80	1.50	15.54	17.04	150.61%
215	South 81, East 64	US 11	0.57	5.89	6.46	1.43	14.76	16.19	150.61%

216	South 81, East 64	07-654	0.57	5.89	6.46	1.43	14.76	16.19	150.61%
217	South 81, East 64	SR 262	0.72	7.44	8.16	1.80	18.65	20.45	150.61%
218	South 81	I-64	0.90	7.50	8.40	2.26	18.80	21.05	150.61%
219	South 81	US 250	0.81	6.75	7.56	2.03	16.92	18.95	150.61%
220	South 81	SR 275	0.75	6.25	7.00	1.88	15.66	17.54	150.61%
221	South 81	07-612	0.66	5.50	6.16	1.65	13.78	15.44	150.61%
222	South 81	SR 256	0.66	5.50	6.16	1.65	13.78	15.44	150.61%
223	South 81	Augusta, Rockingham County Line	0.66	5.50	6.16	1.65	13.79	15.44	150.71%
224	South 81	SR 257	0.72	6.00	6.72	1.80	15.04	16.85	150.71%
225	South 81	SCL Harrisonburg	0.72	6.00	6.72	1.80	15.04	16.85	150.69%
226	South 81	US 11	0.72	6.00	6.72	1.80	15.04	16.85	150.69%
227	South 81	Port Republic Road 82-659	0.78	6.50	7.28	1.95	16.30	18.25	150.69%
228	South 81	US 33	0.69	5.75	6.44	1.73	14.42	16.14	150.69%
229	South 81	NCL Harrisonburg	0.69	5.75	6.44	1.73	14.42	16.14	150.69%
230	South 81	US 11 N	0.66	5.50	6.16	1.65	13.79	15.44	150.71%
231	South 81	US 11 S	0.66	5.50	6.16	1.65	13.79	15.44	150.71%
232	South 81	Rockingham , Shenandoah County Line	0.66	5.50	6.16	1.65	13.79	15.45	150.76%
233	South 81	SCL New Market	0.66	5.50	6.16	1.65	13.79	15.45	150.76%
234	South 81	US 211	0.51	4.25	4.76	1.28	10.66	11.94	150.76%
235	South 81	NCL New Market	0.51	4.25	4.76	1.28	10.66	11.94	150.76%
236	South 81	85-730	0.54	4.50	5.04	1.35	11.28	12.64	150.76%
237	South 81	85-703	0.54	4.50	5.04	1.35	11.28	12.64	150.76%
238	South 81	85-614	0.57	4.75	5.32	1.43	11.91	13.34	150.76%
239	South 81	SR 185	0.54	4.50	5.04	1.35	11.28	12.64	150.76%
240	South 81	SCL Woodstock	0.54	4.50	5.04	1.35	11.28	12.64	150.76%
241	South 81	SR 42	0.57	4.75	5.32	1.43	11.91	13.34	150.76%
242	South 81	NCL Woodstock	0.57	4.75	5.32	1.43	11.91	13.34	150.76%
243	South 81	85-651	0.66	5.50	6.16	1.65	13.79	15.45	150.76%
244	South 81	SR 55	0.63	5.25	5.88	1.58	13.17	14.74	150.76%
245	South 81	US 11	0.63	5.25	5.88	1.58	13.17	14.74	150.76%
246	South 81	Frederick County Maintenance Break	0.63	5.25	5.88	1.58	13.17	14.74	150.76%
247	South 81	Shenandoah, Warren County Line	0.63	5.25	5.88	1.58	13.17	14.75	150.78%
248	South 81	I-66 Warren, Frederick County Line	0.63	5.25	5.88	1.58	13.17	14.75	150.78%
249	South 81	I-66	0.48	3.20	3.68	1.20	8.03	9.23	150.78%
250	South 81	34-627	0.60	4.00	4.60	1.50	10.03	11.54	150.78%
251	South 81	SCL Stephens City	0.60	4.00	4.60	1.50	10.03	11.54	150.78%
252	South 81	NCL Stephens City	0.60	4.00	4.60	1.50	10.03	11.54	150.78%

253	South 81	SR 277	0.66	4.40	5.06	1.65	11.04	12.69	150.78%
254	South 81	SR 37	0.66	4.40	5.06	1.65	11.04	12.69	150.78%
255	South 81	SR 50	0.81	5.40	6.21	2.03	13.54	15.57	150.78%
256	South 81	SCL Winchester	0.81	5.40	6.21	2.03	13.48	15.51	149.69%
257	South 81	NCL Winchester	0.81	5.40	6.21	2.03	13.48	15.51	149.69%
258	South 81	SR 7	0.75	5.00	5.75	1.88	12.54	14.42	150.78%
259	South 81	US 11	0.66	4.40	5.06	1.65	11.04	12.69	150.78%
260	South 81	34-672	0.60	4.00	4.60	1.50	10.03	11.54	150.78%
261	South 81	34-669	0.57	3.80	4.37	1.43	9.53	10.96	150.78%
	South 81	West Virginia State Line							

APPENDIX E - TRUCK TRIP TABLES SUPPORT DATA

2035 Annual Truck Trip Table for the Interstate 81 Corridor-No Build

Origin	Alleghany County , VA	Augusta County , VA	Bath County , VA	Bland County , VA	Botetourt County , VA	Bristol County , VA	Buena Vista County , VA	Clarke County , VA	Clifton Forge County , VA	Covington County , VA	Craig County , VA	Frederick County , VA	Giles County , VA	Harrisonburg County , VA	Highland County , VA	Lexington County , VA	Montgomery County , VA	Norton County , VA	Page County , VA	Pulaski County , VA	Radford County , VA	Roanoke City , VA	Roanoke County , VA	Rockbridge County , VA	Rockingham County , VA	Russell County , VA	Salem City , VA	Scott County , VA	Shenandoah County , VA	Smyth County , VA	Staunton City , VA	Warren County , VA	Washington County , VA	Waynesboro City , VA	Winchester City , VA	Wise County , VA	Wythe County , VA	Rest of Virginia	Exit Road I64	Exit Road I77	Exit Road I81	Exit Road I66 at I81	Rest of US	I77 in NC	I77 in WV	I64 in WV	I81 in WV	I81 in TN	I66 at I495	Total
Alleghany County , VA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	4	0	20	0	0	0	0	0	0	0	17	0	0	0	0	0	10	0	555					1878	445	0	384	328	117	117	2497
Augusta County , VA	0	1900	1	0	37	402	23	0	0	0	0	0	187	0	0	0	175	0	11	0	0	445	181	50	449	12	0	2	0	99	0	0	84	0	0	34	128	31106					96454	13692	0	19258	9283	22770	1574	131780
Bath County , VA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	155					608	67	0	98	90	66	27	770
Bland County , VA	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	17	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	1477					694	411	66	0	27	110	49	2209
Botetourt County , VA	0	721	0	0	2016	326	0	0	12	51	0	213	0	0	0	242	773	0	107	316	0	994	548	0	0	103	468	90	0	313	0	107	0	0	0	168	167	39706					7311	1914	0	1455	284	1162	533	54750
Bristol County , VA	14	1858	69	0	1729	2319	222	16	0	0	0	649	1015	0	0	0	1201	86	203	0	0	2428	838	327	1624	0	0	102	870	1355	396	1164	430	0	0	0	0	101851					42083	5623	2901	0	4057	6422	2087	162852
Buena Vista County , VA	0	17	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	7	0	0	0	0	6	0	0	0	0	0	5430					5151	1081	0	803	729	525	265	10649
Clarke County , VA	0	0	0	0	3	10	0	7	0	0	0	24	0	0	0	0	0	0	0	39	0	0	0	9	0	0	0	3	23	77	0	0	31	0	106	30	8	2753					3902	1122	0	0	342	320	292	7024
Clifton Forge County , VA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	709					290	148	0	29	29	18	6	1003
Covington County , VA	0	0	0	0	93	0	68	0	3	1404	3	0	678	0	0	0	0	32	109	0	0	941	0	60	0	291	0	247	331	0	0	0	0	0	0	409	0	34443					22153	3221	0	6194	2377	2741	1964	61265
Craig County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90					41	12	0	0	3	15	0	131
Frederick County , VA	35	0	73	155	1830	1458	262	178	0	0	0	2376	926	1094	0	127	0	96	107	461	0	0	0	318	0	456	0	2	822	1197	0	1647	83	0	0	81	103	60164					27464	4076	0	3	4517	1267	819	101514
Giles County , VA	0	694	14	0	0	272	0	2	0	370	0	107	1013	0	0	0	82	0	5	0	55	381	0	22	0	15	0	4	122	0	28	0	0	0	0	54	83	11859					11798	6579	0	0	1603	933	337	26980
Harrisonburg County , VA	0	0	0	0	0	0	0	0	0	0	0	27	0	181	0	0	0	4	0	0	0	406	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	9858					21083	3580	0	1611	3337	3104	995	31567
Highland County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	7	0	0	0	0	7	0	0	186					242	157	0	3	10	2	7	445
Lexington County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1858					1673	475	0	210	108	252	197	3545
Montgomery County , VA	0	975	16	0	360	474	36	0	0	0	0	0	194	0	2	0	1116	0	175	0	287	1411	0	138	0	170	0	0	284	497	175	0	425	0	0	0	266	22511					10701	3220	0	0	1009	1547	1007	40212
Norton County , VA	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	4	0	0	0	2	0	0	0	0	0	0	0	0	936					380	356	0	0	19	0	129	1333
Page County , VA	0	60	0	0	17	29	2	0	0	21	0	27	2	0	0	2	68	0	14	44	0	0	0	10	0	0	0	0	0	84	0	48	33	0	0	33	23	11549					7645	1719	0	166	867	1218	1718	19711
Pulaski County , VA	7	0	15	0	815	0	0	8	0	0	0	244	0	0	0	0	0	0	24	369	0	723	0	121	0	0	0	0	312	0	150	0	0	0	0	0	70	33831					40733	5109	0	0	3193	12696	2097	77421
Radford County , VA	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	40	0	0	0	86	92	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	1232					12668	2394	0	0	3728	3160	140	14148
Roanoke City , VA	24	3449	125	327	3346	3081	461	0	34	2538	21	0	1735	2704	16	0	2240	186	0	1332	6634	5504	0	705	2917	999	2484	261	0	2606	0	0	859	983	0	571	698	61114					119978	19035	0	0	24196	11135	4453	227933
Roanoke County , VA	0	1058	0	0	1624	1233	0	0	3	0	0	0	0	0	0	103	0	0	0	0	0	0	467	0	1167	367	0	6	670	1098	325	0	0	0	0	85	93	33726					20586	3748	0	0	2327	1081	902	62610
Rockbridge County , VA	0	219	0	2	0	85	3	7	0	39	0	62	19	0	0	0	151	0	25	92	0	266	0	28	0	37	125	24	70	147	0	0	0	0	0	64	50	23947					8832	2056	0	884	1250	772	711	34294
Rockingham County , VA	0	855	0	0	0	132	8	0	0	0	0	0	0	0	0	0	0	5	0	0	0	422	199	0	704	0	0	11	0	65	0	0	59	115	0	34	22	13061					24732	6580	0	1241	4341	4131	1257	40425
Russell County , VA	0	4	0	0	12	0	0	0	0	1	0	0	609	0	0	0	0	0	0	0	0	1	6	0	0	221	0	0	0	0	0	0	0	0	0	0	0	4087					7081	5067	0	0	230	720	22	12023
Salem City , VA	0	0	0	0	947	0	128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1425	0	207	0	0	1049	0	0	0	0	0	0	0	0	0	0	11040					32850	7445	0	0	4095	5369	1532	47646
Scott County , VA	0	22	0	0	1	5	0	3	0	48	0	0	4	0	0	0	0	0	0	15	0	44	27	5	20	0	0	2	2	33	2	0	16	0	0	0	4	4762					1593	0	0	0	22	0	116	6609
Shenandoah County , VA	0	0	0	0	0	80	0	6	0	108	0	201	9	0	0	0	152	2	0	43	0	0	159	7	0	0	0	3	98	67	0	0	47	0	0	32	7	23694					12732	2309	0	95	1318	3296	936	37447
Smyth County , VA	90	1894	0	0	342	1256	0	105	0	0	26	421	0	0	5	0	1096	19	252	0	0	1764	1076	234	814	0	0	227	394	1310	230	0	0	0	0	415	0	111336					37881	12348	2901	0	1891	7879	1800	161187
Staunton City, VA	0	0	0	0	0	16	0	0	0	0	0	0	2	0	0	0	56	0	0	33	8	0	52	0	0	0	0	2	0	57	4	0	24	0	116	20	6	4515					8151	1349	0	975	1441	685	618	13061
Warren County , VA	57	0	3	0	5	7	5	0	0	0	0	619	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	558	0	0	386	0	3	2913					14512	1020	0	0	4363	822	3952	19087
Washington County , VA	0	552	0	0	0	747	0	11	0	0	0	239	0	0	0	0	266	22	28	0	0	638	0	0	617	204	0	5	343	0	164	571	89	0	0	50	28	31242					14055	3737	1208	0	1374	2790	428	49872
Waynesboro City , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	1199	0	0	0	0	0	0	0	1623	0	0	1490	0	0	0	0	0	0	0	0	676	4566	0	0	77697					31788	5400	0	2822	3863	2238	5111	119040
Winchester City , VA	0	0	15	0	0	0	0	106	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	238	683	0	345	3596	0	0	46974					62406	10772	0	0	10886	11732	2828	114365
Wise County , VA	0	64	0	0	82	0	0	2	0	357	0	23	4002	0	0	0	0	0	2	0	0	95	34	16	60	1047	0	0	34	75	16	0	4	0	0	8	3	17082					2837	1258	0	0	86	0	116	25844
Wythe County , VA	0	621	0	67	792	0	0	8	0	0	0	232	427	0	0	0	319	0	25	220	0	737	177	137	654	196	0	0	330	0	156	547	37	0	0	32	103	44830					15518	4847	2961	0	1251	3173	666	66164
Rest of Virginia	1760	59750	1546	3015	49826	53449	7623	1949	259	38594	135	13784	33672	26634	130	2427	18960	0	4905	19549	21558	19714	13797	11301	42749	14841	4863	3843	23532	44946	11202	22146	12885	16125	58023	7733	8734	697,412					934,004							2307374
Entry Road																																																		
I64																																							0	14991	561	0								
I77																																							62519	0	0	324								
I81																																							224	0	0	0								
I66 at I81																																							0	328	0	0								
Rest of US	638	159048	852	2009	31852	54895	8807	1832	274	27412	16	18108	23776	29367	35	2964	25283	2560	5348	19218	64199	82799	16623	6847	36733	8775	38117	2271	24728	33139	20722	35563	14574	15348	121514	6475	16104	1,576,693					14,398,897							16934416
Entry Road																																																		
I77 in NC	196	24584	187	957	5248	7826	946	337	37	4822	6	2951	12014	4456	10	554	5751	525	915	6352	29812	9239	2704	1279	5877	3524	5083	0	5024	10881	2426	4093	3281	1666	21227	2412	2787						0	2998440	0	1107824	49085	3787	
I77 in WV	0	0	0	390	0	3661	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5488	0	0	975	0	0	0	6049						2438143	0	0	0	181131	0	
I64 in WV	77	44412	98	0	7807	0	4187	0	34	7060	0	0	0	2832	5	757	0	0	85	0	0	0	0	1364	2002	0	0	0	1021	0	8044	0	0	9251	3	0	0						0	0	0	11548	0	8981	
I81 in WV	42	7791	55	115	1987	2645	1031	213	31	2333	1	1730	1889	2508	0	298	1808	34	992	1294	3716	5577	1135	605	2962	429	3026	72	2453	1852	1464	6796	683	602	9804	278	1135						726154	0	11096	0	749576	0	
I81 in TN	104	18296	14	92	3608	9632	730	148	75	1279	0	3565	1357	3864	0	277	3403	0	724	1989	3456	19721	1026	584	3088	1130	6806	0	7644	6729	5515	5026	3793	736	20956	0	1841						14593	473488	0	3053790	0	158652	
I66 at I495	6	1143	37	69	817	878	126	58	9	606	0	293	530	792	4	62	581	45	1012	345	2009	1347	527	184	1086	223	515	45	783	687	245	8451	178	1670	2340	123	107						549	0	662	0	26244	0	
Total	2624	233762	2729	5574	95728	120280	17649	4239	585	70990	201	37354	68283	61183	190	5865	51990	3013	11361	41738	92827	122910	34196	20545	90003	27736	47112	7104	52967	87189	33829	63043	29682	33600	188313	16338	26705	3,158,383					16063382							21031202

2035 Annual Truck Trip Table for the Interstate 81 Corridor-Concept 3H Toll and Rail Diversion

Origin	Alleghany County , VA	Augusta County , VA	Bath County , VA	Bland County , VA	Botetourt County , VA	Bristol County , VA	Buena Vista County , VA	Clarke County , VA	Clifton Forge County , VA	Covington County , VA	Craig County , VA	Frederick County , VA	Giles County , VA	Harrisonburg County , VA	Highland County , VA	Lexington County , VA	Montgomery County , VA	Norton County , VA	Page County , VA	Pulaski County , VA	Radford County , VA	Roanoke City , VA	Roanoke County , VA	Rockbridge County , VA	Rockingham County , VA	Russell County , VA	Salem City , VA	Scott County , VA	Shenandoah County , VA	Smyth County , VA	Staunton City , VA	Warren County , VA	Washington County , VA	Waynesboro City , VA	Winchester City , VA	Wise County , VA	Wythe County , VA	Rest of Virginia	Exit Road I64	Exit Road I77	Exit Road I81	Exit Road I66 at I81	Rest of US	I77 in NC	I77 in WV	I64 in WV	I81 in WV	I81 in TN	I66 at I495	Total
Alleghany County , VA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	4	0	20	0	0	0	0	0	0	0	17	0	0	0	0	0	10	0	555					1878	445	0	384	328	117	117	2497
Augusta County , VA	0	1900	1	0	37	402	23	0	0	0	0	0	187	0	0	0	175	0	11	0	0	445	181	50	449	12	0	2	0	99	0	0	84	0	0	34	128	31106					96418	13692	0	19254	9283	22738	1574	131744
Bath County , VA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	155					608	67	0	98	90	66	27	770
Bland County , VA	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	17	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	1477					694	411	66	0	27	110	49	2209
Botetourt County , VA	0	721	0	0	2016	326	0	0	12	51	0	213	0	0	0	242	773	0	107	316	0	994	548	0	0	103	468	90	0	313	0	107	0	0	0	168	167	39706					7311	1914	0	1455	284	1162	533	54750
Bristol County , VA	14	1858	69	0	1729	2319	222	16	0	0	0	649	1015	0	0	0	1201	86	203	0	0	2428	838	327	1624	0	0	102	870	1355	396	1164	430	0	0	0	0	101851					42083	5623	2901	0	4057	6422	2087	162852
Buena Vista County , VA	0	17	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	7	0	0	0	0	6	0	0	0	0	0	5430					5135	1081	0	796	729	517	265	10633
Clarke County , VA	0	0	0	0	3	10	0	7	0	0	0	24	0	0	0	0	0	0	0	39	0	0	0	9	0	0	0	3	23	77	0	0	31	0	106	30	8	2753					3902	1122	0	0	342	320	292	7024
Clifton Forge County , VA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	709					290	148	0	29	29	18	6	1003
Covington County , VA	0	0	0	0	93	0	68	0	3	1404	3	0	678	0	0	0	0	32	109	0	0	941	0	60	0	291	0	247	331	0	0	0	0	0	0	409	0	34443					22096	3221	0	6138	2377	2741	1964	61208
Craig County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90					27	12	0	0	3	2	0	118
Frederick County , VA	35	0	73	155	1830	1458	262	178	0	0	0	2376	926	1094	0	127	0	96	107	461	0	0	0	318	0	456	0	2	822	1197	0	1647	83	0	0	81	103	60164					27464	4076	0	3	4517	1267	819	101514
Giles County , VA	0	694	14	0	0	272	0	2	0	370	0	107	1013	0	0	0	82	0	5	0	55	381	0	22	0	15	0	4	122	0	28	0	0	0	0	54	83	11859					11779	6579	0	0	1603	914	337	26961
Harrisonburg County , VA	0	0	0	0	0	0	0	0	0	0	0	27	0	181	0	0	0	4	0	0	0	406	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	9858					21076	3580	0	1607	3337	3100	995	31559
Highland County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	7	0	0	0	0	7	0	0	186					242	157	0	3	10	2	7	445
Lexington County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1858					1673	475	0	210	108	252	197	3545
Montgomery County , VA	0	975	16	0	360	474	36	0	0	0	0	0	194	0	2	0	1116	0	175	0	287	1411	0	138	0	170	0	0	284	497	175	0	425	0	0	0	266	22511					10701	3220	0	0	1009	1547	1007	40212
Norton County , VA	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	4	0	0	0	2	0	0	0	0	0	0	0	0	936					380	356	0	0	19	0	129	1333
Page County , VA	0	60	0	0	17	29	2	0	0	21	0	27	2	0	0	2	68	0	14	44	0	0	0	10	0	0	0	0	0	84	0	48	33	0	0	33	23	11549					7620	1719	0	155	867	1203	1718	19685
Pulaski County , VA	7	0	15	0	815	0	0	8	0	0	0	244	0	0	0	0	0	0	24	369	0	723	0	121	0	0	0	0	312	0	150	0	0	0	0	0	70	33831					40719	5109	0	0	3193	12682	2097	77408
Radford County , VA	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	40	0	0	0	86	92	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	1232					12500	2394	0	0	3728	2992	140	13980
Roanoke City , VA	24	3449	125	327	3346	3081	461	0	34	2538	21	0	1735	2704	16	0	2240	186	0	1332	6634	5504	0	705	2917	999	2484	261	0	2606	0	0	859	983	0	571	698	61114					119920	19035	0	0	24196	11077	4453	227875
Roanoke County , VA	0	1058	0	0	1624	1233	0	0	3	0	0	0	0	0	0	103	0	0	0	0	0	0	467	0	1167	367	0	6	670	1098	325	0	0	0	0	85	93	33726					20586	3748	0	0	2327	1081	902	62610
Rockbridge County , VA	0	219	0	2	0	85	3	7	0	39	0	62	19	0	0	0	151	0	25	92	0	266	0	28	0	37	125	24	70	147	0	0	0	0	0	64	50	23947					8755	2056	0	864	1250	715	711	34217
Rockingham County , VA	0	855	0	0	0	132	8	0	0	0	0	0	0	0	0	0	0	5	0	0	0	422	199	0	704	0	0	11	0	65	0	0	59	115	0	34	22	13061					24656	6580	0	1220	4341	4076	1257	40349
Russell County , VA	0	4	0	0	12	0	0	0	0	1	0	0	609	0	0	0	0	0	0	0	0	1	6	0	0	221	0	0	0	0	0	0	0	0	0	0	0	4087					7026	5067	0	0	230	664	22	11967
Salem City , VA	0	0	0	0	947	0	128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1425	0	207	0	0	1049	0	0	0	0	0	0	0	0	0	0	11040					32772	7445	0	0	4095	5291	1532	47568
Scott County , VA	0	22	0	0	1	5	0	3	0	48	0	0	4	0	0	0	0	0	0	15	0	44	27	5	20	0	0	2	2	33	2	0	16	0	0	0	4	4762					1593	0	0	0	22	0	116	6609
Shenandoah County , VA	0	0	0	0	0	80	0	6	0	108	0	201	9	0	0	0	152	2	0	43	0	0	159	7	0	0	0	3	98	67	0	0	47	0	0	32	7	23694					12722	2309	0	95	1318	3286	936	37437
Smyth County , VA	90	1894	0	0	342	1256	0	105	0	0	26	421	0	0	5	0	1096	19	252	0	0	1764	1076	234	814	0	0	227	394	1310	230	0	0	0	0	415	0	111336					37866	12348	2901	0	1891	7864	1800	161172
Staunton City, VA	0	0	0	0	0	16	0	0	0	0	0	0	2	0	0	0	56	0	0	33	8	0	52	0	0	0	0	2	0	57	4	0	24	0	116	20	6	4515					8140	1349	0	970	1441	680	618	13050
Warren County , VA	57	0	3	0	5	7	5	0	0	0	0	619	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	558	0	0	386	0	3	2913					14422	1020	0	0	4363	732	3952	18997
Washington County , VA	0	552	0	0	0	747	0	11	0	0	0	239	0	0	0	0	266	22	28	0	0	638	0	0	617	204	0	5	343	0	164	571	89	0	0	50	28	31242					14055	3737	1208	0	1374	2790	428	49872
Waynesboro City , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	1199	0	0	0	0	0	0	0	1623	0	0	1490	0	0	0	0	0	0	0	0	676	4566	0	0	77697					31440	5400	0	2741	3863	1971	5111	118691
Winchester City , VA	0	0	15	0	0	0	0	106	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	238	683	0	345	3596	0	0	46974					62398	10772	0	0	10886	11724	2828	114357
Wise County , VA	0	64	0	0	82	0	0	2	0	357	0	23	4002	0	0	0	0	0	2	0	0	95	34	16	60	1047	0	0	34	75	16	0	4	0	0	8	3	17082					2837	1258	0	0	86	0	116	25844
Wythe County , VA	0	621	0	67	792	0	0	8	0	0	0	232	427	0	0	0	319	0	25	220	0	737	177	137	654	196	0	0	330	0	156	547	37	0	0	32	103	44830					15518	4847	2961	0	1251	3173	666	66164
Rest of Virginia	1760	59750	1546	3015	49826	53449	7623	1949	259	38594	135	13784	33672	26634	130	2427	18960	0	4905	19549	21558	19714	13797	11301	42749	14841	4863	3843	23532	44946	11202	22146	12885	16125	58023	7733	8734	697412					934004							2307374
Entry Road																																																		
I64																																							0	14991	561	0								
I77																																							62519	0	0	324								
I81																																							224	0	0	0								
I66 at I81																																							0	328	0	0								
Rest of US	638	159048	852	2009	31852	54895	8795	1832	274	27412	16	18027	23776	29367	35	2959	25283	2560	5328	19218	64199	82765	16623	6847	36733	8770	38083	2271	24728	33135	20689	35519	14574	15341	121477	6475	16104	1576693					11112947							13648150
Entry Road																																																		
I77 in NC	196	24584	187	957	5248	7826	946	337	37	4822	6	2951	12014	4456	10	554	5751	525	915	6352	29812	9239	2704	1279	5877	3524	5083	0	5024	10881	2426	4093	3281	1666	21227	2412	2787						0	2951282	0	728180	49085	3787	
I77 in WV	0	0	0	390	0	3661	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5488	0	0	975	0	0	0	6049						2420587	0	0	0	175578	0	
I64 in WV	77	44412	98	0	7807	0	4187	0	34	7060	0	0	0	2832	5	757	0	0	85	0	0	0	0	1364	2002	0	0	0	1021	0	8044	0	0	9251	3	0	0						0	0	0	11548	0	8981	
I81 in WV	42	7791	55	115	1987	2645	1031	213	31	2333	1	1730	1889	2508	0	298	1808	34	992	1294	3716	5577	1135	605	2962	429	3026	72	2453	1852	1464	6796	683	602	9804	278	1135						504093	0	11096	0	460314	0	
I81 in TN	104	18296	14	92	3608	9632	717	148	75	1279	0	3485	1357	3864	0	272	3403	0	704	1989	3456	19687	1026	584	3088	1125	6773	0	7644	6725	5482	4983	3793	729	20919	0	1841						14593	471141	0	2177169	0	154935	
I66 at I495	6	1143	37	69	817	878	126	58	9	606	0	293	530	792	4	62	581	45	1012	345	2009	1347	527	184	1086	223	515	45	783	687	245	8451	178	1670	2340	123	107						549	0	662	0	23947	0	
Total	2624	233762	2729	5574	95728	120280	17649	4159	585	70990	201	37334	68283	61183	190	5865	51985	3013	11361	41734	92784	122910	34196	20545	90003	27723	47112	7104	52967	87184	33829	63043	29648	33567	188280	16330	26668	3,158,383					12776251							17743754

2035 Annual Truck Trip Table for the Interstate 81 Corridor-Concept 3L Toll and Rail Diversion

Origin	Alleghany County , VA	Augusta County , VA	Bath County , VA	Bland County , VA	Botetourt County , VA	Bristol County , VA	Buena Vista County , VA	Clarke County , VA	Clifton Forge County , VA	Covington County , VA	Craig County , VA	Frederick County , VA	Giles County , VA	Harrisonburg County , VA	Highland County , VA	Lexington County , VA	Montgomery County , VA	Norton County , VA	Page County , VA	Pulaski County , VA	Radford County , VA	Roanoke City , VA	Roanoke County , VA	Rockbridge County , VA	Rockingham County , VA	Russell County , VA	Salem City , VA	Scott County , VA	Shenandoah County , VA	Smyth County , VA	Staunton City , VA	Warren County , VA	Washington County , VA	Waynesboro City , VA	Winchester City , VA	Wise County , VA	Wythe County , VA	Rest of Virginia	Exit Road I64	Exit Road I77	Exit Road I81	Exit Road I66 at I81	Rest of US	I77 in NC	I77 in WV	I64 in WV	I81 in WV	I81 in TN	I66 at I495	Total
Alleghany County , VA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	4	0	20	0	0	0	0	0	0	0	17	0	0	0	0	0	10	0	555					1878	445	0	384	328	117	117	2497
Augusta County , VA	0	1900	1	0	37	402	23	0	0	0	0	0	187	0	0	0	175	0	11	0	0	445	181	50	449	12	0	2	0	99	0	0	84	0	0	34	128	31106					96418	13692	0	19254	9283	22738	1574	131744
Bath County , VA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	155					608	67	0	98	90	66	27	770
Bland County , VA	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	17	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	1477					694	411	66	0	27	110	49	2209
Botetourt County , VA	0	721	0	0	2016	326	0	0	12	51	0	213	0	0	0	242	773	0	107	316	0	994	548	0	0	103	468	90	0	313	0	107	0	0	0	168	167	39706					7311	1914	0	1455	284	1162	533	54750
Bristol County , VA	14	1858	69	0	1729	2319	222	16	0	0	0	649	1015	0	0	0	1201	86	203	0	0	2428	838	327	1624	0	0	102	870	1355	396	1164	430	0	0	0	0	101851					42083	5623	2901	0	4057	6422	2087	162852
Buena Vista County , VA	0	17	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	7	0	0	0	0	6	0	0	0	0	0	5430					5135	1081	0	796	729	517	265	10633
Clarke County , VA	0	0	0	0	3	10	0	7	0	0	0	24	0	0	0	0	0	0	0	39	0	0	0	9	0	0	0	3	23	77	0	0	31	0	106	30	8	2753					3902	1122	0	0	342	320	292	7024
Clifton Forge County , VA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	709					290	148	0	29	29	18	6	1003
Covington County , VA	0	0	0	0	93	0	68	0	3	1404	3	0	678	0	0	0	0	32	109	0	0	941	0	60	0	291	0	247	331	0	0	0	0	0	0	409	0	34443					22096	3221	0	6138	2377	2741	1964	61208
Craig County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90					27	12	0	0	3	2	0	118
Frederick County , VA	35	0	73	155	1830	1458	262	178	0	0	0	2376	926	1094	0	127	0	96	107	461	0	0	0	318	0	456	0	2	822	1197	0	1647	83	0	0	81	103	60164					27464	4076	0	3	4517	1267	819	101514
Giles County , VA	0	694	14	0	0	272	0	2	0	370	0	107	1013	0	0	0	82	0	5	0	55	381	0	22	0	15	0	4	122	0	28	0	0	0	0	54	83	11859					11779	6579	0	0	1603	914	337	26961
Harrisonburg County , VA	0	0	0	0	0	0	0	0	0	0	0	27	0	181	0	0	0	4	0	0	0	406	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	9858					21076	3580	0	1607	3337	3100	995	31559
Highland County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	7	0	0	0	0	7	0	0	186					242	157	0	3	10	2	7	445
Lexington County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1858					1673	475	0	210	108	252	197	3545
Montgomery County , VA	0	975	16	0	360	474	36	0	0	0	0	0	194	0	2	0	1116	0	175	0	287	1411	0	138	0	170	0	0	284	497	175	0	425	0	0	0	266	22511					10701	3220	0	0	1009	1547	1007	40212
Norton County , VA	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	4	0	0	0	2	0	0	0	0	0	0	0	0	936					380	356	0	0	19	0	129	1333
Page County , VA	0	60	0	0	17	29	2	0	0	21	0	27	2	0	0	2	68	0	14	44	0	0	0	10	0	0	0	0	0	84	0	48	33	0	0	33	23	11549					7620	1719	0	155	867	1203	1718	19685
Pulaski County , VA	7	0	15	0	815	0	0	8	0	0	0	244	0	0	0	0	0	0	24	369	0	723	0	121	0	0	0	0	312	0	150	0	0	0	0	0	70	33831					40719	5109	0	0	3193	12682	2097	77408
Radford County , VA	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	40	0	0	0	86	92	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	1232					12500	2394	0	0	3728	2992	140	13980
Roanoke City , VA	24	3449	125	327	3346	3081	461	0	34	2538	21	0	1735	2704	16	0	2240	186	0	1332	6634	5504	0	705	2917	999	2484	261	0	2606	0	0	859	983	0	571	698	61114					119920	19035	0	0	24196	11077	4453	227875
Roanoke County , VA	0	1058	0	0	1624	1233	0	0	3	0	0	0	0	0	0	103	0	0	0	0	0	0	467	0	1167	367	0	6	670	1098	325	0	0	0	0	85	93	33726					20586	3748	0	0	2327	1081	902	62610
Rockbridge County , VA	0	219	0	2	0	85	3	7	0	39	0	62	19	0	0	0	151	0	25	92	0	266	0	28	0	37	125	24	70	147	0	0	0	0	0	64	50	23947					8755	2056	0	864	1250	715	711	34217
Rockingham County , VA	0	855	0	0	0	132	8	0	0	0	0	0	0	0	0	0	0	5	0	0	0	422	199	0	704	0	0	11	0	65	0	0	59	115	0	34	22	13061					24656	6580	0	1220	4341	4076	1257	40349
Russell County , VA	0	4	0	0	12	0	0	0	0	1	0	0	609	0	0	0	0	0	0	0	0	1	6	0	0	221	0	0	0	0	0	0	0	0	0	0	0	4087					7026	5067	0	0	230	664	22	11967
Salem City , VA	0	0	0	0	947	0	128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1425	0	207	0	0	1049	0	0	0	0	0	0	0	0	0	0	11040					32772	7445	0	0	4095	5291	1532	47568
Scott County , VA	0	22	0	0	1	5	0	3	0	48	0	0	4	0	0	0	0	0	0	15	0	44	27	5	20	0	0	2	2	33	2	0	16	0	0	0	4	4762					1593	0	0	0	22	0	116	6609
Shenandoah County , VA	0	0	0	0	0	80	0	6	0	108	0	201	9	0	0	0	152	2	0	43	0	0	159	7	0	0	0	3	98	67	0	0	47	0	0	32	7	23694					12722	2309	0	95	1318	3286	936	37437
Smyth County , VA	90	1894	0	0	342	1256	0	105	0	0	26	421	0	0	5	0	1096	19	252	0	0	1764	1076	234	814	0	0	227	394	1310	230	0	0	0	0	415	0	111336					37866	12348	2901	0	1891	7864	1800	161172
Staunton City, VA	0	0	0	0	0	16	0	0	0	0	0	0	2	0	0	0	56	0	0	33	8	0	52	0	0	0	0	2	0	57	4	0	24	0	116	20	6	4515					8140	1349	0	970	1441	680	618	13050
Warren County , VA	57	0	3	0	5	7	5	0	0	0	0	619	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	558	0	0	386	0	3	2913					14422	1020	0	0	4363	732	3952	18997
Washington County , VA	0	552	0	0	0	747	0	11	0	0	0	239	0	0	0	0	266	22	28	0	0	638	0	0	617	204	0	5	343	0	164	571	89	0	0	50	28	31242					14055	3737	1208	0	1374	2790	428	49872
Waynesboro City , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	1199	0	0	0	0	0	0	0	1623	0	0	1490	0	0	0	0	0	0	0	0	676	4566	0	0	77697					31440	5400	0	2741	3863	1971	5111	118691
Winchester City , VA	0	0	15	0	0	0	0	106	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	238	683	0	345	3596	0	0	46974					62398	10772	0	0	10886	11724	2828	114357
Wise County , VA	0	64	0	0	82	0	0	2	0	357	0	23	4002	0	0	0	0	0	2	0	0	95	34	16	60	1047	0	0	34	75	16	0	4	0	0	8	3	17082					2837	1258	0	0	86	0	116	25844
Wythe County , VA	0	621	0	67	792	0	0	8	0	0	0	232	427	0	0	0	319	0	25	220	0	737	177	137	654	196	0	0	330	0	156	547	37	0	0	32	103	44830					15518	4847	2961	0	1251	3173	666	66164
Rest of Virginia	1760	59750	1546	3015	49826	53449	7623	1949	259	38594	135	13784	33672	26634	130	2427	18960	0	4905	19549	21558	19714	13797	11301	42749	14841	4863	3843	23532	44946	11202	22146	12885	16125	58023	7733	8734	697412					934004							2307374
Entry Road																																																		
I64																																							0	14991	561	0								
I77																																							62519	0	0	324								
I81																																							224	0	0	0								
I66 at I81																																							0	328	0	0								
Rest of US	638	159048	852	2009	31852	54895	8795	1832	274	27412	16	18027	23776	29367	35	2959	25283	2560	5328	19218	64199	82765	16623	6847	36733	8770	38083	2271	24728	33135	20689	35519	14574	15341	121477	6475	16104	1576693					13391512							15926715
Entry Road																																																		
I77 in NC	196	24584	187	957	5248	7826	946	337	37	4822	6	2951	12014	4456	10	554	5751	525	915	6352	29812	9239	2704	1279	5877	3524	5083	0	5024	10881	2426	4093	3281	1666	21227	2412	2787						0	2974821	0	953039	49085	3787	
I77 in WV	0	0	0	390	0	3661	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5488	0	0	975	0	0	0	6049						2425349	0	0	0	179730	0	
I64 in WV	77	44412	98	0	7807	0	4187	0	34	7060	0	0	0	2832	5	757	0	0	85	0	0	0	0	1364	2002	0	0	0	1021	0	8044	0	0	9251	3	0	0						0	0	0	11548	0	8981	
I81 in WV	42	7791	55	115	1987	2645	1031	213	31	2333	1	1730	1889	2508	0	298	1808	34	992	1294	3716	5577	1135	605	2962	429	3026	72	2453	1852	1464	6796	683	602	9804	278	1135						628454	0	11096	0	687479	0	
I81 in TN	104	18296	14	92	3608	9632	717	148	75	1279	0	3485	1357	3864	0	272	3403	0	704	1989	3456	19687	1026	584	3088	1125	6773	0	7644	6725	5482	4983	3793	729	20919	0	1841						14593	472430	0	2759120	0	158592	
I66 at I495	6	1143	37	69	817	878	126	58	9	606	0	293	530	792	4	62	581	45	1012	345	2009	1347	527	184	1086	223	515	45	783	687	245	8451	178	1670	2340	123	107						549	0	662	0	26197	0	
Total	2624	233762	2729	5574	95728	120280	17649	4159	585	70990	201	37334	68283	61183	190	5865	51985	3013	11361	41734	92784	122910	34196	20545	90003	27723	47112	7104	52967	87184	33829	63043	29648	33567	188280	16330	26668	3,158,383					15054816							20022319

2035 Annual Truck Trip Table for the Interstate 81 Corridor-Concept 4H Toll and Rail Diversion

Origin	Alleghany County , VA	Augusta County , VA	Bath County , VA	Bland County , VA	Botetourt County , VA	Bristol County , VA	Buena Vista County , VA	Clarke County , VA	Clifton Forge County , VA	Covington County , VA	Craig County , VA	Frederick County , VA	Giles County , VA	Harrisonburg County , VA	Highland County , VA	Lexington County , VA	Montgomery County , VA	Norton County , VA	Page County , VA	Pulaski County , VA	Radford County , VA	Roanoke City , VA	Roanoke County , VA	Rockbridge County , VA	Rockingham County , VA	Russell County , VA	Salem City , VA	Scott County , VA	Shenandoah County , VA	Smyth County , VA	Staunton City , VA	Warren County , VA	Washington County , VA	Waynesboro City , VA	Winchester City , VA	Wise County , VA	Wythe County , VA	Rest of Virginia	Exit Road I64	Exit Road I77	Exit Road I81	Exit Road I66 at I81	Rest of US	I77 in NC	I77 in WV	I64 in WV	I81 in WV	I81 in TN	I66 at I495	Total
Alleghany County , VA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	4	0	20	0	0	0	0	0	0	0	17	0	0	0	0	0	10	0	555					1824	445	0	330	328	117	117	2444
Augusta County , VA	0	1900	1	0	37	402	23	0	0	0	0	0	187	0	0	0	175	0	11	0	0	445	181	50	449	12	0	2	0	99	0	0	84	0	0	34	128	31106					95352	13692	0	18672	9283	22255	1574	130678
Bath County , VA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	155					608	67	0	98	90	66	27	770
Bland County , VA	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	17	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	1477					682	411	54	0	27	110	49	2197
Botetourt County , VA	0	721	0	0	2016	326	0	0	12	51	0	213	0	0	0	242	773	0	107	316	0	994	548	0	0	103	468	90	0	313	0	107	0	0	0	168	167	39706					6969	1914	0	1407	284	869	533	54409
Bristol County , VA	14	1858	69	0	1729	2319	222	16	0	0	0	649	1015	0	0	0	1201	86	203	0	0	2428	838	327	1624	0	0	102	870	1355	396	1164	430	0	0	0	0	101851					42083	5623	2901	0	4057	6422	2087	162852
Buena Vista County , VA	0	17	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	7	0	0	0	0	6	0	0	0	0	0	5430					5082	1081	0	792	729	468	265	10580
Clarke County , VA	0	0	0	0	3	10	0	7	0	0	0	24	0	0	0	0	0	0	0	39	0	0	0	9	0	0	0	3	23	77	0	0	31	0	106	30	8	2753					3873	1122	0	0	342	291	292	6995
Clifton Forge County , VA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	709					290	148	0	29	29	18	6	1003
Covington County , VA	0	0	0	0	93	0	68	0	3	1404	3	0	678	0	0	0	0	32	109	0	0	941	0	60	0	291	0	247	331	0	0	0	0	0	0	409	0	34443					22071	3221	0	6112	2377	2741	1964	61183
Craig County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90					27	12	0	0	3	2	0	118
Frederick County , VA	35	0	73	155	1830	1458	262	178	0	0	0	2376	926	1094	0	127	0	96	107	461	0	0	0	318	0	456	0	2	822	1197	0	1647	83	0	0	81	103	60164					27291	4076	0	3	4517	1094	819	101341
Giles County , VA	0	694	14	0	0	272	0	2	0	370	0	107	1013	0	0	0	82	0	5	0	55	381	0	22	0	15	0	4	122	0	28	0	0	0	0	54	83	11859					11771	6579	0	0	1603	907	337	26954
Harrisonburg County , VA	0	0	0	0	0	0	0	0	0	0	0	27	0	181	0	0	0	4	0	0	0	406	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	9858					20409	3580	0	1178	3337	2864	995	30893
Highland County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	7	0	0	0	0	7	0	0	186					242	157	0	3	10	2	7	445
Lexington County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1858					1651	475	0	207	108	234	197	3524
Montgomery County , VA	0	975	16	0	360	474	36	0	0	0	0	0	194	0	2	0	1116	0	175	0	287	1411	0	138	0	170	0	0	284	497	175	0	425	0	0	0	266	22511					10361	3220	0	0	1009	1207	1007	39872
Norton County , VA	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	4	0	0	0	2	0	0	0	0	0	0	0	0	936					380	356	0	0	19	0	129	1333
Page County , VA	0	60	0	0	17	29	2	0	0	21	0	27	2	0	0	2	68	0	14	44	0	0	0	10	0	0	0	0	0	84	0	48	33	0	0	33	23	11549					7545	1719	0	155	867	1129	1718	19611
Pulaski County , VA	7	0	15	0	815	0	0	8	0	0	0	244	0	0	0	0	0	0	24	369	0	723	0	121	0	0	0	0	312	0	150	0	0	0	0	0	70	33831					40532	5109	0	0	3193	12495	2097	77221
Radford County , VA	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	40	0	0	0	86	92	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	1232					12389	2394	0	0	3728	2881	140	13869
Roanoke City , VA	24	3449	125	327	3346	3081	461	0	34	2538	21	0	1735	2704	16	0	2240	186	0	1332	6634	5504	0	705	2917	999	2484	261	0	2606	0	0	859	983	0	571	698	61114					119453	19035	0	0	24196	10611	4453	227408
Roanoke County , VA	0	1058	0	0	1624	1233	0	0	3	0	0	0	0	0	0	103	0	0	0	0	0	0	467	0	1167	367	0	6	670	1098	325	0	0	0	0	85	93	33726					20446	3748	0	0	2327	940	902	62470
Rockbridge County , VA	0	219	0	2	0	85	3	7	0	39	0	62	19	0	0	0	151	0	25	92	0	266	0	28	0	37	125	24	70	147	0	0	0	0	0	64	50	23947					8742	2056	0	864	1250	702	711	34204
Rockingham County , VA	0	855	0	0	0	132	8	0	0	0	0	0	0	0	0	0	0	5	0	0	0	422	199	0	704	0	0	11	0	65	0	0	59	115	0	34	22	13061					24358	6580	0	1112	4341	3886	1257	40051
Russell County , VA	0	4	0	0	12	0	0	0	0	1	0	0	609	0	0	0	0	0	0	0	0	1	6	0	0	221	0	0	0	0	0	0	0	0	0	0	0	4087					7004	5067	0	0	230	643	22	11945
Salem City , VA	0	0	0	0	947	0	128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1425	0	207	0	0	1049	0	0	0	0	0	0	0	0	0	0	11040					32267	7445	0	0	4095	4786	1532	47063
Scott County , VA	0	22	0	0	1	5	0	3	0	48	0	0	4	0	0	0	0	0	0	15	0	44	27	5	20	0	0	2	2	33	2	0	16	0	0	0	4	4762					1593	0	0	0	22	0	116	6609
Shenandoah County , VA	0	0	0	0	0	80	0	6	0	108	0	201	9	0	0	0	152	2	0	43	0	0	159	7	0	0	0	3	98	67	0	0	47	0	0	32	7	23694					12465	2309	0	95	1318	3029	936	37180
Smyth County , VA	90	1894	0	0	342	1256	0	105	0	0	26	421	0	0	5	0	1096	19	252	0	0	1764	1076	234	814	0	0	227	394	1310	230	0	0	0	0	415	0	111336					37578	12348	2901	0	1891	7576	1800	160884
Staunton City, VA	0	0	0	0	0	16	0	0	0	0	0	0	2	0	0	0	56	0	0	33	8	0	52	0	0	0	0	2	0	57	4	0	24	0	116	20	6	4515					8075	1349	0	956	1441	629	618	12986
Warren County , VA	57	0	3	0	5	7	5	0	0	0	0	619	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	558	0	0	386	0	3	2913					14386	1020	0	0	4363	695	3952	18961
Washington County , VA	0	552	0	0	0	747	0	11	0	0	0	239	0	0	0	0	266	22	28	0	0	638	0	0	617	204	0	5	343	0	164	571	89	0	0	50	28	31242					14023	3737	1208	0	1374	2759	428	49841
Waynesboro City , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	1199	0	0	0	0	0	0	0	1623	0	0	1490	0	0	0	0	0	0	0	0	676	4566	0	0	77697					31374	5400	0	2716	3863	1929	5111	118625
Winchester City , VA	0	0	15	0	0	0	0	106	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	238	683	0	345	3596	0	0	46974					61449	10772	0	0	10886	10775	2828	113408
Wise County , VA	0	64	0	0	82	0	0	2	0	357	0	23	4002	0	0	0	0	0	2	0	0	95	34	16	60	1047	0	0	34	75	16	0	4	0	0	8	3	17082					2837	1258	0	0	86	0	116	25844
Wythe County , VA	0	621	0	67	792	0	0	8	0	0	0	232	427	0	0	0	319	0	25	220	0	737	177	137	654	196	0	0	330	0	156	547	37	0	0	32	103	44830					15361	4847	2951	0	1251	3026	666	66007
Rest of Virginia	1760	59750	1546	3015	49826	53449	7623	1949	259	38594	135	13784	33672	26634	130	2427	18960	0	4905	19549	21558	19714	13797	11301	42749	14841	4863	3843	23532	44946	11202	22146	12885	16125	58023	7733	8734	697412					934004							2307374
Entry Road																																																		
I64																																							0	14991	561	0								
I77																																							62519	0	0	324								
I81																																							224	0	0	0								
I66 at I81																																							0	328	0	0								
Rest of US	638	158316	852	2009	31766	54895	8775	1816	274	27371	16	17896	23765	29240	35	2959	25124	2560	5294	19140	64087	81409	16567	6830	36627	8767	37764	2271	24677	33038	19763	34952	14561	15269	121221	6475	16037	1576693					11084930							13615145
Entry Road																																																		
I77 in NC	196	24584	187	957	5248	7826	946	337	37	4822	6	2951	12014	4456	10	554	5751	525	915	6352	29812	9239	2704	1279	5877	3524	5083	0	5024	10881	2426	4093	3281	1666	21227	2412	2787						0	2948432	0	728180	49085	3787	
I77 in WV	0	0	0	390	0	3661	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5488	0	0	975	0	0	0	6006						2416951	0	0	0	175578	0	
I64 in WV	77	44241	98	0	7795	0	4180	0	34	7018	0	0	0	2800	5	757	0	0	85	0	0	0	0	1355	1974	0	0	0	1021	0	7983	0	0	9235	3	0	0						0	0	0	11548	0	8981	
I81 in WV	42	7791	55	115	1987	2645	1031	213	31	2333	1	1730	1889	2508	0	298	1808	34	992	1294	3716	5577	1135	605	2962	429	3026	72	2453	1852	1464	6796	683	602	9804	278	1135						504093	0	11096	0	459938	0	
I81 in TN	104	17736	14	92	3534	9632	705	132	75	1279	0	3353	1345	3767	0	272	3244	0	670	1911	3343	18331	970	576	3009	1122	6454	0	7592	6628	4618	4415	3781	673	20663	0	1818						14593	471141	0	2160488	0	154841	
I66 at I495	6	1143	37	69	817	878	126	58	9	606	0	293	530	792	4	62	581	45	1012	345	2009	1347	527	184	1086	223	515	45	783	687	245	8451	178	1670	2340	123	107						549	0	662	0	23947	0	
Total	2624	233031	2729	5574	95642	120265	17649	4091	573	70990	201	37301	68205	61126	184	5759	51981	3013	11309	41638	92216	122897	34196	20522	90003	27710	47112	7104	52839	87184	33829	62930	28292	33248	187413	16338	26412	3,158,383					12741779							17704293

2035 Annual Truck Trip Table for the Interstate 81 Corridor-Concept 4L Toll and Rail Diversion

Origin	Alleghany County , VA	Augusta County , VA	Bath County , VA	Bland County , VA	Botetourt County , VA	Bristol County , VA	Buena Vista County , VA	Clarke County , VA	Clifton Forge County , VA	Covington County , VA	Craig County , VA	Frederick County , VA	Giles County , VA	Harrisonburg County , VA	Highland County , VA	Lexington County , VA	Montgomery County , VA	Norton County , VA	Page County , VA	Pulaski County , VA	Radford County , VA	Roanoke City , VA	Roanoke County , VA	Rockbridge County , VA	Rockingham County , VA	Russell County , VA	Salem City , VA	Scott County , VA	Shenandoah County , VA	Smyth County , VA	Staunton City , VA	Warren County , VA	Washington County , VA	Waynesboro City , VA	Winchester City , VA	Wise County , VA	Wythe County , VA	Rest of Virginia	Exit Road I64	Exit Road I77	Exit Road I81	Exit Road I66 at I81	Rest of US	I77 in NC	I77 in WV	I64 in WV	I81 in WV	I81 in TN	I66 at I495	Total
Alleghany County , VA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	4	0	20	0	0	0	0	0	0	0	17	0	0	0	0	0	10	0	555					1824	445	0	330	328	117	117	2444
Augusta County , VA	0	1900	1	0	37	402	23	0	0	0	0	0	187	0	0	0	175	0	11	0	0	445	181	50	449	12	0	2	0	99	0	0	84	0	0	34	128	31106					95352	13692	0	18672	9283	22255	1574	130678
Bath County , VA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	155					608	67	0	98	90	66	27	770
Bland County , VA	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	17	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	1477					682	411	54	0	27	110	49	2197
Botetourt County , VA	0	721	0	0	2016	326	0	0	12	51	0	213	0	0	0	242	773	0	107	316	0	994	548	0	0	103	468	90	0	313	0	107	0	0	0	168	167	39706					6969	1914	0	1407	284	869	533	54409
Bristol County , VA	14	1858	69	0	1729	2319	222	16	0	0	0	649	1015	0	0	0	1201	86	203	0	0	2428	838	327	1624	0	0	102	870	1355	396	1164	430	0	0	0	0	101851					42083	5623	2901	0	4057	6422	2087	162852
Buena Vista County , VA	0	17	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	7	0	0	0	0	6	0	0	0	0	0	5430					5082	1081	0	792	729	468	265	10580
Clarke County , VA	0	0	0	0	3	10	0	7	0	0	0	24	0	0	0	0	0	0	0	39	0	0	0	9	0	0	0	3	23	77	0	0	31	0	106	30	8	2753					3873	1122	0	0	342	291	292	6995
Clifton Forge County , VA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	709					290	148	0	29	29	18	6	1003
Covington County , VA	0	0	0	0	93	0	68	0	3	1404	3	0	678	0	0	0	0	32	109	0	0	941	0	60	0	291	0	247	331	0	0	0	0	0	0	409	0	34443					22071	3221	0	6112	2377	2741	1964	61183
Craig County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90					27	12	0	0	3	2	0	118
Frederick County , VA	35	0	73	155	1830	1458	262	178	0	0	0	2376	926	1094	0	127	0	96	107	461	0	0	0	318	0	456	0	2	822	1197	0	1647	83	0	0	81	103	60164					27291	4076	0	3	4517	1094	819	101341
Giles County , VA	0	694	14	0	0	272	0	2	0	370	0	107	1013	0	0	0	82	0	5	0	55	381	0	22	0	15	0	4	122	0	28	0	0	0	0	54	83	11859					11771	6579	0	0	1603	907	337	26954
Harrisonburg County , VA	0	0	0	0	0	0	0	0	0	0	0	27	0	181	0	0	0	4	0	0	0	406	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	9858					20409	3580	0	1178	3337	2864	995	30893
Highland County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	7	0	0	0	0	7	0	0	186					242	157	0	3	10	2	7	445
Lexington County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1858					1651	475	0	207	108	234	197	3524
Montgomery County , VA	0	975	16	0	360	474	36	0	0	0	0	0	194	0	2	0	1116	0	175	0	287	1411	0	138	0	170	0	0	284	497	175	0	425	0	0	0	266	22511					10361	3220	0	0	1009	1207	1007	39872
Norton County , VA	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	4	0	0	0	2	0	0	0	0	0	0	0	0	936					380	356	0	0	19	0	129	1333
Page County , VA	0	60	0	0	17	29	2	0	0	21	0	27	2	0	0	2	68	0	14	44	0	0	0	10	0	0	0	0	0	84	0	48	33	0	0	33	23	11549					7545	1719	0	155	867	1129	1718	19611
Pulaski County , VA	7	0	15	0	815	0	0	8	0	0	0	244	0	0	0	0	0	0	24	369	0	723	0	121	0	0	0	0	312	0	150	0	0	0	0	0	70	33831					40532	5109	0	0	3193	12495	2097	77221
Radford County , VA	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	40	0	0	0	86	92	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	1232					12389	2394	0	0	3728	2881	140	13869
Roanoke City , VA	24	3449	125	327	3346	3081	461	0	34	2538	21	0	1735	2704	16	0	2240	186	0	1332	6634	5504	0	705	2917	999	2484	261	0	2606	0	0	859	983	0	571	698	61114					119453	19035	0	0	24196	10611	4453	227408
Roanoke County , VA	0	1058	0	0	1624	1233	0	0	3	0	0	0	0	0	0	103	0	0	0	0	0	0	467	0	1167	367	0	6	670	1098	325	0	0	0	0	85	93	33726					20446	3748	0	0	2327	940	902	62470
Rockbridge County , VA	0	219	0	2	0	85	3	7	0	39	0	62	19	0	0	0	151	0	25	92	0	266	0	28	0	37	125	24	70	147	0	0	0	0	0	64	50	23947					8742	2056	0	864	1250	702	711	34204
Rockingham County , VA	0	855	0	0	0	132	8	0	0	0	0	0	0	0	0	0	0	5	0	0	0	422	199	0	704	0	0	11	0	65	0	0	59	115	0	34	22	13061					24358	6580	0	1112	4341	3886	1257	40051
Russell County , VA	0	4	0	0	12	0	0	0	0	1	0	0	609	0	0	0	0	0	0	0	0	1	6	0	0	221	0	0	0	0	0	0	0	0	0	0	0	4087					7004	5067	0	0	230	643	22	11945
Salem City , VA	0	0	0	0	947	0	128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1425	0	207	0	0	1049	0	0	0	0	0	0	0	0	0	0	11040					32267	7445	0	0	4095	4786	1532	47063
Scott County , VA	0	22	0	0	1	5	0	3	0	48	0	0	4	0	0	0	0	0	0	15	0	44	27	5	20	0	0	2	2	33	2	0	16	0	0	0	4	4762					1593	0	0	0	22	0	116	6609
Shenandoah County , VA	0	0	0	0	0	80	0	6	0	108	0	201	9	0	0	0	152	2	0	43	0	0	159	7	0	0	0	3	98	67	0	0	47	0	0	32	7	23694					12465	2309	0	95	1318	3029	936	37180
Smyth County , VA	90	1894	0	0	342	1256	0	105	0	0	26	421	0	0	5	0	1096	19	252	0	0	1764	1076	234	814	0	0	227	394	1310	230	0	0	0	0	415	0	111336					37578	12348	2901	0	1891	7576	1800	160884
Staunton City, VA	0	0	0	0	0	16	0	0	0	0	0	0	2	0	0	0	56	0	0	33	8	0	52	0	0	0	0	2	0	57	4	0	24	0	116	20	6	4515					8075	1349	0	956	1441	629	618	12986
Warren County , VA	57	0	3	0	5	7	5	0	0	0	0	619	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	558	0	0	386	0	3	2913					14386	1020	0	0	4363	695	3952	18961
Washington County , VA	0	552	0	0	0	747	0	11	0	0	0	239	0	0	0	0	266	22	28	0	0	638	0	0	617	204	0	5	343	0	164	571	89	0	0	50	28	31242					14023	3737	1208	0	1374	2759	428	49841
Waynesboro City , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	1199	0	0	0	0	0	0	0	1623	0	0	1490	0	0	0	0	0	0	0	0	676	4566	0	0	77697					31374	5400	0	2716	3863	1929	5111	118625
Winchester City , VA	0	0	15	0	0	0	0	106	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	238	683	0	345	3596	0	0	46974					61449	10772	0	0	10886	10775	2828	113408
Wise County , VA	0	64	0	0	82	0	0	2	0	357	0	23	4002	0	0	0	0	0	2	0	0	95	34	16	60	1047	0	0	34	75	16	0	4	0	0	8	3	17082					2837	1258	0	0	86	0	116	25844
Wythe County , VA	0	621	0	67	792	0	0	8	0	0	0	232	427	0	0	0	319	0	25	220	0	737	177	137	654	196	0	0	330	0	156	547	37	0	0	32	103	44830					15361	4847	2951	0	1251	3026	666	66007
Rest of Virginia	1760	59750	1546	3015	49826	53449	7623	1949	259	38594	135	13784	33672	26634	130	2427	18960	0	4905	19549	21558	19714	13797	11301	42749	14841	4863	3843	23532	44946	11202	22146	12885	16125	58023	7733	8734	697412					934004							2307374
Entry Road																																																		
I64																																							0	14991	561	0								
I77																																							62519	0	0	324								
I81																																							224	0	0	0								
I66 at I81																																							0	328	0	0								
Rest of US	638	158316	852	2009	31766	54895	8775	1816	274	27371	16	17896	23765	29240	35	2959	25124	2560	5294	19140	64087	81409	16567	6830	36627	8767	37764	2271	24677	33038	19763	34952	14561	15269	121221	6475	16037	1576693					13364320							15894535
Entry Road																																																		
I77 in NC	196	24584	187	957	5248	7826	946	337	37	4822	6	2951	12014	4456	10	554	5751	525	915	6352	29812	9239	2704	1279	5877	3524	5083	0	5024	10881	2426	4093	3281	1666	21227	2412	2787						0	2972745	0	953039	49085	3787	
I77 in WV	0	0	0	390	0	3661	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5488	0	0	975	0	0	0	6006						2421713	0	0	0	179730	0	
I64 in WV	77	44241	98	0	7795	0	4180	0	34	7018	0	0	0	2800	5	757	0	0	85	0	0	0	0	1355	1974	0	0	0	1021	0	7983	0	0	9235	3	0	0						0	0	0	11548	0	8981	
I81 in WV	42	7791	55	115	1987	2645	1031	213	31	2333	1	1730	1889	2508	0	298	1808	34	992	1294	3716	5577	1135	605	2962	429	3026	72	2453	1852	1464	6796	683	602	9804	278	1135						628454	0	11096	0	687103	0	
I81 in TN	104	17736	14	92	3534	9632	705	132	75	1279	0	3353	1345	3767	0	272	3244	0	670	1911	3343	18331	970	576	3009	1122	6454	0	7592	6628	4618	4415	3781	673	20663	0	1818						14593	472430	0	2742439	0	158498	
I66 at I495	6	1143	37	69	817	878	126	58	9	606	0	293	530	792	4	62	581	45	1012	345	2009	1347	527	184	1086	223	515	45	783	687	245	8451	178	1670	2340	123	107						549	0	662	0	26197	0	
Total	2624	233031	2729	5574	95642	120265	17649	4091	573	70990	201	37301	68205	61126	184	5759	51981	3013	11309	41638	92216	122897	34196	20522	90003	27710	47112	7104	52839	87184	33829	62930	28292	33248	187413	16338	26412	3,158,383					15021169							19983683

2035 Annual Truck Trip Table for the Interstate 81 Corridor-Concept 5H Toll and Rail Diversion

Origin	Alleghany County , VA	Augusta County , VA	Bath County , VA	Bland County , VA	Botetourt County , VA	Bristol County , VA	Buena Vista County , VA	Clarke County , VA	Clifton Forge County , VA	Covington County , VA	Craig County , VA	Frederick County , VA	Giles County , VA	Harrisonburg County , VA	Highland County , VA	Lexington County , VA	Montgomery County , VA	Norton County , VA	Page County , VA	Pulaski County , VA	Radford County , VA	Roanoke City , VA	Roanoke County , VA	Rockbridge County , VA	Rockingham County , VA	Russell County , VA	Salem City , VA	Scott County , VA	Shenandoah County , VA	Smyth County , VA	Staunton City , VA	Warren County , VA	Washington County , VA	Waynesboro City , VA	Winchester City , VA	Wise County , VA	Wythe County , VA	Rest of Virginia	Exit Road I64	Exit Road I77	Exit Road I81	Exit Road I66 at I81	Rest of US	I77 in NC	I77 in WV	I64 in WV	I81 in WV	I81 in TN	I66 at I495	Total
Alleghany County , VA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	4	0	20	0	0	0	0	0	0	0	17	0	0	0	0	0	10	0	555					1831	445	0	337	328	117	117	2450
Augusta County , VA	0	1900	1	0	37	402	23	0	0	0	0	0	187	0	0	0	175	0	11	0	0	445	181	50	449	12	0	2	0	99	0	0	84	0	0	34	128	31106					95482	13692	0	18741	9283	22316	1574	130808
Bath County , VA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	155					608	67	0	98	90	66	27	770
Bland County , VA	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	17	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	1477					683	411	55	0	27	110	49	2198
Botetourt County , VA	0	721	0	0	2016	326	0	0	12	51	0	213	0	0	0	242	773	0	107	316	0	994	548	0	0	103	468	90	0	313	0	107	0	0	0	168	167	39706					7010	1914	0	1412	284	903	533	54449
Bristol County , VA	14	1858	69	0	1729	2319	222	16	0	0	0	649	1015	0	0	0	1201	86	203	0	0	2428	838	327	1624	0	0	102	870	1355	396	1164	430	0	0	0	0	101851					42083	5623	2901	0	4057	6422	2087	162852
Buena Vista County , VA	0	17	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	7	0	0	0	0	6	0	0	0	0	0	5430					5090	1081	0	793	729	475	265	10588
Clarke County , VA	0	0	0	0	3	10	0	7	0	0	0	24	0	0	0	0	0	0	0	39	0	0	0	9	0	0	0	3	23	77	0	0	31	0	106	30	8	2753					3876	1122	0	0	342	294	292	6998
Clifton Forge County , VA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	709					290	148	0	29	29	18	6	1003
Covington County , VA	0	0	0	0	93	0	68	0	3	1404	3	0	678	0	0	0	0	32	109	0	0	941	0	60	0	291	0	247	331	0	0	0	0	0	0	409	0	34443					22077	3221	0	6118	2377	2741	1964	61188
Craig County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90					29	12	0	0	3	3	0	119
Frederick County , VA	35	0	73	155	1830	1458	262	178	0	0	0	2376	926	1094	0	127	0	96	107	461	0	0	0	318	0	456	0	2	822	1197	0	1647	83	0	0	81	103	60164					27311	4076	0	3	4517	1114	819	101361
Giles County , VA	0	694	14	0	0	272	0	2	0	370	0	107	1013	0	0	0	82	0	5	0	55	381	0	22	0	15	0	4	122	0	28	0	0	0	0	54	83	11859					11774	6579	0	0	1603	910	337	26957
Harrisonburg County , VA	0	0	0	0	0	0	0	0	0	0	0	27	0	181	0	0	0	4	0	0	0	406	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	9858					20489	3580	0	1229	3337	2892	995	30973
Highland County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	7	0	0	0	0	7	0	0	186					242	157	0	3	10	2	7	445
Lexington County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1858					1654	475	0	207	108	236	197	3526
Montgomery County , VA	0	975	16	0	360	474	36	0	0	0	0	0	194	0	2	0	1116	0	175	0	287	1411	0	138	0	170	0	0	284	497	175	0	425	0	0	0	266	22511					10401	3220	0	0	1009	1247	1007	39912
Norton County , VA	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	4	0	0	0	2	0	0	0	0	0	0	0	0	936					380	356	0	0	19	0	129	1333
Page County , VA	0	60	0	0	17	29	2	0	0	21	0	27	2	0	0	2	68	0	14	44	0	0	0	10	0	0	0	0	0	84	0	48	33	0	0	33	23	11549					7554	1719	0	156	867	1136	1718	19619
Pulaski County , VA	7	0	15	0	815	0	0	8	0	0	0	244	0	0	0	0	0	0	24	369	0	723	0	121	0	0	0	0	312	0	150	0	0	0	0	0	70	33831					40556	5109	0	0	3193	12519	2097	77245
Radford County , VA	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	40	0	0	0	86	92	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	1232					12378	2394	0	0	3728	2870	140	13858
Roanoke City , VA	24	3449	125	327	3346	3081	461	0	34	2538	21	0	1735	2704	16	0	2240	186	0	1332	6634	5504	0	705	2917	999	2484	261	0	2606	0	0	859	983	0	571	698	61114					119515	19035	0	0	24196	10672	4453	227470
Roanoke County , VA	0	1058	0	0	1624	1233	0	0	3	0	0	0	0	0	0	103	0	0	0	0	0	0	467	0	1167	367	0	6	670	1098	325	0	0	0	0	85	93	33726					20453	3748	0	0	2327	948	902	62477
Rockbridge County , VA	0	219	0	2	0	85	3	7	0	39	0	62	19	0	0	0	151	0	25	92	0	266	0	28	0	37	125	24	70	147	0	0	0	0	0	64	50	23947					8753	2056	0	866	1250	710	711	34214
Rockingham County , VA	0	855	0	0	0	132	8	0	0	0	0	0	0	0	0	0	0	5	0	0	0	422	199	0	704	0	0	11	0	65	0	0	59	115	0	34	22	13061					24400	6580	0	1127	4341	3913	1257	40093
Russell County , VA	0	4	0	0	12	0	0	0	0	1	0	0	609	0	0	0	0	0	0	0	0	1	6	0	0	221	0	0	0	0	0	0	0	0	0	0	0	4087					7013	5067	0	0	230	652	22	11954
Salem City , VA	0	0	0	0	947	0	128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1425	0	207	0	0	1049	0	0	0	0	0	0	0	0	0	0	11040					32336	7445	0	0	4095	4855	1532	47132
Scott County , VA	0	22	0	0	1	5	0	3	0	48	0	0	4	0	0	0	0	0	0	15	0	44	27	5	20	0	0	2	2	33	2	0	16	0	0	0	4	4762					1593	0	0	0	22	0	116	6609
Shenandoah County , VA	0	0	0	0	0	80	0	6	0	108	0	201	9	0	0	0	152	2	0	43	0	0	159	7	0	0	0	3	98	67	0	0	47	0	0	32	7	23694					12497	2309	0	95	1318	3061	936	37211
Smyth County , VA	90	1894	0	0	342	1256	0	105	0	0	26	421	0	0	5	0	1096	19	252	0	0	1764	1076	234	814	0	0	227	394	1310	230	0	0	0	0	415	0	111336					37614	12348	2901	0	1891	7612	1800	160920
Staunton City, VA	0	0	0	0	0	16	0	0	0	0	0	0	2	0	0	0	56	0	0	33	8	0	52	0	0	0	0	2	0	57	4	0	24	0	116	20	6	4515					8084	1349	0	958	1441	636	618	12995
Warren County , VA	57	0	3	0	5	7	5	0	0	0	0	619	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	558	0	0	386	0	3	2913					14401	1020	0	0	4363	710	3952	18976
Washington County , VA	0	552	0	0	0	747	0	11	0	0	0	239	0	0	0	0	266	22	28	0	0	638	0	0	617	204	0	5	343	0	164	571	89	0	0	50	28	31242					14008	3737	1208	0	1374	2744	428	49826
Waynesboro City , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	1199	0	0	0	0	0	0	0	1623	0	0	1490	0	0	0	0	0	0	0	0	676	4566	0	0	77697					31422	5400	0	2729	3863	1965	5111	118674
Winchester City , VA	0	0	15	0	0	0	0	106	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	238	683	0	345	3596	0	0	46974					61562	10772	0	0	10886	10887	2828	113521
Wise County , VA	0	64	0	0	82	0	0	2	0	357	0	23	4002	0	0	0	0	0	2	0	0	95	34	16	60	1047	0	0	34	75	16	0	4	0	0	8	3	17082					2837	1258	0	0	86	0	116	25844
Wythe County , VA	0	621	0	67	792	0	0	8	0	0	0	232	427	0	0	0	319	0	25	220	0	737	177	137	654	196	0	0	330	0	156	547	37	0	0	32	103	44830					15380	4847	2952		1251	3044	666	66026
Rest of Virginia	1760	59750	1546	3015	49826	53449	7623	1949	259	38594	135	13784	33672	26634	130	2427	18960	0	4905	19549	21558	19714	13797	11301	42749	14841	4863	3843	23532	44946	11202	22146	12885	16125	58023	7733	8734	697412					934004							2307374
Entry Road																																																		
I64																																							0	14991	561	0								
I77																																							62519	0	0	324								
I81																																							224	0	0	0								
I66 at I81																																							0	328	0	0								
Rest of US	638	158316	852	2009	31766	54895	8775	1816	274	27360	16	17896	23765	29240	35	2959	25124	2560	5294	19140	64087	81409	16567	6830	36627	8767	37760	2271	24677	33038	19763	34948	14561	15269	121221	6475	16037	1576693					11057880							13588086
Entry Road																																																		
I77 in NC	196	24584	187	957	5248	7826	946	337	37	4822	6	2951	12014	4456	10	554	5751	525	915	6352	29812	9239	2704	1279	5877	3524	5083	0	5024	10881	2426	4093	3281	1666	21227	2412	2787						0	2946495	0	728180	49085	3787	
I77 in WV	0	0	0	390	0	3661	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5488	0	0	975	0	0	0	6006						2415822	0	0	0	175578	0	
I64 in WV	77	44241	98	0	7795	0	4180	0	34	7007	0	0	0	2800	5	757	0	0	85	0	0	0	0	1355	1974	0	0	0	1021	0	7983	0	0	9235	3	0	0						0	0	0	11548	0	8981	
I81 in WV	42	7791	55	115	1987	2645	1031	213	31	2333	1	1730	1889	2508	0	298	1808	34	992	1294	3716	5577	1135	605	2962	429	3026	72	2453	1852	1464	6796	683	602	9804	278	1135						504093	0	11096	0	452718	0	
I81 in TN	104	17736	14	92	3534	9632	705	132	75	1279	0	3353	1345	3767	0	272	3244	0	670	1911	3343	18331	970	576	3009	1122	6450	0	7592	6628	4618	4411	3781	673	20663	0	1818						14593	471141	0	2145867	0	154837	
I66 at I495	6	1143	37	69	817	878	126	58	9	606	0	293	530	792	4	62	581	45	1012	345	2009	1347	527	184	1086	223	515	45	783	687	245	8451	178	1670	2340	123	107						549	0	662	0	23943	0	
Total	2624	233031	2729	5574	95642	120265	17649	4091	573	70990	201	37301	68205	61126	184	5759	51981	3013	11309	41638	92212	122897	34196	20522	90003	27710	47112	7104	52839	87184	33829	62930	28292	33244	187413	16338	26412	3,158,383					12715549							17678055

2035 Annual Truck Trip Table for the Interstate 81 Corridor-Concept 5L Toll and Rail Diversion

Origin	Alleghany County , VA	Augusta County , VA	Bath County , VA	Bland County , VA	Botetourt County , VA	Bristol County , VA	Buena Vista County , VA	Clarke County , VA	Clifton Forge County , VA	Covington County , VA	Craig County , VA	Frederick County , VA	Giles County , VA	Harrisonburg County , VA	Highland County , VA	Lexington County , VA	Montgomery County , VA	Norton County , VA	Page County , VA	Pulaski County , VA	Radford County , VA	Roanoke City , VA	Roanoke County , VA	Rockbridge County , VA	Rockingham County , VA	Russell County , VA	Salem City , VA	Scott County , VA	Shenandoah County , VA	Smyth County , VA	Staunton City , VA	Warren County , VA	Washington County , VA	Waynesboro City , VA	Winchester City , VA	Wise County , VA	Wythe County , VA	Rest of Virginia	Exit Road I64	Exit Road I77	Exit Road I81	Exit Road I66 at I81	Rest of US	I77 in NC	I77 in WV	I64 in WV	I81 in WV	I81 in TN	I66 at I495	Total
Alleghany County , VA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	4	0	20	0	0	0	0	0	0	0	17	0	0	0	0	10	0	555					1831	445	0	337	328	117	117	2450
Augusta County , VA	0	1900	1	0	37	402	23	0	0	0	0	0	187	0	0	0	175	0	11	0	0	445	181	50	449	12	0	2	0	99	0	0	84	0	0	34	128	31106					95482	13692	0	18741	9283	22316	1574	130808
Bath County , VA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	155					608	67	0	98	90	66	27	770
Bland County , VA	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	17	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	1477					683	411	55	0	27	110	49	2198
Botetourt County , VA	0	721	0	0	2016	326	0	0	12	51	0	213	0	0	0	242	773	0	107	316	0	994	548	0	0	103	468	90	0	313	0	107	0	0	0	168	167	39706					7010	1914	0	1412	284	903	533	54449
Bristol County , VA	14	1858	69	0	1729	2319	222	16	0	0	0	649	1015	0	0	0	1201	86	203	0	0	2428	838	327	1624	0	0	102	870	1355	396	1164	430	0	0	0	0	101851					42083	5623	2901	0	4057	6422	2087	162852
Buena Vista County , VA	0	17	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	7	0	0	0	0	6	0	0	0	0	0	5430					5090	1081	0	793	729	475	265	10588
Clarke County , VA	0	0	0	0	3	10	0	7	0	0	0	24	0	0	0	0	0	0	0	39	0	0	0	9	0	0	0	3	23	77	0	0	31	0	106	30	8	2753					3876	1122	0	0	342	294	292	6998
Clifton Forge County , VA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	709					290	148	0	29	29	18	6	1003
Covington County , VA	0	0	0	0	93	0	68	0	3	1404	3	0	678	0	0	0	0	32	109	0	0	941	0	60	0	291	0	247	331	0	0	0	0	0	0	409	0	34443					22077	3221	0	6118	2377	2741	1964	61188
Craig County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90					29	12	0	0	3	3	0	119
Frederick County , VA	35	0	73	155	1830	1458	262	178	0	0	0	2376	926	1094	0	127	0	96	107	461	0	0	0	318	0	456	0	2	822	1197	0	1647	83	0	0	81	103	60164					27311	4076	0	3	4517	1114	819	101361
Giles County , VA	0	694	14	0	0	272	0	2	0	370	0	107	1013	0	0	0	82	0	5	0	55	381	0	22	0	15	0	4	122	0	28	0	0	0	0	54	83	11859					11774	6579	0	0	1603	910	337	26957
Harrisonburg County , VA	0	0	0	0	0	0	0	0	0	0	0	27	0	181	0	0	0	4	0	0	0	406	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	9858					20489	3580	0	1229	3337	2892	995	30973
Highland County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	7	0	0	0	0	7	0	0	186					242	157	0	3	10	2	7	445
Lexington County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1858					1654	475	0	207	108	236	197	3526
Montgomery County , VA	0	975	16	0	360	474	36	0	0	0	0	0	194	0	2	0	1116	0	175	0	287	1411	0	138	0	170	0	0	284	497	175	0	425	0	0	0	266	22511					10401	3220	0	0	1009	1247	1007	39912
Norton County , VA	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	4	0	0	0	2	0	0	0	0	0	0	0	0	936					380	356	0	0	19	0	129	1333
Page County , VA	0	60	0	0	17	29	2	0	0	21	0	27	2	0	0	2	68	0	14	44	0	0	0	10	0	0	0	0	0	84	0	48	33	0	0	33	23	11549					7554	1719	0	156	867	1136	1718	19619
Pulaski County , VA	7	0	15	0	815	0	0	8	0	0	0	244	0	0	0	0	0	0	24	369	0	723	0	121	0	0	0	0	312	0	150	0	0	0	0	0	70	33831					40556	5109	0	0	3193	12519	2097	77245
Radford County , VA	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	40	0	0	0	86	92	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	1232					12378	2394	0	0	3728	2870	140	13858
Roanoke City , VA	24	3449	125	327	3346	3081	461	0	34	2538	21	0	1735	2704	16	0	2240	186	0	1332	6634	5504	0	705	2917	999	2484	261	0	2606	0	0	859	983	0	571	698	61114					119515	19035	0	0	24196	10672	4453	227470
Roanoke County , VA	0	1058	0	0	1624	1233	0	0	3	0	0	0	0	0	0	103	0	0	0	0	0	0	467	0	1167	367	0	6	670	1098	325	0	0	0	0	85	93	33726					20453	3748	0	0	2327	948	902	62477
Rockbridge County , VA	0	219	0	2	0	85	3	7	0	39	0	62	19	0	0	0	151	0	25	92	0	266	0	28	0	37	125	24	70	147	0	0	0	0	0	64	50	23947					8753	2056	0	866	1250	710	711	34214
Rockingham County , VA	0	855	0	0	0	132	8	0	0	0	0	0	0	0	0	0	0	5	0	0	0	422	199	0	704	0	0	11	0	65	0	0	59	115	0	34	22	13061					24400	6580	0	1127	4341	3913	1257	40093
Russell County , VA	0	4	0	0	12	0	0	0	0	1	0	0	609	0	0	0	0	0	0	0	0	1	6	0	0	221	0	0	0	0	0	0	0	0	0	0	0	4087					7013	5067	0	0	230	652	22	11954
Salem City , VA	0	0	0	0	947	0	128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1425	0	207	0	0	1049	0	0	0	0	0	0	0	0	0	0	11040					32336	7445	0	0	4095	4855	1532	47132
Scott County , VA	0	22	0	0	1	5	0	3	0	48	0	0	4	0	0	0	0	0	0	15	0	44	27	5	20	0	0	2	2	33	2	0	16	0	0	0	4	4762					1593	0	0	0	22	0	116	6609
Shenandoah County , VA	0	0	0	0	0	80	0	6	0	108	0	201	9	0	0	0	152	2	0	43	0	0	159	7	0	0	0	3	98	67	0	0	47	0	0	32	7	23694					12497	2309	0	95	1318	3061	936	37211
Smyth County , VA	90	1894	0	0	342	1256	0	105	0	0	26	421	0	0	5	0	1096	19	252	0	0	1764	1076	234	814	0	0	227	394	1310	230	0	0	0	0	415	0	111336					37614	12348	2901	0	1891	7612	1800	160920
Staunton City, VA	0	0	0	0	0	16	0	0	0	0	0	0	2	0	0	0	56	0	0	33	8	0	52	0	0	0	0	2	0	57	4	0	24	0	116	20	6	4515					8084	1349	0	958	1441	636	618	12995
Warren County , VA	57	0	3	0	5	7	5	0	0	0	0	619	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	558	0	0	386	0	3	2913					14401	1020	0	0	4363	710	3952	18976
Washington County , VA	0	552	0	0	0	747	0	11	0	0	0	239	0	0	0	0	266	22	28	0	0	638	0	0	617	204	0	5	343	0	164	571	89	0	0	50	28	31242					14008	3737	1208	0	1374	2744	428	49826
Waynesboro City , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	1199	0	0	0	0	0	0	0	1623	0	0	1490	0	0	0	0	0	0	0	0	676	4566	0	0	77697					31422	5400	0	2729	3863	1965	5111	118674
Winchester City , VA	0	0	15	0	0	0	0	106	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	238	683	0	345	3596	0	0	46974					61562	10772	0	0	10886	10887	2828	113521
Wise County , VA	0	64	0	0	82	0	0	2	0	357	0	23	4002	0	0	0	0	0	2	0	0	95	34	16	60	1047	0	0	34	75	16	0	4	0	0	8	3	17082					2837	1258	0	0	86	0	116	25844
Wythe County , VA	0	621	0	67	792	0	0	8	0	0	0	232	427	0	0	0	319	0	25	220	0	737	177	137	654	196	0	0	330	0	156	547	37	0	0	32	103	44830					15380	4847	2952		1251	3044	666	66026
Rest of Virginia	1760	59750	1546	3015	49826	53449	7623	1949	259	38594	135	13784	33672	26634	130	2427	18960	0	4905	19549	21558	19714	13797	11301	42749	14841	4863	3843	23532	44946	11202	22146	12885	16125	58023	7733	8734	697412					934004							2307374
Entry Road																																																		
I64																																							0	14991	561	0								
I77																																							62519	0	0	324								
I81																																							224	0	0	0								
I66 at I81																																							0	328	0	0								
Rest of US	638	158316	852	2009	31766	54895	8775	1816	274	27360	16	17896	23765	29240	35	2959	25124	2560	5294	19140	64087	81409	16567	6830	36627	8767	37760	2271	24677	33038	19763	34948	14561	15269	121221	6475	16037	1576693					13334384							15864590
Entry Road																																																		
I77 in NC	196	24584	187	957	5248	7826	946	337	37	4822	6	2951	12014	4456	10	554	5751	525	915	6352	29812	9239	2704	1279	5877	3524	5083	0	5024	10881	2426	4093	3281	1666	21227	2412	2787						0	2970035	0	953039	49085	3787	
I77 in WV	0	0	0	390	0	3661	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5488	0	0	975	0	0	0	6006						2420584	0	0	0	179730	0	
I64 in WV	77	44241	98	0	7795	0	4180	0	34	7007	0	0	0	2800	5	757	0	0	85	0	0	0	0	1355	1974	0	0	0	1021	0	7983	0	0	9235	3	0	0						0	0	0	11548	0	8981	
I81 in WV	42	7791	55	115	1987	2645	1031	213	31	2333	1	1730	1889	2508	0	298	1808	34	992	1294	3716	5577	1135	605	2962	429	3026	72	2453	1852	1464	6796	683	602	9804	278	1135						628454	0	11096	0	678596	0	
I81 in TN	104	17736	14	92	3534	9632	705	132	75	1279	0	3353	1345	3767	0	272	3244	0	670	1911	3343	18331	970	576	3009	1122	6450	0	7592	6628	4618	4411	3781	673	20663	0	1818						14593	472430	0	2727080	0	158495	
I66 at I495	6	1143	37	69	817	878	126	58	9	606	0	293	530	792	4	62	581	45	1012	345	2009	1347	527	184	1086	223	515	45	783	687	245	8451	178	1670	2340	123	107						549	0	662	0	26193	0	
Total	2624	233031	2729	5574	95642	120265	17649	4091	573	70990	201	37301	68205	61126	184	5759	51981	3013	11309	41638	92212	122897	34196	20522	90003	27710	47112	7104	52839	87184	33829	62930	28292	33244	187413	16338	26412	3,158,383					14992053							19954559

2035 Annual Truck Trip Table for the Interstate 81 Corridor-Concept 6H Toll and Rail Diversion

Origin	Alleghany County , VA	Augusta County , VA	Bath County , VA	Bland County , VA	Botetourt County , VA	Bristol County , VA	Buena Vista County , VA	Clarke County , VA	Clifton Forge County , VA	Covington County , VA	Craig County , VA	Frederick County , VA	Giles County , VA	Harrisonburg County , VA	Highland County , VA	Lexington County , VA	Montgomery County , VA	Norton County , VA	Page County , VA	Pulaski County , VA	Radford County , VA	Roanoke City , VA	Roanoke County , VA	Rockbridge County , VA	Rockingham County , VA	Russell County , VA	Salem City , VA	Scott County , VA	Shenandoah County , VA	Smyth County , VA	Staunton City , VA	Warren County , VA	Washington County , VA	Waynesboro City , VA	Winchester City , VA	Wise County , VA	Wythe County , VA	Rest of Virginia	Exit Road I64	Exit Road I77	Exit Road I81	Exit Road I66 at I81	Rest of US	I77 in NC	I77 in WV	I64 in WV	I81 in WV	I81 in TN	I66 at I495	Total
Alleghany County , VA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	4	0	20	0	0	0	0	0	0	0	17	0	0	0	0	0	10	0	555					1878	445	0	384	328	117	117	2497
Augusta County , VA	0	1900	1	0	37	402	23	0	0	0	0	0	187	0	0	0	175	0	11	0	0	445	181	50	449	12	0	2	0	99	0	0	84	0	0	34	128	31106					96454	13692	0	19258	9283	22770	1574	131780
Bath County , VA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	155					608	67	0	98	90	66	27	770
Bland County , VA	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	17	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	1477					694	411	66	0	27	110	49	2209
Botetourt County , VA	0	721	0	0	2016	326	0	0	12	51	0	213	0	0	0	242	773	0	107	316	0	994	548	0	0	103	468	90	0	313	0	107	0	0	0	168	167	39706					7311	1914	0	1455	284	1162	533	54750
Bristol County , VA	14	1858	69	0	1729	2319	222	16	0	0	0	649	1015	0	0	0	1201	86	203	0	0	2428	838	327	1624	0	0	102	870	1355	396	1164	430	0	0	0	0	101851					42083	5623	2901	0	4057	6422	2087	162852
Buena Vista County , VA	0	17	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	7	0	0	0	0	6	0	0	0	0	0	5430					5151	1081	0	803	729	525	265	10649
Clarke County , VA	0	0	0	0	3	10	0	7	0	0	0	24	0	0	0	0	0	0	0	39	0	0	0	9	0	0	0	3	23	77	0	0	31	0	106	30	8	2753					3902	1122	0	0	342	320	292	7024
Clifton Forge County , VA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	709					290	148	0	29	29	18	6	1003
Covington County , VA	0	0	0	0	93	0	68	0	3	1404	3	0	678	0	0	0	0	32	109	0	0	941	0	60	0	291	0	247	331	0	0	0	0	0	0	409	0	34443					22153	3221	0	6194	2377	2741	1964	61265
Craig County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90					41	12	0	0	3	15	0	131
Frederick County , VA	35	0	73	155	1830	1458	262	178	0	0	0	2376	926	1094	0	127	0	96	107	461	0	0	0	318	0	456	0	2	822	1197	0	1647	83	0	0	81	103	60164					27464	4076	0	3	4517	1267	819	101514
Giles County , VA	0	694	14	0	0	272	0	2	0	370	0	107	1013	0	0	0	82	0	5	0	55	381	0	22	0	15	0	4	122	0	28	0	0	0	0	54	83	11859					11798	6579	0	0	1603	933	337	26980
Harrisonburg County , VA	0	0	0	0	0	0	0	0	0	0	0	27	0	181	0	0	0	4	0	0	0	406	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	9858					21083	3580	0	1611	3337	3104	995	31567
Highland County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	7	0	0	0	0	7	0	0	186					242	157	0	3	10	2	7	445
Lexington County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1858					1673	475	0	210	108	252	197	3545
Montgomery County , VA	0	975	16	0	360	474	36	0	0	0	0	0	194	0	2	0	1116	0	175	0	287	1411	0	138	0	170	0	0	284	497	175	0	425	0	0	0	266	22511					10701	3220	0	0	1009	1547	1007	40212
Norton County , VA	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	4	0	0	0	2	0	0	0	0	0	0	0	0	936					380	356	0	0	19	0	129	1333
Page County , VA	0	60	0	0	17	29	2	0	0	21	0	27	2	0	0	2	68	0	14	44	0	0	0	10	0	0	0	0	0	84	0	48	33	0	0	33	23	11549					7645	1719	0	166	867	1218	1718	19711
Pulaski County , VA	7	0	15	0	815	0	0	8	0	0	0	244	0	0	0	0	0	0	24	369	0	723	0	121	0	0	0	0	312	0	150	0	0	0	0	0	70	33831					40733	5109	0	0	3193	12696	2097	77421
Radford County , VA	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	40	0	0	0	86	92	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	1232					12668	2394	0	0	3728	3160	140	14148
Roanoke City , VA	24	3449	125	327	3346	3081	461	0	34	2538	21	0	1735	2704	16	0	2240	186	0	1332	6634	5504	0	705	2917	999	2484	261	0	2606	0	0	859	983	0	571	698	61114					119978	19035	0	0	24196	11135	4453	227933
Roanoke County , VA	0	1058	0	0	1624	1233	0	0	3	0	0	0	0	0	0	103	0	0	0	0	0	0	467	0	1167	367	0	6	670	1098	325	0	0	0	0	85	93	33726					20586	3748	0	0	2327	1081	902	62610
Rockbridge County , VA	0	219	0	2	0	85	3	7	0	39	0	62	19	0	0	0	151	0	25	92	0	266	0	28	0	37	125	24	70	147	0	0	0	0	0	64	50	23947					8832	2056	0	884	1250	772	711	34294
Rockingham County , VA	0	855	0	0	0	132	8	0	0	0	0	0	0	0	0	0	0	5	0	0	0	422	199	0	704	0	0	11	0	65	0	0	59	115	0	34	22	13061					24732	6580	0	1241	4341	4131	1257	40425
Russell County , VA	0	4	0	0	12	0	0	0	0	1	0	0	609	0	0	0	0	0	0	0	0	1	6	0	0	221	0	0	0	0	0	0	0	0	0	0	0	4087					7081	5067	0	0	230	720	22	12023
Salem City , VA	0	0	0	0	947	0	128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1425	0	207	0	0	1049	0	0	0	0	0	0	0	0	0	0	11040					32850	7445	0	0	4095	5369	1532	47646
Scott County , VA	0	22	0	0	1	5	0	3	0	48	0	0	4	0	0	0	0	0	0	15	0	44	27	5	20	0	0	2	2	33	2	0	16	0	0	0	4	4762					1593	0	0	0	22	0	116	6609
Shenandoah County , VA	0	0	0	0	0	80	0	6	0	108	0	201	9	0	0	0	152	2	0	43	0	0	159	7	0	0	0	3	98	67	0	0	47	0	0	32	7	23694					12732	2309	0	95	1318	3296	936	37447
Smyth County , VA	90	1894	0	0	342	1256	0	105	0	0	26	421	0	0	5	0	1096	19	252	0	0	1764	1076	234	814	0	0	227	394	1310	230	0	0	0	0	415	0	111336					37881	12348	2901	0	1891	7879	1800	161187
Staunton City, VA	0	0	0	0	0	16	0	0	0	0	0	0	2	0	0	0	56	0	0	33	8	0	52	0	0	0	0	2	0	57	4	0	24	0	116	20	6	4515					8151	1349	0	975	1441	685	618	13061
Warren County , VA	57	0	3	0	5	7	5	0	0	0	0	619	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	558	0	0	386	0	3	2913					14512	1020	0	0	4363	822	3952	19087
Washington County , VA	0	552	0	0	0	747	0	11	0	0	0	239	0	0	0	0	266	22	28	0	0	638	0	0	617	204	0	5	343	0	164	571	89	0	0	50	28	31242					14055	3737	1208	0	1374	2790	428	49872
Waynesboro City , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	1199	0	0	0	0	0	0	0	1623	0	0	1490	0	0	0	0	0	0	0	0	676	4566	0	0	77697					31788	5400	0	2822	3863	2238	5111	119040
Winchester City , VA	0	0	15	0	0	0	0	106	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	238	683	0	345	3596	0	0	46974					62406	10772	0	0	10886	11732	2828	114365
Wise County , VA	0	64	0	0	82	0	0	2	0	357	0	23	4002	0	0	0	0	0	2	0	0	95	34	16	60	1047	0	0	34	75	16	0	4	0	0	8	3	17082					2837	1258	0	0	86	0	116	25844
Wythe County , VA	0	621	0	67	792	0	0	8	0	0	0	232	427	0	0	0	319	0	25	220	0	737	177	137	654	196	0	0	330	0	156	547	37	0	0	32	103	44830					15518	4847	2961	0	1251	3173	666	66164
Rest of Virginia	1760	59750	1546	3015	49826	53449	7623	1949	259	38594	135	13784	33672	26634	130	2427	18960	0	4905	19549	21558	19714	13797	11301	42749	14841	4863	3843	23532	44946	11202	22146	12885	16125	58023	7733	8734	697412					934004							2307374
Entry Road																																																		
I64																																							0	14991	561	0								
I77																																							62519	0	0	324								
I81																																							224	0	0	0								
I66 at I81																																							0	328	0	0								
Rest of US	638	159048	852	2009	31852	54895	8807	1832	274	27412	16	18108	23776	29367	35	2964	25283	2560	5348	19218	64199	82799	16623	6847	36733	8775	38117	2271	24728	33139	20722	35563	14574	15348	121514	6475	16104	1576693					11139568							13675087
Entry Road																																																		
I77 in NC	196	24584	187	957	5248	7826	946	337	37	4822	6	2951	12014	4456	10	554	5751	525	915	6352	29812	9239	2704	1279	5877	3524	5083	0	5024	10881	2426	4093	3281	1666	21227	2412	2787						0	2961988	0	793452	49085	3787	
I77 in WV	0	0	0	390	0	3661	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5488	0	0	975	0	0	0	6049						2424360	0	0	0	176536	0	
I64 in WV	77	44412	98	0	7807	0	4187	0	34	7060	0	0	0	2832	5	757	0	0	85	0	0	0	0	1364	2002	0	0	0	1021	0	8044	0	0	9251	3	0	0						0	0	0	11548	0	8981	
I81 in WV	42	7791	55	115	1987	2645	1031	213	31	2333	1	1730	1889	2508	0	298	1808	34	992	1294	3716	5577	1135	605	2962	429	3026	72	2453	1852	1464	6796	683	602	9804	278	1135						541442	0	11096	0	505282	0	
I81 in TN	104	18296	14	92	3608	9632	730	148	75	1279	0	3565	1357	3864	0	277	3403	0	724	1989	3456	19721	1026	584	3088	1130	6806	0	7644	6729	5515	5026	3793	736	20956	0	1841						14593	471546	0	2324305	0	155306	
I66 at I495	6	1143	37	69	817	878	126	58	9	606	0	293	530	792	4	62	581	45	1012	345	2009	1347	527	184	1086	223	515	45	783	687	245	8451	178	1670	2340	123	107						549	0	662	0	24343	0	
Total	2624	233762	2729	5574	95728	120280	17649	4239	585	70990	201	37354	68283	61183	190	5865	51990	3013	11361	41738	92827	122910	34196	20545	90003	27736	47112	7104	52967	87189	33829	63043	29682	33600	188313	16338	26705	3,158,383					12804054							17771873

2035 Annual Truck Trip Table for the Interstate 81 Corridor-Concept 6L Toll and Rail Diversion

Origin	Alleghany County , VA	Augusta County , VA	Bath County , VA	Bland County , VA	Botetourt County , VA	Bristol County , VA	Buena Vista County , VA	Clarke County , VA	Clifton Forge County , VA	Covington County , VA	Craig County , VA	Frederick County , VA	Giles County , VA	Harrisonburg County , VA	Highland County , VA	Lexington County , VA	Montgomery County , VA	Norton County , VA	Page County , VA	Pulaski County , VA	Radford County , VA	Roanoke City , VA	Roanoke County , VA	Rockbridge County , VA	Rockingham County , VA	Russell County , VA	Salem City , VA	Scott County , VA	Shenandoah County , VA	Smyth County , VA	Staunton City , VA	Warren County , VA	Washington County , VA	Waynesboro City , VA	Winchester City , VA	Wise County , VA	Wythe County , VA	Rest of Virginia	Exit Road I64	Exit Road I77	Exit Road I81	Exit Road I66 at I81	Rest of US	I77 in NC	I77 in WV	I64 in WV	I81 in WV	I81 in TN	I66 at I495	Total
Alleghany County , VA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	4	0	20	0	0	0	0	0	0	0	17	0	0	0	0	0	10	0	555					1878	445	0	384	328	117	117	2497
Augusta County , VA	0	1900	1	0	37	402	23	0	0	0	0	0	187	0	0	0	175	0	11	0	0	445	181	50	449	12	0	2	0	99	0	0	84	0	0	34	128	31106					96454	13692	0	19258	9283	22770	1574	131780
Bath County , VA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	155					608	67	0	98	90	66	27	770
Bland County , VA	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	17	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	1477					694	411	66	0	27	110	49	2209
Botetourt County , VA	0	721	0	0	2016	326	0	0	12	51	0	213	0	0	0	242	773	0	107	316	0	994	548	0	0	103	468	90	0	313	0	107	0	0	0	168	167	39706					7311	1914	0	1455	284	1162	533	54750
Bristol County , VA	14	1858	69	0	1729	2319	222	16	0	0	0	649	1015	0	0	0	1201	86	203	0	0	2428	838	327	1624	0	0	102	870	1355	396	1164	430	0	0	0	0	101851					42083	5623	2901	0	4057	6422	2087	162852
Buena Vista County , VA	0	17	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	7	0	0	0	0	6	0	0	0	0	0	5430					5151	1081	0	803	729	525	265	10649
Clarke County , VA	0	0	0	0	3	10	0	7	0	0	0	24	0	0	0	0	0	0	0	39	0	0	0	9	0	0	0	3	23	77	0	0	31	0	106	30	8	2753					3902	1122	0	0	342	320	292	7024
Clifton Forge County , VA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	709					290	148	0	29	29	18	6	1003
Covington County , VA	0	0	0	0	93	0	68	0	3	1404	3	0	678	0	0	0	0	32	109	0	0	941	0	60	0	291	0	247	331	0	0	0	0	0	0	409	0	34443					22153	3221	0	6194	2377	2741	1964	61265
Craig County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90					41	12	0	0	3	15	0	131
Frederick County , VA	35	0	73	155	1830	1458	262	178	0	0	0	2376	926	1094	0	127	0	96	107	461	0	0	0	318	0	456	0	2	822	1197	0	1647	83	0	0	81	103	60164					27464	4076	0	3	4517	1267	819	101514
Giles County , VA	0	694	14	0	0	272	0	2	0	370	0	107	1013	0	0	0	82	0	5	0	55	381	0	22	0	15	0	4	122	0	28	0	0	0	0	54	83	11859					11798	6579	0	0	1603	933	337	26980
Harrisonburg County , VA	0	0	0	0	0	0	0	0	0	0	0	27	0	181	0	0	0	4	0	0	0	406	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	9858					21083	3580	0	1611	3337	3104	995	31567
Highland County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	7	0	0	0	0	7	0	0	186					242	157	0	3	10	2	7	445
Lexington County , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1858					1673	475	0	210	108	252	197	3545
Montgomery County , VA	0	975	16	0	360	474	36	0	0	0	0	0	194	0	2	0	1116	0	175	0	287	1411	0	138	0	170	0	0	284	497	175	0	425	0	0	0	266	22511					10701	3220	0	0	1009	1547	1007	40212
Norton County , VA	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	4	0	0	0	2	0	0	0	0	0	0	0	0	936					380	356	0	0	19	0	129	1333
Page County , VA	0	60	0	0	17	29	2	0	0	21	0	27	2	0	0	2	68	0	14	44	0	0	0	10	0	0	0	0	0	84	0	48	33	0	0	33	23	11549					7645	1719	0	166	867	1218	1718	19711
Pulaski County , VA	7	0	15	0	815	0	0	8	0	0	0	244	0	0	0	0	0	0	24	369	0	723	0	121	0	0	0	0	312	0	150	0	0	0	0	0	70	33831					40733	5109	0	0	3193	12696	2097	77421
Radford County , VA	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	40	0	0	0	86	92	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	1232					12668	2394	0	0	3728	3160	140	14148
Roanoke City , VA	24	3449	125	327	3346	3081	461	0	34	2538	21	0	1735	2704	16	0	2240	186	0	1332	6634	5504	0	705	2917	999	2484	261	0	2606	0	0	859	983	0	571	698	61114					119978	19035	0	0	24196	11135	4453	227933
Roanoke County , VA	0	1058	0	0	1624	1233	0	0	3	0	0	0	0	0	0	103	0	0	0	0	0	0	467	0	1167	367	0	6	670	1098	325	0	0	0	0	85	93	33726					20586	3748	0	0	2327	1081	902	62610
Rockbridge County , VA	0	219	0	2	0	85	3	7	0	39	0	62	19	0	0	0	151	0	25	92	0	266	0	28	0	37	125	24	70	147	0	0	0	0	0	64	50	23947					8832	2056	0	884	1250	772	711	34294
Rockingham County , VA	0	855	0	0	0	132	8	0	0	0	0	0	0	0	0	0	0	5	0	0	0	422	199	0	704	0	0	11	0	65	0	0	59	115	0	34	22	13061					24732	6580	0	1241	4341	4131	1257	40425
Russell County , VA	0	4	0	0	12	0	0	0	0	1	0	0	609	0	0	0	0	0	0	0	0	1	6	0	0	221	0	0	0	0	0	0	0	0	0	0	0	4087					7081	5067	0	0	230	720	22	12023
Salem City , VA	0	0	0	0	947	0	128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1425	0	207	0	0	1049	0	0	0	0	0	0	0	0	0	0	11040					32850	7445	0	0	4095	5369	1532	47646
Scott County , VA	0	22	0	0	1	5	0	3	0	48	0	0	4	0	0	0	0	0	0	15	0	44	27	5	20	0	0	2	2	33	2	0	16	0	0	0	4	4762					1593	0	0	0	22	0	116	6609
Shenandoah County , VA	0	0	0	0	0	80	0	6	0	108	0	201	9	0	0	0	152	2	0	43	0	0	159	7	0	0	0	3	98	67	0	0	47	0	0	32	7	23694					12732	2309	0	95	1318	3296	936	37447
Smyth County , VA	90	1894	0	0	342	1256	0	105	0	0	26	421	0	0	5	0	1096	19	252	0	0	1764	1076	234	814	0	0	227	394	1310	230	0	0	0	0	415	0	111336					37881	12348	2901	0	1891	7879	1800	161187
Staunton City, VA	0	0	0	0	0	16	0	0	0	0	0	0	2	0	0	0	56	0	0	33	8	0	52	0	0	0	0	2	0	57	4	0	24	0	116	20	6	4515					8151	1349	0	975	1441	685	618	13061
Warren County , VA	57	0	3	0	5	7	5	0	0	0	0	619	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	558	0	0	386	0	3	2913					14512	1020	0	0	4363	822	3952	19087
Washington County , VA	0	552	0	0	0	747	0	11	0	0	0	239	0	0	0	0	266	22	28	0	0	638	0	0	617	204	0	5	343	0	164	571	89	0	0	50	28	31242					14055	3737	1208	0	1374	2790	428	49872
Waynesboro City , VA	0	0	0	0	0	0	0	0	0	0	0	0	0	1199	0	0	0	0	0	0	0	1623	0	0	1490	0	0	0	0	0	0	0	0	676	4566	0	0	77697					31788	5400	0	2822	3863	2238	5111	119040
Winchester City , VA	0	0	15	0	0	0	0	106	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	238	683	0	345	3596	0	0	46974					62406	10772	0	0	10886	11732	2828	114365
Wise County , VA	0	64	0	0	82	0	0	2	0	357	0	23	4002	0	0	0	0	0	2	0	0	95	34	16	60	1047	0	0	34	75	16	0	4	0	0	8	3	17082					2837	1258	0	0	86	0	116	25844
Wythe County , VA	0	621	0	67	792	0	0	8	0	0	0	232	427	0	0	0	319	0	25	220	0	737	177	137	654	196	0	0	330	0	156	547	37	0	0	32	103	44830					15518	4847	2961	0	1251	3173	666	66164
Rest of Virginia	1760	59750	1546	3015	49826	53449	7623	1949	259	38594	135	13784	33672	26634	130	2427	18960	0	4905	19549	21558	19714	13797	11301	42749	14841	4863	3843	23532	44946	11202	22146	12885	16125	58023	7733	8734	697412					934004							2307374
Entry Road																																																		
I64																																							0	14991	561	0								
I77																																							62519	0	0	324								
I81																																							224	0	0	0								
I66 at I81																																							0	328	0	0								
Rest of US	638	#####	852	2009	31852	54895	8807	1832	274	27412	16	18108	23776	29367	35	2964	25283	2560	5348	19218	64199	82799	16623	6847	36733	8775	38117	2271	24728	33139	20722	35563	14574	15348	#####	6475	16104	1576693					13414955							########
Entry Road																																																		
I77 in NC	196	24584	187	957	5248	7826	946	337	37	4822	6	2951	12014	4456	10	554	5751	525	915	6352	29812	9239	2704	1279	5877	3524	5083	0	5024	10881	2426	4093	3281	1666	21227	2412	2787						0	2981554	0	974353	49085	3787	
I77 in WV	0	0	0	390	0	3661	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5488	0	0	975	0	0	0	6049						2428511	0	0	0	179970	0	
I64 in WV	77	44412	98	0	7807	0	4187	0	34	7060	0	0	0	2832	5	757	0	0	85	0	0	0	0	1364	2002	0	0	0	1021	0	8044	0	0	9251	3	0	0						0	0	0	11548	0	8981	
I81 in WV	42	7791	55	115	1987	2645	1031	213	31	2333	1	1730	1889	2508	0	298	1808	34	992	1294	3716	5577	1135	605	2962	429	3026	72	2453	1852	1464	6796	683	602	9804	278	1135						645112	0	11096	0	697896	0	
I81 in TN	104	18296	14	92	3608	9632	730	148	75	1279	0	3565	1357	3864	0	277	3403	0	724	1989	3456	19721	1026	584	3088	1130	6806	0	7644	6729	5515	5026	3793	736	20956	0	1841						14593	472502	0	######	0	#####	
I66 at I495	6	1143	37	69	817	878	126	58	9	606	0	293	530	792	4	62	581	45	1012	345	2009	1347	527	184	1086	223	515	45	783	687	245	8451	178	1670	2340	123	107						549	0	662	0	26205	0	
Total	2624	#####	2729	5574	95728	#####	17649	4239	585	70990	201	37354	68283	61183	190	5865	51990	3013	11361	41738	92827	#####	34196	20545	90003	27736	47112	7104	52967	87189	33829	63043	29682	33600	#####	16338	26705	3,158,383					15079440							#######

APPENDIX F - RAIL DIVERSION MODEL SUPPORT DATA

Data Inputs to the ITIC Model

ITIC predicts modal diversion by calculating and comparing the Total Transportation and Logistics Costs for different modes of freight transportation. The model assigns a commodity movement to the lowest total transportation and logistics cost.

Transportation costs considered in the model include all costs to the shipper of moving commodities from an origin to a destination. Trailer on Flat Car (TOFC) intermodal transportation costs include rail line haul costs and truck drayage costs at the origin and destination of the shipment. FRA staff suggested intermodal rail operators will compete with truck carriers by charging 95 percent of the truck rate to a shipper, where they can meet their variable and drayage costs plus 10 percent. This was used as an assumption in the model.

Logistics costs considered in the model include inventory-carrying costs, storage costs, handling, insurance, taxes, and obsolescence. There are additional assumptions made for claims costs (loss and damage), cycle and safety stock holding costs, in-transit stock and for protection for a receiver's "stock-out" of a particular commodity. These logistics values are default assumptions built into the model, and can vary by commodity and mode.

1998 Virginia Transearch Commodity Movement Data

The Transearch database is the basis for the data input to ITIC in this analysis. Transearch provides information for the annual tonnage by commodity, between specific origin-destination pairs that use Virginia highways. A subset of the Transearch database is being examined for the modal diversion analysis. If the distance between an origin and destination is less than 500 miles, the commodity flow was not analyzed for mode diversion potential. Moves of less than 500 miles are generally not considered modally competitive.

Rail Line-Haul Mileages

The model considers the total distance of an intermodal move in calculating total logistics costs. Total distance includes drayage to and from intermodal terminals, and estimates of the transportation costs while a TOFC trailer is carried on the railroad. Rail line haul distances are estimated between selected truck-rail intermodal terminals at the origin and destination regions for each record.

Intermodal Truck Drayage Mileages

Drayage estimates are made at the Bureau of Economic Analysis (BEA) level geography, which is outlined in the ITIC model documentation. Intermodal terminals in BEA regions were identified and the straight line distances between the designated terminal and zip code centroid points in selected BEA regions were calculated with the ***Maptitude*** GIS application. Distances between zip code areas and a terminal were also weighted based on the number of manufacturing jobs within a zip code area to calculate the expected drayage distance for each BEA.

Truck Rates

The Study Team used the 2004 North American Truckload Rate Index produced by the KPMG Company. It provides dry van truckload rates for 120 market areas in the United States.

Intermodal Shipper Cost

Rail variable costs for the rail line haul portion of a commodity were developed using Uniform Rail Costing System (URCS) methodology. The model was run assuming URCS Plan 2.5 service, where the Norfolk Southern railroad provides ramp to ramp service with railroad owned trailers and Plan 3.0 service with the railroad providing ramp to ramp service with third party owned trailers.

Plan 2.0 service estimates the cost for Norfolk Southern to provide “Door-to-Door” TOFC service, and all shipper costs are presumed to be reflected in the variable cost figure. The variable cost “per hundredweight (hundred pounds)” is used by the model to calculate the rail movement portion of the transportation costs for an intermodal move. An estimate of variable cost was developed for each commodity movement in the Transearch database based on weight and distance.

In addition to rail line haul variable costs, estimates were made for terminal lift charges, minimum shipper drayage costs, and truck rate per mile estimate for the drayage after 30 miles. Estimates of these costs were provided by Federal Railroad Administration staff, for use with the Plan 2.5 variable cost estimate model run.

Summary of recommendations to the Study Team from Norfolk Southern Railroad Staff

The Study Team held three conference calls, and email correspondence with staff from the Norfolk Southern Railroad (NSRR). The purpose of the discussions was to assist the study team in developing intermodal truck/rail cost estimates for the ITIC model. This section highlights significant points raised in the three discussions the study team had with Robert Holland of NSRR.

Email 1, Received Friday, September 3, 2004:

- After forwarding URCS Plan 2.5 and Plan 2.0 estimates to NSRR for review, NSRR staff recommended the study team use Plan 3.0 in URCS, and t0 adjust the cars per TOFC ratio to 1.8 from 1.77.

Conference Call 1 and 2, Thursday, September 9, 2004:

- Mr. Holland recommended:
    - Using Plan 1.0 of the URCS, noting that there is little difference between Plan 1.0 and Plan 3.0.
    - Not using Plan 2.0 to estimate intermodal costs. He said Plan 2.0 “door-to-door” intermodal service was not really used except in specific circumstances, and the cost estimates were not reliable as the sample size is so small.
    - Not using Plan 2.5 to estimate costs for similar reasons as Plan 2.0, although Plan 2.5 estimates cost for ramp-to-ramp service.
    - Adding a per unit capital recovery factor to the Plan 1.0 estimate.
    - Modifying a parameter in the model to estimate costs using three locomotives.
    - Not charging for dwell time at a facility.
    - Estimating diversion at different drayage distances, or with different truck rates. (The study team purchased data from KPMG – The North American Truckload Rate Index used for the study).
    - Not including a lift charge in the cost estimate, as it is accounted for in the Plan 1.0 costs.
- He discussed facility issues related to the Canadian Pacific Expressway service, and compared it with similarities to older “circus style” intermodal service used by the railroads in the past. He said facility and track space will be a limiting factor in implementing new services.
- He said intermodal service can make complex movements that make drayage difficult to estimate, and provided an example of a trailer moving by rail from Tennessee to New Jersey, and then by truck from New Jersey to Maine.
- He had general comments on truck rates, but no specific advice to estimate drayage truck rates in the model.
- He said he could not disclose how NSRR estimates intermodal costs.

- He briefly discussed rail operating speeds but had no specific comments in the discussion.

Conference Call 3, Monday, September 13, 2004:

- Mr. Holland suggested to include an equipment lease cost of $15-20 per day for a trailer unit should be included in the cost estimate.
- Mr. Holland reiterated that lift charges were included in Plan 1.0 cost estimates at both the origin and destination.
- He said a 33 mile per hour rail operating speed is a projection, and that the average current operating speed is between 20 and 25 miles per hour.