REPORT OF THE
SECRETARY OF TRANSPORTATION ON

The Potential for Shifting Virginia's Highway Traffic to Railroads

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

SENATE DOCUMENT NO. 30

COMMONWEALTH OF VIRGINIA
RICHMOND
2001

COMMONWEALTH *of* VIRGINIA

Office of the Governor

James S. Gilmore, III
Governor

Shirley J. Ybarra
Secretary of Transportation

February 6, 2001

The Honorable James S. Gilmore, III
Members, Virginia General Assembly

Dear Governor Gilmore and General Assembly Members:

Pursuant to Senate Joint Resolution No. 55 of the 2000 Session of the General Assembly, the Secretary of Transportation was requested to expand the scope of the study on the desirability and feasibility of establishing additional intermodal transfer facilities (House Joint Resolution No. 704 (1999) to include the potential for shifting Virginia's highway traffic to railroads. The resolution further stated that the Department of Rail and Public Transportation (DRPT) and the Virginia Department of Transportation (VDOT) would assist the Secretary in the conduct of the study. DRPT was subsequently designated to lead the effort and commissioned Wilbur Smith Associates in Association with Dr. Denver Tolliver, Belstar, Inc. and Fitzerald-Halliday, Inc. perform the study.

The "SJR-55 Study" report concludes that all of the presently planned highway improvements on route I-81 are needed, and that the Commonwealth should consider making improvements in the rail facilities to avoid future congestion. The study further recommends that additional details including the use of this route in conjunction with alternate routes, be collected to permit a more refined analysis. We concur in these recommendations.

Thank you for the opportunity to conduct this study. As always, let me know if you have any questions.

Sincerely,

Shirley J. Ybarra

SJY/smm

Attachment

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PREFACE

The 2000 Session of the General Assembly, through Senate Joint Resolution No. 55 stated the following:

"Requesting the Secretary of Transportation to expand the scope of her study on the desirability and feasibility of establishing additional intermodal transfer facilities (House Joint Resolution No. 704 (1999)) to include the potential for shifting Virginia's highway traffic to railroads."

The Department of Rail and Public Transportation (DRPT) and the Virginia Department of Transportation (VDOT) were asked to assist the Secretary of Transportation in the conduct of the study. DRPT was subsequently designated to lead the effort and commissioned Wilbur Smith Associates in association with Dr. Denver Tolliver, Belstar, Inc., and Fitzgerald-Halliday, Inc. to perform the study. The Department of Rail and Public Transportation staff included George R. Conner and Ranjeet Rathore. Erik Johnson of the Department of Transportation, Transportation Planning Division, provided I-81 data as needed and provided assistance. Stephen Brich from the Transportation Research Council acted as an advisor. The study was coordinated with Norfolk Southern Railway.

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EXECUTIVE SUMMARY

The 2000 Session of the General Assembly, through Senate Joint Resolution No. 55 stated the following:

Requesting the Secretary of Transportation to expand the scope of her study on the desirability and feasibility of establishing additional intermodal transfer facilities (House Joint Resolution No. 704 (1999)) to include the potential for shifting Virginia's highway traffic to railroads.

Interstate 81 was cited as an "acute example" as its current traffic is made up of as much as 40 percent trucks although it was designed to carry no more than 15 percent.

Study Purpose and Conduct

This report presents the results of a study designed and commissioned by the Virginia Department of Rail and Public Transportation to address SJR-55. The purpose of the study is to determine if the potential exists to divert enough highway traffic fromI-81 to rail transport to significantly impact the need for planned improvements, and if the impacts over time would justify public expenditures for rail improvements. The approach to making the determinations involved a number of factors.

A variety of data on truck movements, I-81 characteristics and improvement plans, and railroad plans were gathered and analyzed. The analyses conducted examined the reasonableness of both highway and railroad plans and cost estimates, the amount of highway traffic which might be diverted to rail, and the extent to which those diversions might impact I-81. In the case of the latter, both planned capital expenditures and long-range maintenance and environmental consequences were considered.

Data Collected

Data on truck traffic (base and forecast years) were obtained from commercial freight data sources and prior VDOT studies and work in which it had participated. I-81 traffic and roadway data, including forecasts were provided by VDOT. Potential rail passenger volumes in the corridor were supplied by DRPT.

Details of the Norfolk Southern (NS) proposal, including estimates of potential diversion and rail line improvement costs, were supplied by the railway. Officials of the company involved in preparation of the estimates were made available for questions and discussion in two meetings.

Analyses Performed

A number of analyses were performed in conduct of the study. First the various truck traffic flows contained in the various databases were examined and assigned to the highway system. The trucks that would use I-81, all or part of the length in Virginia, were identified by route segment.

The NS freight diversion methodology and estimate were reviewed and compared with other estimates and current market shares. Diversions of 10 and 25 percent were examined. The potential to divert automobile occupants to passenger trains was found not to be significant. In the final analysis, actual diversions are dependent on the quality of service the carrier is able to provide. A diversion potential of around 10 percent[1] is a reasonable expectation.

The cost estimates prepared by both VDOT for the 20-year I-81 program, and by NS for its rail route parallel to I-81 were examined and found to be reasonable. Both are, however, order-of-magnitude estimates based on conceptual/preliminary planning, and would need to be refined at some point.

Highway impacts were estimated using the Highway Economic Requirements System (HERS). HERS is a comprehensive highway performance model used to develop testimony for the U.S. Congress. Output from HERS is used in preparing the U.S. Department of Transportation's biennial report to Congress on the "Status of the Nation's Surface Transportation System."

HERS uses the Highway Performance Monitoring System (HPMS) database, which is a stratified random sample of a state's highway system. Each state transportation department collects traffic, pavement, ride quality, and other highway data needed to update the database each year. FHWA uses data from all states to develop reports for Congress. In this case HERS was applied to Virginia's database to produce state-specific reports.

Using the HERS model, it was determined that the planned improvements to I-81 will have to proceed, and, in fact additional capacity improvements should be considered. Even with additional capacity improvements, the removal of trucks (diverted to rail) impacts the amount and timing of those improvements. An analysis of the present value of the benefits that would be attributable to the diversion of trucks over the 22-year study period was conducted. The results reveal that at a 10 percent diversion level, almost $400 million worth of benefits are generated which increases to almost $1 billion at the 25 percent level. The 25 percent level is the upper most end of the range and would only occur under almost ideal conditions.

Summary

The analyses conducted indicate that consideration of public investment in rail improvements in the I-81 Corridor is warranted based on the potential to accrue public benefits. There are still many unanswered questions and issues to resolve, but that should not deter further consideration and examination of the NS and other similar proposals. Highway improvements in addition to those planned are needed. It is believed that the rail capacity improvements proposed exceed those necessary for the projected intermodal volumes. The Commonwealth should work with NS to reduce the scope of rail improvements to that which is required.

[1] Percent of trucks with dry van semi-trailers moving in excess of 500 miles. Trucks with those characteristics comprise approximately 70 percent of all trucks.

INTRODUCTION

The General Assembly requested the Secretary of Transportation to expand a previous study of establishing additional intermodal facilities (HJR-704) to include the potential for shifting Virginia's highway traffic to railroads. Interstate 81 was cited as an "acute example" in the resolution as its current traffic is made up of as much as 40 percent trucks although it was designed to carry no more than 15 percent.

Background

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) represented a most ambitious overhaul of the nation's transportation programs and goals. The intent of ISTEA was to "develop a national intermodal transportation system that is economically efficient, environmentally sound, provides the foundation for the Nation to compete in the global economy, and will move people and goods in an energy efficient manner." The Act changed the manner in which states were to perform transportation planning and resulted in more diverse approaches to meeting transportation needs. The 1998 successor to ISTEA, the Transportation Equity Act for the 21st Century, TEA-21, builds on ISTEA's initiatives and offers new initiatives to continue development of efficient and flexible transportation. The subject discussed in this report, shifting Virginia's highway traffic to rail, is a prime example of the "efficient and flexible" transportation sought through ISTEA and TEA-21.

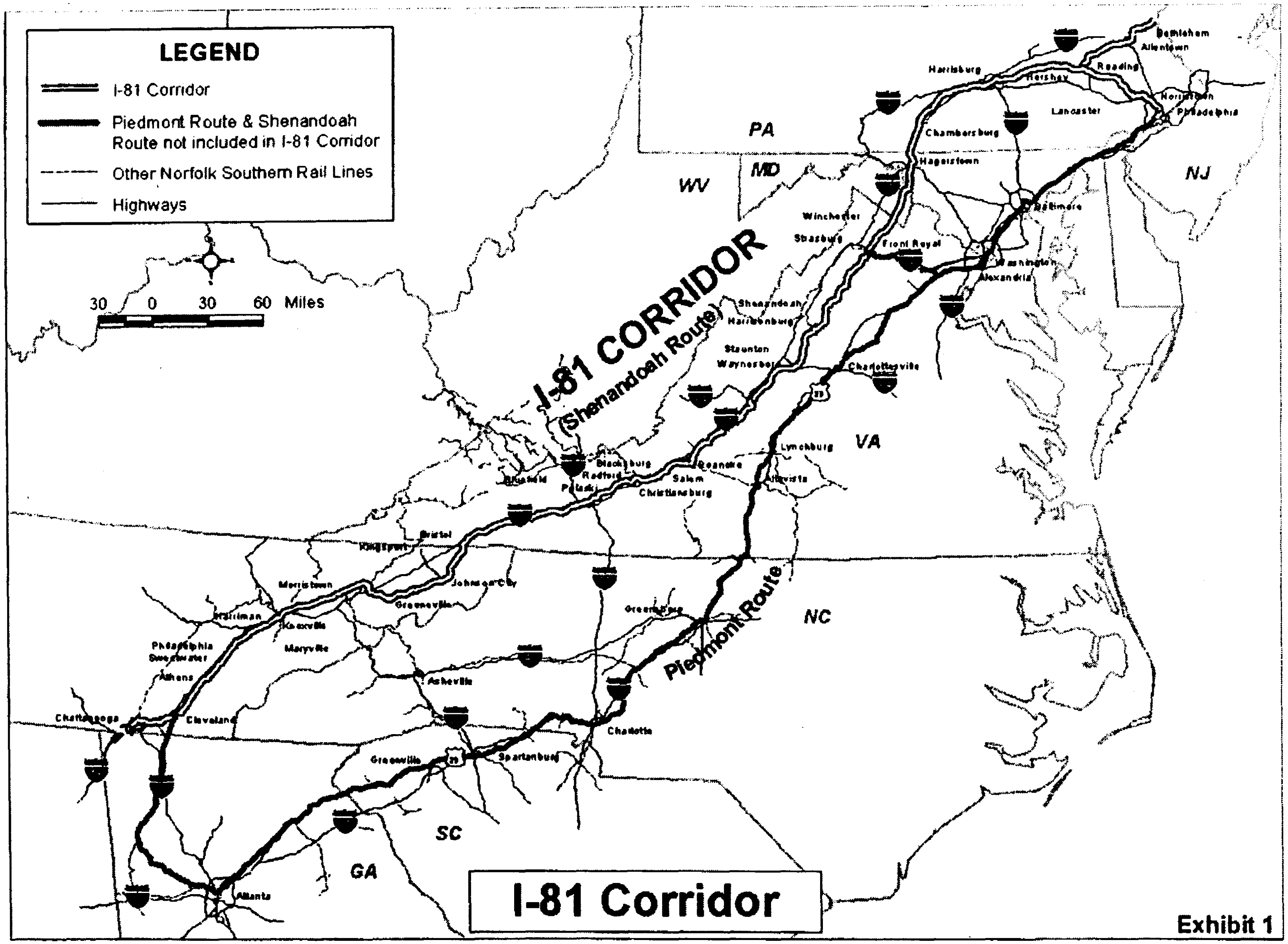
The Virginia Department of Transportation's announced program to widen and make other capacity and safety improvements to I-81 at a cost of $3.4 billion prompted a proposal from the Norfolk Southern Railway (NS) for the Commonwealth to consider investing in an alternative. Paralleling the highway are NS rail lines (see Exhibit 1) and the proposal advanced consists of investing in improvements to these lines which would promote diversion of highway traffic to rail as intermodal moves. NS suggested that rail line capacity could be increased faster and cheaper than that of the highway, eliminating or delaying improvements to I-81, and that investment of public funds should be considered for this purpose.

Study Rationale and Approach

The purpose of the study is to determine if the potential exists to divert enough truck traffic from I-81 to significantly impact the need for planned improvements,[2] and if the impacts over time would justify public expenditures for rail improvements. The approach to making the determinations includes a number of factors.

A variety of data on truck movements, I-81 characteristics and improvement plans, and railroad plans were gathered and analyzed. The analyses conducted examined the reasonableness of both highway and railroad plans and cost estimates, the amount of truck traffic

[2] Virginia and North Carolina have been studying the capital investment needed to provide rail passenger service improvements in the I-95 Corridor, the state's other major north-south route. These studies are being coordinated with Amtrak, CSXT, NS. VRE, FRA, FHWA, and FTA. These improvements will also benefit freight operation and provide capacity for diverted highway movements in that corridor.


LEGEND
I-81 Corridor
Piedmont Route & Shenandoah Route not included in I-81 Corridor
Other Norfolk Southern Rail Lines
Highways
30 0 30 60 Miles
PA
MD
WV
NJ
VA
NC
SC
GA
I-81 CORRIDOR
(Shenandoah Route)
Piedmont Route
Harrisburg
Bethlehem
Allentown
Reading
Hershey
Lancaster
Norristown
Philadelphia
Chambersburg
Hagerstown
Baltimore
Winchester
Front Royal
Washington
Alexandria
Harrisonburg
Staunton
Charlottesville
Lynchburg
Roanoke
Salem
Blacksburg
Radford
Christiansburg
Bristol
Kingsport
Johnson City
Morristown
Greeneville
Knoxville
Maryville
Harriman
Athens
Cleveland
Chattanooga
Asheville
Charlotte
Greenville
Spartanburg
Atlanta
I-81 Corridor
Exhibit 1

which might be diverted to rail, and the extent to which those diversions might impact I-81. In the case of the latter, both planned capital expenditures and long-range maintenance and environmental consequences were considered. The steps are discussed in more detail on the following pages.

DATA COLLECTED

Data to drive the study and its analyses are needed to portray a variety of activities. The first relates to the truck traffic, both total truck movements and the proportion of total trucks that has the potential to move by rail. Using the same measure as the HJR-704 study, the latter consists of truck shipments of the types of commodities would typically move in dry van semi-trailers (as opposed to flat bed, tank, or refrigerated van trailers) traveling over 500 miles.

HJR-704

The HJR-704 data prepared by Reebie Associates from its 1996 TRANSEARCH Database (a proprietary database derived and maintained by the firm) and analyzed by Parsons, Brinckerhoff, Quade and Douglas, became the initial data for this effort, but was superceded by a 1998 data set from the same source acquired by VDOT. The HJR-704 data, however, is limited to select commodities (those that would move in a dry van) and movement distances (over 500 miles), most likely to be diverted to rail intermodal, while the 1998 data is all-inclusive and more detailed. Reebie made forecasts of the 1998 data for the Year 2020 for the purpose of this study.

LATTS

The TRANSEARCH data set contains domestic traffic and international traffic moving inland from the country's ports. Cross-border traffic, such as that to/from Mexico and Canada is not included, however, requiring the use of other sources. For Mexican traffic, a database prepared by DRI for the *Latin America Trade and Transportation Study* (LATTS) sponsored by the Southeastern Transportation Alliance (comprised of 13 Southeastern states and Puerto Rico) of which Virginia is a member was used. DRI is the economics consulting unit of Standard and Poor's, a division of the McGraw-Hill Companies. The database contains freight traffic for two years – a 1996 base year, and a 2020 forecast year.

Canadian Traffic

Canadian traffic was captured using the International TRANSEARCH database for 1998. Forecasts were not available at the time of this printing, but estimates were prepared using the same growth rate as US domestic traffic.

Interstate-81 Improvement Studies

Roadway improvement needs for I-81 were established by a series of ten independent studies conducted by various consultants for VDOT in 1998. Combined, these studies investigated improvement needs based on projected 2020 traffic demands for the entire I-81 corridor, with the exception of two areas where significant improvements were underway (widening from the Tennessee state line through Bristol and construction of the Route 460/11 interchange). The composite recommendations and cost estimates developed in these studies form the basis of the I-81 improvement program.

Traffic and Roadway Data

Traffic and roadway data were provided by VDOT. Traffic data consisted of total traffic volumes and percentage trucks (single unit and combination vehicles) at selected locations along the I-81 corridor. These data included 1996/97 traffic counts and traffic forecasts for 2005, 2010, 2015 and 2020. DRPT provided estimates of potential rail passenger ridership which could impact automobile traffic on I-81.

VDOT also provided the Highway Performance Monitoring System (HPMS) data base, which was used in conjunction with the US DOT Highway Economic Requirements System (HERS) computer model to evaluate the impacts of freight diversion on I-81 improvement needs.

Norfolk Southern

Plans and cost estimates for railway improvements were obtained from and discussed with NS engineering officials. The plans and estimates were prepared as part of an NS evaluation of the project's potential.

Estimates of the potential for diversion of truck traffic to NS intermodal movements were also provided by the railroad. The estimates were prepared using the carrier's own methodology which considered the factors involved including proximity of freight to terminal locations, rail distance, ratio of rail line haul miles to truck mileage, how the movement fit the NS intermodal network, and service provision in both terms of speed and consistency.

ANALYSES PERFORMED

Once the necessary data were collected, a variety of analyses were conducted. The analyses are discussed in the following paragraphs.

Truck Assignments

Reebie Associates assigned truck flows for the 1996 data used in the HJR-704 study, and for the 2020 forecasts and included the assignments in those databases. The Canadian truck flows were assigned by Wilbur Smith Associates using a method developed by Oak Ridge National Laboratories jointly being used by Reebie Associates and Wilbur Smith Associates for the nationwide FHWA Freight Framework. Truck flows from the 1998 TRANSEARCH data and the LATTS traffic databases were assigned by Wilbur Smith Associates using an interstate system network and a shortest path approach. Assignments were made from the centroids of the applicable traffic analysis zones using TransCAD routines. The zones varied in the many databases from county to BEA to state levels.

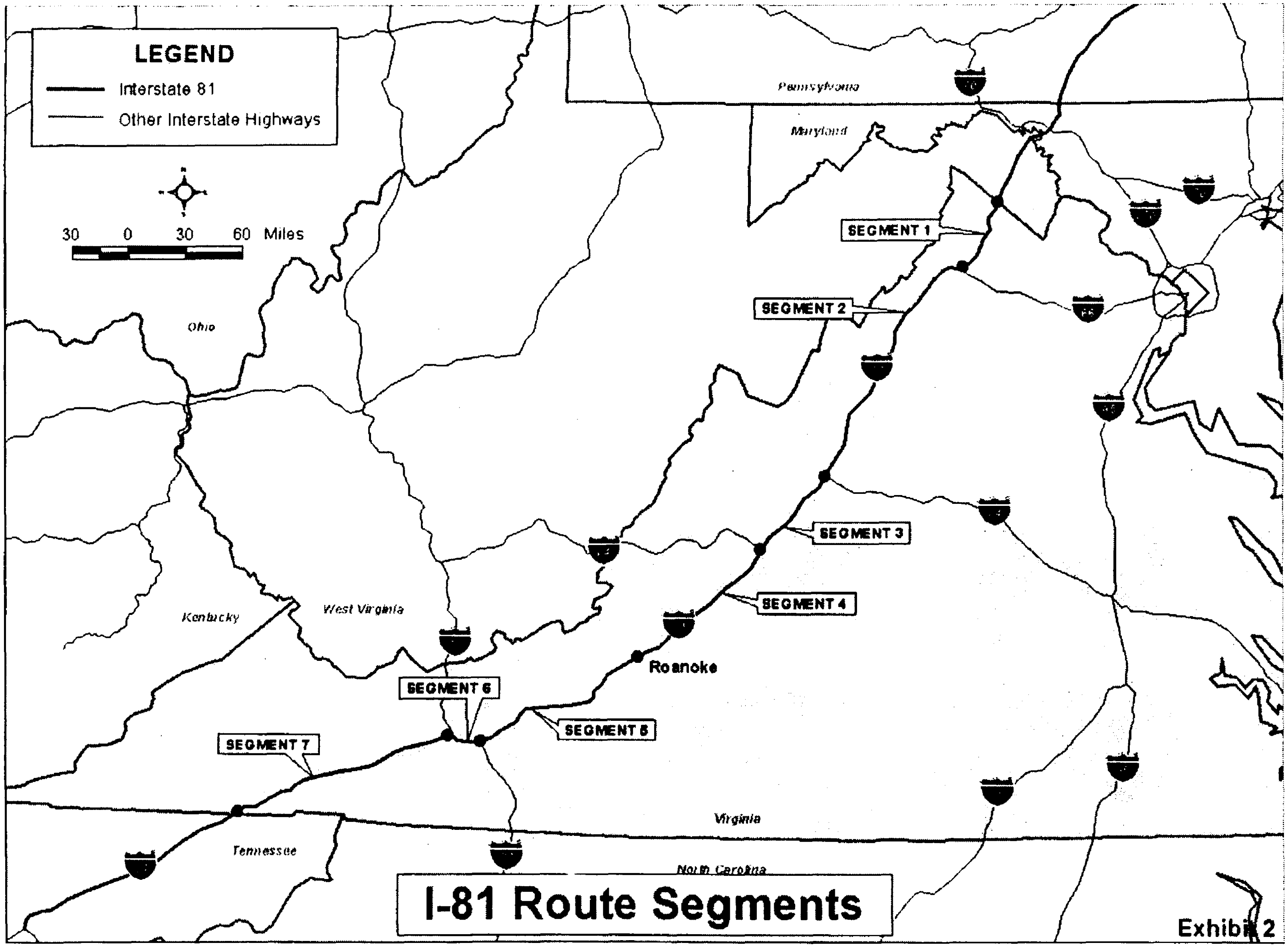
The 1996 and 2020 TRANSEARCH data sets contained only the movements of dry van trucks over 500 miles which had already been designated as the most likely candidates for diversion to rail intermodal. The 1998 TRANSEACH, the LATTS and Reebie Canadian databases had to be sorted by commodity at the 2- or 4-digit STCC level,[3] depending on the database, prior to route assignments. Where only 2-digit STCC data were available, a factor was applied to reduce the truckloads to an equivalent 4-digit level. The factor was derived from a ratio of the two STCC levels from the 1998 TRANSEARCH data.

The results of the assignments by I-81 segment (the segment designations are shown in Exhibit 2) are the subject of Exhibits 3 and 4. The segment volumes reflect the movement of trucks on and off I-81 at connecting roadways. Exhibit 3 displays the base year data while Exhibit 4 contains 2020 forecasts. The forecasts for traffic from Mexico increase over five fold for the period while the domestic traffic is forecast to grow 30 to 50 percent. Equivalent annual growth rates (compounded) are 7.1 and approximately 2 percent, or on an average annual basis, 17.4 and 1.7 to 2.4 percent, respectively. Forecasts by the Bureau of Labor Statistics are 6.4 to 6.9 percent for exports and imports and 2.4 percent for the gross domestic product.

Diversion Potential

Railroad intermodal traffic (trailers and containers transported by rail using a variety of equipment) is one of the fastest growing segments of the industry's freight traffic. The concept was also embraced by many segments of the trucking industry, both the truckload and less-than-truckload (LTL) carriers. It provided that industry with economical over-the-road transport and an alternative solution to selected industry problems such as the shortage of drivers, not to mention today's fuel costs.

[3] Standard Transportation Commodity Code (STCC), a 7-digit numeric code used to identify commodities. The first 2 digits in the code identify the commodity group, for example wood products, and each additional digit provides more detail leading up to the specific product.



I-81 Route Segments

Exhibit 2

Exhibit 3
BASE YEAR TRUCKLOADS

I-81 Segment	DATA SOURCE			TOTAL
		TRANSEARCH		
	DRI LATTS[1]	Canadian[2]	Domestic[3]	
1. WV-VA Border to I-66	61,185	48,489	1,854,923	1,964,597
2. I-66 to I-64	145,910	50,035	2,313,480	2,509,425
3. Joint w/I-64	147,173	47,695	2,313,480	2,508,348
4. I-64 to Roanoke	147,173	47,089	2,717,723	2,911,985
5. Roanoke to I-77	151,593	43,427	2,596,453	2,791,473
6. Joint w/I-77	151,593	101,732	2,743,778	2,997,103
7. I-77 to VA-TN Border	151,593	75,428	1,992,392	2,219,413

(1) 1996
(2) 1998
(3) 1998 includes international trade to/from domestic seaports.

Note: All truckloads are dry vans traveling > 500 miles.

Exhibit 4
FORECAST YEAR TRUCKLOADS

I-81 Segment	DATA SOURCE			TOTAL
		TRANSEARCH		
	DRI LATTS[1]	Canadian[2]	Domestic[3]	
1. WV-VA Border to I-66	321,431	83,277	3,185,728	3,590,436
2. I-66 to I-64	753,845	76,762	3,549,297	4,379,904
3. Joint w/I-64	761,048	73,205	3,550,870	4,385,123
4. I-64 to Roanoke	761,048	73,205	3,544,776	4,379,029
5. Roanoke to I-77	783,948	59,363	3,549,257	4,392,568
6. Joint w/I-77	783,948	131,979	3,559,555	4,475,482
7. I-77 to VA-TN Border	783,948	90,279	2,384,677	3,258,904

(1) 2020
(2) 2020
(3) 2020, includes international trade to/from domestic seaports.

Note: All truckloads are dry vans traveling > 500 miles.

The recent mega railroad mergers, both east and west of the Mississippi, however, resulted in railroad operating problems which led to severe service degradation. Intermodal traffic is very service sensitive and it left the rails during these periods of time. With service problems being resolved (an arguable point with some parties), intermodal traffic is beginning to return to the railroads.

Conrail Acquisition Application – One of the major benefits of the Conrail (CR) acquisition and split-up claimed by CSXT and NS was the potential to divert truck traffic to both rail intermodal and carload movement to the benefit of the highway system. The two railroads, CSXT and NS, combined estimated that almost 800,000 truckloads of freight could be diverted to rail intermodal annually. Included in the estimate were 179,946 truckloads in the I-81/77 corridor moving between the Northeast and Southeast.[4]

The Section of Environmental Analysis (SEA) of the Surface Transportation Board (STB) reviewed the diversion estimates and found the procedures and results reasonable. Although SEA expects that between the two railroads some double counting occurred, it was not to an extent to change the order-of-magnitude of the estimates.

HJR-704 Study – This examination of the potential for additional intermodal facilities in Virginia developed estimates of major origin and destination points of long-haul truck traffic passing through, and either originating or terminating in Virginia (with the other end of the move out-of-state) that had the most diversion potential. Intrastate traffic was not considered, as it would not meet the long-haul criterion of 500 miles. Highway assignments were also made. The total divertible traffic assigned to I-81 was over 2 million truckloads annually.[5] Estimates of the amount of this traffic that the railroads would likely capture were not made.

NS Diversion Estimates – As alluded to earlier, NS made its own evaluation of the potential to use its railroad in lieu of improvements to I-81.[6] This evaluation included an estimated range of diversion potential. A variety of factors were included in its estimate of the potential including: proximity of traffic movement end points to NS intermodal terminals; ratio of rail line haul miles to truck line haul miles; total rail distance; how the movement fits the NS intermodal network; and, service requirements in terms of speed and consistency. The latter consideration, especially service consistency, has been the rail industry's principal problem in attracting and maintaining intermodal business. In all, 310 origin-destination pairs involving 2.4 million shipments were considered.

The NS estimate was based on the same 1996 data used for the HJR-704 Study. Considering speed and service levels as the last step in its analysis, NS ended up with 3x3 matrix with an annual range from just over 2,000 units for the lowest combination of speed and service

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[4] Table 4-10, P. 4-43 Draft Environmental Impact Statement, Proposed Conrail Acquisition, Surface Transportation Board, December 1977 (based on 1995 data).

[5] These forecasts, based on 1996 data, were made by Reebie Associates using the same methodology as they use for STB proceedings.

[6] All of the NS estimates are considered preliminary in nature and were presented as a starting point for further study.

to just over 760,000 units for the highest combination.[7] Market share expressed as a percentage ranged from less than one percent to over 22 percent.

Existing Intermodal Market Share – The origin-destination pairs in intermodal terms are known as "lanes." The capture rate in lanes differs depending on the amount of traffic available and potential transit times over connecting routes and other factors. In lanes with high volumes, such as Los Angeles-Chicago, which permit frequent trains, and with a good route and service such as now provided by BNSF, continuing that initiated by its predecessor ATSF, capture rates have been reported as high as 80 percent of available traffic. Others are much lower at 5 to 10 percent, Winston-Salem, North Carolina to New York, New York and Memphis, Tennessee to New York, for example, respectively. The 704 Study cites a June 1999 NS press release, which states it "has captured a high percentage – 27 percent – of this very truck competitive traffic within its territory,[8] about twice Conrail's market penetration within its territory."

Long-distance trucks using I-81 are basically bi-direction movements between the Southeast/Southwest and the Northeast. Major origin-destination pairs identified in the data reviewed in this study effort are between points in the South such as: Piedmont North and South Carolina; Atlanta, Georgia; Nashville, Tennessee; Houston and Dallas-Ft. Worth, Texas; Birmingham and Huntsville, Alabama; and points in the Northeast such as New York, Philadelphia, Washington-Baltimore, and Boston. Based on tables compiled and presented in the HJR-704 Study, the relative rail intermodal market share ran from 1 to 27 percent for these movements, with 10 to 20 percent typical. In comparison, the rail intermodal market share between the two major urban centers of New York and Chicago, based on 1998 TRANSEARCH data is 38 percent.

Haul Distances – The haul distance cut-off for diversion of truck to rail used in the HJR-704 study, and adopted for this effort, was 500 miles. The economies of long-distance rail movement have to overcome the costs of the transfer between rail and truck (twice) and local truck pick-up and delivery. Many parties would argue that hauls of 750 to 1,000 miles are necessary before the economies of rail intermodal transport can be realized. Fortunately, the longer distances are prevalent as the average haul is just over 1,300 miles for the primary movements being considered. Movements from Texas to the Northeast are 1,500 to 1,700 miles long. The shorter moves, e.g., Nashville to Washington-Baltimore, Charlotte to New York, are 600-700 miles long.

Freight Diversion Expectations – The volumes shown in the NS-CSXT-CR merger/acquisition application and review documents to be attracted to rail from the I-77/I-81 corridor, 179,949, represent approximately 8.5 percent of the 1996 divertible loads on I-66 revealed in the HJR-704 study, not accounting for any growth between 1995 and 1996. The approximate 180,000 truckloads do not, however, account for any cross-border NAFTA traffic, nor any domestic traffic from Texas. Access to both Canadian and Mexican traffic (as well as Texas traffic) is available to NS over its own lines in the first case, and through marketing

[7] NS expanded the 1996 data by a factor of 1.41 based on VDOT counts. The result is very close to assignments using 1998 TRANSEARCH data.
[8] Norfolk Southern service territory.

alliances in both cases. As shown in Exhibits 3 and 4, cross-border traffic on I-66 is estimated to be just less than 10 percent of the total truck flows in the base year and 20 percent in 2020. As discussed earlier, Texas – Northeast highway traffic flows represent one of the larger origin-destination pairings making use of I-81.

Using a different analytical approach in the merger documentation, CSXT estimated a 13-point gain in a 1995 market share of 13.6 percent for intermodal in the I-85 corridor.[9] CSXT's I-85 corridor is a Southeast-Northeast lane very similar to the I-66 corridor of NS, with most of the same major origin-destination pairs. CSXT, however, announced in June of 2000 that it was demarketing service to and from Charlotte and Atlanta and several points including the Northeast to concentrate on longer-haul Florida business. While this marketing shift may only be temporary, it will certainly impact NS-CSXT competition for the business in addition to having the potential to increase truck flows over I-66. CSXT's lack of double-stack clearances in Washington, DC and Baltimore, MD tunnels also impacts competition for Southeast-Northeast intermodal traffic.

In addition to the longer haul characteristics stated just before, the targeted freight flows between areas that have not had the benefit of single-line service previously and thus offer a better opportunity to attract traffic to rail than would where the service already exists.

The ten percent diversion range was a mid-point in the NS estimate prepared as part of its current proposal to the Commonwealth. The estimate, however, is highly dependent on service characteristics, principally transit time and consistency. Projected schedules shown for new intermodal services in the CR transaction documentation reflect the required service for this diversion rate. While physical improvements can be made to increase the possibility of attaining the necessary goals, the final result is really dependent on the carrier's marketing and operations.

Based on the factors considered above and combined with service improvements, a ten percent diversion factor would appear to be a reasonable expectation and is adopted for analysis purposes for this study.

Passenger Diversions (Bristol) – In 1994, VDRPT initiated a study of the feasibility of instituting passenger rail service between Bristol and both Richmond and Washington, DC. The proposed service uses the existing NS tracks through Lynchburg where the service is to branch between the two proposed termini. The initial study, completed in early 1996, indicated that it is feasible to operate two round trips per day utilizing modern tilting trains equipped with steerable wheelsets. Ridership and revenues were projected to be strong and to grow steadily as the population and economy of the region continued to expand.

A second phase of the project was initiated to analyze in greater detail the issues raised in the initial study, with the most important task being to establish the ability of the proposed passenger service to operate without impeding existing and future freight service. Several refinements were made, and a complete financial analysis was conducted to identify the capital, operating and maintenance costs, along with revenues necessary to operate the proposed service. The projected ridership generated in Phase 2 are shown following:

[9] Finance Docket No. 33388, Volume 2A, June 1997, p.252.

Year	2000	2005	2010	2020
Ridership	372,100	476,000	582,500	782,100

Amtrak is currently reviewing the Department's report and is preparing independent forecasts using its national "gravity" model, which is based solely on population served and service frequency, to estimate ridership. The Department's model uses information on current-year travel in Virginia and forecasts of change in demographics and economics to determine potential ridership.

Amtrak forecasts reflect significantly lower ridership levels than those projected by the DRPT study. While the Amtrak analysis has not been finalized, its preliminary estimate is that approximately 70,000 passengers per year will use the Bristol rail passenger service initially, as compared to the 372,000 riders projected in the DRPT study. For the purposes of this study, the two estimates are used as the maximum and minimum forecast of ridership.

In order to estimate the impact of the proposed passenger rail service on I-81 improvement needs, projected ridership levels were used to estimate the potential diversion of passenger vehicles from I-81. Using passenger origin-destination data reported in the Bristol studies, it was estimated that approximately 80 percent of the potential rail service patrons would have traveled on I-81 south of Roanoke, while 40 percent would have traveled on I-81 north of Roanoke. Based on these factors and an average automobile occupancy of 1.2 passengers, it was estimated that diversion of passenger trips to the proposed Bristol service could reduce total vehicle trips on I-81 by a range of less than one percent on the low end of the range, and up to one to two percent on the high end.

NS Costs

The Norfolk Southern capital costs were estimated by its engineering department. The stated objective for NS Engineering was to prepare a preliminary engineering evaluation of the physical improvements required to provide additional capacity and increased operating speed on the NS rail lines in the I-81 Corridor. The original plan was to provide bi-directional running double track for the entire corridor. After a cursory review, NS engineering felt that a second track was impractical in several locations and the plan developed and presented was one of bi-directional running double track at every location practical, with bi-directional single track over the remainder. The single-track portions total 98 miles or 14 percent of the total corridor. In Virginia, 69 of the 356 miles, or 19 percent would be single track. Therefore, this plan should be considered as a maximum improvement.

Both the quantities and unit costs contained in the estimate were closely examined. It was not possible to evaluate all costs, however, as some were provided as lump sums, and others, such as bridges and structures (the largest component of the estimate in Virginia at 48 percent of total costs) were provided without sufficient detail for evaluation. Those items that were examined, however, were prepared with a high degree of accuracy.

Of the total estimated railway cost of $2.3 billion, improvements equating to $1.2 billion would lie in Virginia. As shown in Exhibit 5, most (70 percent) are related to capacity increases.

Exhibit 5
SUMMARY OF ESTIMATED PROJECT COST IN VIRGINIA

Item	Cost (Millions)	Percentage
Capacity Improvements	$862	70.4
Speed Improvements	$140	11.4
Other	$122	10.0
Eng. Contingency	$100	8.2
TOTALS	$1,224	100.0

Given the complexity (703 miles), limited traffic information, and time frame to complete the estimate, the NS engineering staff did a creditable job. Although there are some arguable items in the estimate, in the aggregate the project cost of $2.3 billion is a good order-of-magnitude value or as stated by NS, a preliminary "doorknob" cost estimate. The project is estimated to be implemented over a period of seven years – three years engineering and permitting, and four years construction.

The capacity improvements are significant as indicated by the cost estimate. They provide the capacity to handle many more trains than anticipated at the 10 percent diversion level, especially if the use of alternate routes is considered as discussed in the following paragraphs. While the NS cost estimate is reasonable for the scope of the project presented, the project itself should be redefined considering likely traffic levels and routing alternatives, and the estimate revised accordingly for evaluation purposes.

NS Routes

The NS route through Virginia that is the subject of the railroad's proposal is a portion of one of the Railway's two principal North-South routes designated as the Shenandoah Route in its application to the Surface Transportation Board in the Conrail Acquisition[10]. The route is also shown in the same document as a component of the new NS intermodal system whereas only the portion of the route from Roanoke to Knoxville had been previously included as a component of the network (and that portion for east-west traffic). The route was represented to be the recipient of $12.1 million in improvements in new sidings and siding extensions, four in Virginia and two in Tennessee. In addition, clearance improvements were listed for the Shenandoah route and connecting lines. Based on the STB Operational Monitoring Report on the NS website dated December 31, 2000, all but three siding extensions had been completed.

[10] Finance Docket No. 33388, Volume 3B, June 1997.

The principal NS North-South intermodal route prior to the acquisition was the former Southern Railway Washington – Atlanta main track (designated the Piedmont Route, see Exhibit 1) connecting with Conrail at Hagerstown, Maryland via Manassas and Front Royal (Riverton Junction). Adoption of the Shenandoah Route would not preclude continued use of the Piedmont Route, and in fact for some of the Southeastern major origins/destinations in the Piedmont Carolinas, such as Charlotte and Greensboro, the Piedmont Route is a more logical choice.

The two routes also offer the potential to be used in combination with each other, spreading capacity demands and providing operating flexibility. Connections between the two routes exist in the Roanoke-Lynchburg/AltaVista area in addition to the Manassas – Riverton Junction line. Thus, improvements in the Piedmont Route may also be considered or made in lieu of Shenandoah route improvements.

In reality, it doesn't matter over which route the rail traffic moves as long as the truck traffic is removed from I-81. In an extreme case, traffic from Mexico, for example, moving over the Union Pacific Railroad or the Burlington Northern and Santa Fe Railway to Chicago and then east to the Northeast, would serve to remove trucks from I-81.

I-81 Improvement Needs

The *Interstate-81 Improvement Studies* identified roadway improvement needs through the year 2020 for the entire 324-mile I-81 Corridor in Virginia. These needs, combined with ongoing improvement projects, form the basis of the $3.4 billion (1998) I-81 improvement program that is the subject of the NS proposal.

The I-81 studies identified improvements needed to provide the desired quality of traffic service in the year 2020. Consistent with current highway planning and design practice, operating Level of Service[11] (LOS) C was used as the quality of service goal for these studies. With some exceptions, these studies found that I-81 was currently operating with demand below capacity and above minimum service levels. Failing and/or near failing conditions were beginning to develop at certain interchanges, near steep grades where truck operations were reduced and around some urban locations. Based on projected traffic demand for 2020, failing traffic conditions were found to be widespread, indicating the need for significant capacity improvements throughout the corridor. In addition, these studies also found that due to changes in standards since the design of I-81, numerous locations failed to meet minimum safety and operating standards. Typical of these deficiencies were inadequate shoulder widths and substandard clearances beneath bridges and overpasses.

Collectively, the I-81 studies recommend approximately 230 improvements needed in the I-81 Corridor by the year 2020, although no general implementation plan or schedule was proposed. Primarily based on projected capacity deficiencies, the study recommendations generally consisted of:

[11] Level of Service (LOS) is a qualitative measure of the overall quality of traffic service for a highway facility. Much like a report card, LOS A indicates the best possible operating conditions. Levels B through D indicate increasing, but still acceptable, levels of traffic density and interaction among vehicles. LOS E indicates operation at capacity and LOS F indicates congested traffic conditions with demand exceeding capacity.

- Roadway widening throughout the corridor,
- Auxiliary lanes (truck climbing lanes) at selected locations,
- Interchange improvements, and
- Interchange reconstruction.

As part of the concept plans for these improvements, substandard design elements were eliminated, and aging or failing infrastructure replaced or rehabilitated.

VDOT's Transportation Development Program (TDP) for FY 2000-2001 identifies almost 70 projects that are currently programmed for implementation or feasibility study within the I-81 Corridor. Included in the current TDP are projects that are currently under construction (widening from the Tennessee state line through Bristol and the Route 460/11 interchange near Roanoke), improvements identified in the *Interstate-81 Improvement Studies* and other projects, such as rest area construction and improvements, identified as corridor needs. Almost one-half of the projects in the TDP are "priority projects" as defined in the *Virginia Transportation Act of 2000* and twenty are elements of the I-81 Safety Improvement Program. Specific I-81 corridor projects are presented in the Transportation Development Program for FY 2000-2001.

I-81 Improvement Costs

Estimates of I-81 improvement costs were obtained from the current Transportation Development Program and the *Interstate-81 Improvement Studies* and are summarized in Appendix C. The current TDP provides total funding for projects in the I-81 Corridor of $744,753,000. This includes projects that are currently under construction, VTA 2000 priority projects, I-81 Safety Improvement Program projects and other improvements.

Improvements currently under underway in the I-81 Corridor include widening from the Tennessee state line through Bristol and construction of an interchange with Route 460/11 near Roanoke. The current cost estimates in the TDP for these projects, which were included in the total $3.4 billion cost estimate for I-81 improvements, are:

Widening near Bristol	$82,404,000
Route 460/11 interchange	63,738,000
Total	$146,142,000

Projects in the TDP identified as "priority projects" in the VTA 2000 and/or are elements of the I-81 Safety Improvement Program that are related to recommendations in the I-81 improvement studies represent the following estimated total costs:

VTA 2000 Priority Projects (including related safety projects)	$448,616,000
Other projects	149,995,000

Improvements recommended in the *Interstate-81 Improvement Studies* were estimated to cost approximately $3.3 billion. Summary cost estimates for these improvements were included in the study reports. By study section, the estimated improvement costs are:

Study Section	Milepost		Improvements Costs
	From	To	
1	7	22	$104,054,718
2	22	72	371,300,500
3	72	83	354,182,000
4	83	116	352,071,000
5	118	163	508,273,729
6	163	180	150,564,800
7	180	229	477,557,000
8	229	264	361,135,000
9	264	305	380,302,000
10	305	324	239,000,000
	Total Estimated Costs		$3,298,440,747

The cost estimates for improvements recommended in the I-81 improvement studies were critically reviewed for their overall reasonableness and consistency. Recognizing these estimates were preliminary in nature, this review concluded that although there were minor differences among the individual studies, collectively they:

- Were based on reasonable concept improvement plans;
- Reflect generally accepted procedures and level of detail for estimates of this type;
- Were developed in a generally consistent manner among the ten studies; and
- Represent reasonable preliminary cost estimates for the recommended improvements.

These improvement recommendations were also reviewed to determine which, if any, were required regardless of the potential diversion of future traffic to rail. While this review was intended to identify critical improvements justified primarily by safety and/or infrastructure rehabilitation/preservation, the emphasis of these studies on capacity-based needs and limited information on safety and infrastructure needs made direct assessment of these critical improvements infeasible. There are, however, a number of improvements included among the VTA 2000 "priority projects" and in the I-81 Safety Improvement Program that relate directly to recommendations of the *Interstate-81 Improvement Studies*. These projects, mentioned earlier, were not considered to be impacted by diversion of highway traffic to rail.

For this study, the net improvement costs considered to have the potential to be impacted are as follows:

Total I-81 Improvement Costs	$3,298,440,747
Costs not Subject to Elimination or Deferral	594,758,000
Net Costs Subject to be Impacted	$2,703,682,747

Highway Impact Analysis

This section of the report describes the potential effects of shifting traffic from highways to railroads. Specifically, it examines the effects of less truck traffic on highway users and the infrastructure. Three types of effects are analyzed: capacity-related, safety-related, and pavement-related effects.

Marginal Costs of Automobile and Heavy Truck Travel - The Federal Highway Administration (FHWA) recently published the results of a detailed highway cost allocation study. As part of the study, FHWA developed a set of marginal cost factors for travel by various types of vehicles on principal highways. Exhibit 6 presents a partial list of marginal cost factors attributable to automobiles and heavy trucks when traveling over interstate highways. Although these are national values, they illustrate the general congestion, pavement, and safety effects of heavy truck travel.

Exhibit 6
MARGINAL PAVEMENT, CONGESTION, AND CRASH COSTS FOR ILLUSTRATIVE VEHICLE CLASSES: 2000

Vehicle Class / Highway Class	Marginal Costs (cents per mile)		
	Pavement	Congestion	Crash
Autos / Rural Interstate	0	0.78	0.98
Autos / Urban Interstate	0.1	7.70	1.19
80-kip 5-axle Truck / Rural Interstate	12.7	2.23	0.88
80-kip 5-axle Truck / Urban Interstate	40.9	20.06	1.15

Notes: 1 kip equals 1,000 pounds. Costs reflect middle range estimates.
Source: Federal Highway Administration, *1997 Federal Highway Cost Allocation Study.*

According to FHWA, the marginal pavement cost of an 80,000-pound combination truck traveling on a rural interstate highway is 12.7 cents per mile. In comparison, the marginal pavement cost of the same truck is almost 41 cents per mile on urban interstate highways. Marginal congestion costs are approximately 20 cents per mile for an 80,000-pound truck traveling on urban interstate highways, but only 2.23 cents per mile on rural interstate highways. Finally, marginal crash costs are 1.15 and 0.88 cents per mile for an 80,000-pound truck traveling on urban and rural interstate highways, respectively.

The congestion and crash costs shown in Exhibit 6 are not used directly in the analysis. Instead, congestion and crash costs are estimated for specific highway sections of I-81 using specific traffic and vehicle class data. The basic concepts underlying the calculations are highlighted next.

General Capacity-Related Effects of Truck Traffic - The capacity of a highway segment is the maximum flow that can be accommodated during an interval of time, as measured in passenger cars per hour per lane (pcphpl). The *Highway Capacity Manual* defines six levels of service for basic freeway segments (A-F).[12] Exhibit 7 shows the maximum flows and travel conditions associated with these service levels for a "free-flow" speed of 70 mph under ideal conditions.[13]

Two important indicators of congestion are minimum travel speed and volume-to-capacity (v/c) ratio.[14] Generally, highway segments with v/c ratios of .80 to .95 are described as "moderately congested" while segments with v/c ratios of .96 or greater are described as "highly congested."[15] A v/c ratio of .80 typically corresponds to Level of Service D. At this ratio, the volume of traffic is 80 percent of the maximum that can be accommodated on a highway. A driver's "freedom to maneuver is noticeably limited" and incidents "result in substantial delays."[16]

Exhibit 7
LEVEL OF SERVICE CRITERIA FOR BASIC FREEWAY SECTIONS: FREE-FLOW SPEED = 70 MPH

Level of Service	Minimum Speed (mph)	Maximum Flow Rate (pcphpl)	Maximum v/c Ratio
A	70.0	700	.29
B	70.0	1120	.47
C	68.0	1632	.68
D	64.0	2048	.85
E	53.0	2400	1.00
F	variable	variable	variable

As level of service declines from A to E for a basic freeway segment with a free-flow speed of 70 mph, the volume-to-capacity ratio increases from .29 to 1.0, while travel speed declines from 70 mph to 53 mph (Exhibit 7). At level of service E, the traffic volume consumes the theoretical capacity of the lane. Below level of service E, travel speeds are unstable with frequent speed-change cycles.

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[12] Transportation Research Board, National Research Council. *Highway Capacity Manual*, Special Report 229, Washington, DC, 1998.

[13] Free flow represents traffic flow that is unaffected by upstream or downstream conditions (TRB, 1998).

[14] The source of the data is Table 3-1 of the *Highway Capacity Manual*. The average travel speeds shown in Table 3-1 represent ideal conditions. Average speeds under less-than-ideal conditions may be lower than those shown in Table 3-1.

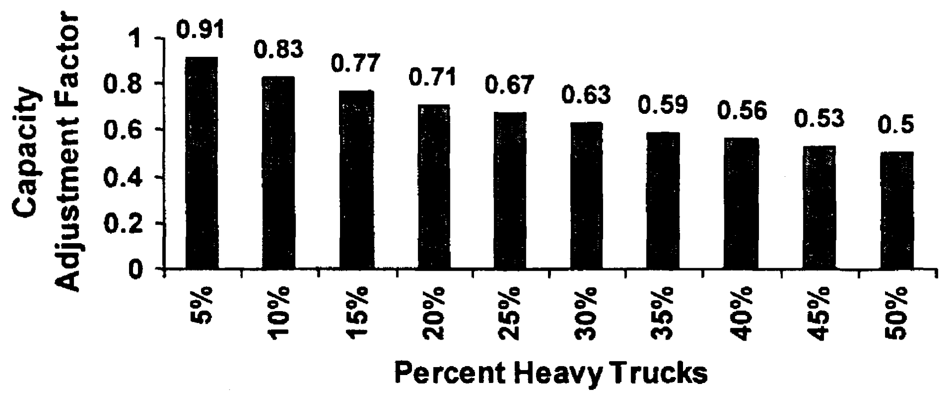
[15] The United States Secretary of Transportation. *The Status of the Nation's Highways, Bridges and Transit: Conditions and Performance*, 1993, page 98.

[16] U.S. Department of Transportation, Federal Highway Administration. *1999 Status of Nation's Surface Transportation: Conditions and Performance Report*, Washington, DC, Page 4-3.

As shown in Exhibit 7 the theoretical (ideal) capacity of a basic freeway segment with a free-flow speed of 70 mph at level of service E is 2,400 passenger cars per hour per lane. It is important to note that the removal of a truck from a traffic stream increases the maximum capacity of a lane by more than one unit. On a general freeway segment, each additional truck is equivalent to 1.5 passenger cars on level terrain and 3.0 and 6.0 cars on rolling and mountainous terrain, respectively.[17]

The effects of truck traffic on lane capacity are illustrated in Exhibit 8 for rolling terrain. Five percent trucks in the peak-travel period lowers the ideal flow of a highway section in passenger cars per hour per lane (pcphpl) to 91 percent of its theoretical maximum. This latter value is the maximum flow possible if all vehicles in a traffic stream are passenger cars. As shown in Exhibit 8, the maximum service flow of a highway section (in pcphpl) is half of its theoretical maximum with 50 percent trucks in the peak-period traffic stream.

Exhibit 8
RELATIONSHIP BETWEEN PERCENT TRUCKS AND HIGHWAY CAPACITY FOR ROLLING TERRAIN



Peak-Period Lane Capacity Drops to Two-Thirds of Ideal Capacity with 25% Trucks
and to One-Half of Ideal Capacity with 50% Trucks

Highway user costs are impacted by higher v/c ratios in two major ways. Vehicle operating costs (fuel, oil, tires, maintenance and repairs, and use-related depreciation) increase as travel speeds decrease and as the frequency of stop-cycles and idling times increase. Slower speeds also result in greater travel-time costs.

Overview of Analytical Approach - The effects of shifting truck traffic to railroads are analyzed by comparing highway conditions and performance levels in a "base case" to conditions and performance levels in an "impact case." In the impact case, highway traffic

[17] These are typical factors for travel on a general freeway segment. The data are derived from Table 3-2 of *Highway Capacity Manual 1997*, Transportation Research Board.

levels reflect the diversion of truck traffic to railroads. This truck traffic is referred to as *incremental* traffic, because it would move by rail in the impact case. The objective of the analysis is to compare highway conditions and performance with and without the incremental truck traffic.

The capacity and safety impacts presented in this report have been computed using the Highway Economic Requirements System (HERS). HERS is a comprehensive highway performance model used to develop testimony for Congress. Output from HERS is used in preparing the U.S. Department of Transportation's biennial report to Congress on the "Status of the Nation's Surface Transportation System."

The HERS methodology used in this study differs from the methodology used in the *Interstate-81 Improvement Studies* in two key aspects: These are:

- The HERS methodology is an economic analysis which uses projected highway operating conditions (as defined by volume-to-capacity ratio), accident occurrence, environmental factors and maintenance needs to estimate user and agency costs and benefits and determine future improvement needs. The *Interstate-81 Improvement Studies* used highway capacity analysis procedures to determine future operating conditions and identify improvements needed to maintain acceptable quality of service.
- The *Interstate-81 Improvement Studies* considered the effects of restricting heavy trucks to the outer two lanes of travel in areas where three or more lanes were provided. The HERS analysis does not reflect this restriction of truck operations.

HERS uses the Highway Performance Monitoring System (HPMS) database, which is a stratified random sample of a state's highway system. Each state transportation department collects traffic, pavement, ride quality, and other highway data needed to update the database each year. FHWA uses data from all states to develop reports for Congress. However, HERS can be applied to an individual state's database to produce specific state reports.

HERS reports are organized by functional highway class. They show vehicle-miles of travel, average speed, hours of congestion delay, crashes, fatalities, injuries, and unit costs of highway travel. HERS performs many highway capacity calculations using factors from the *1997 Highway Capacity Manual*, such as those shown in Exhibit 7. It evaluates the AADT, v/c ratio, theoretical peak capacity, percent trucks, pavement serviceability rating (PSR), and other highway or travel conditions that affect highway user costs. These evaluations are performed for each sample highway section in the HPMS database. Using this information, HERS estimates a set of unit costs per thousand vehicle-miles of travel for the three cost categories mentioned earlier: vehicle-operating costs, travel-time costs, and safety costs. A separate set of unit costs is estimated for each highway functional class.

In this analysis, highway capacity is assumed to be fixed. Highway benefits are defined as changes in travel-time, vehicle-operating, and accident costs, assuming that part of the truck traffic moving on I-81 is shifted to railroads. Analyses are performed for a base year (1998) and a forecast year (2020). In both analyses, the number of lane-miles remains the same.[18]

Many steps are necessary before HERS is used in a multimodal comparison such as this. The main steps followed in the analysis are outlined below.

1. Assign the incremental truck traffic to general segments of I-81.

2. Make a detailed assignment of the incremental truck traffic to sections of I-81 in the Virginia HPMS database.

3. Run HERS using the traffic and highway data contained in the 1998 HPMS database. (The purpose of this initial HERS run is to create a base case for purposes of comparison.)

4. Remove the incremental truck traffic from the HPMS sample sections and re-compute the average annual daily traffic, the percentage of trucks in the traffic stream, the peak capacity, and the maximum volume-to-service flow. (These calculations are necessary to reflect the removal of truck traffic from the existing traffic base.)

5. Run HERS using the adjusted HPMS data file. The only difference between the impact case and the base case is the incremental truck traffic that is removed from the potentially affected highway sections.

It is important to note that changes in vehicle-operating and travel-time costs are estimated for highway users other than the incremental truck traffic. Vehicle-operating and travel-time costs are **not** computed for the incremental trucks. In a multimodal analysis, the user costs incurred by these trucks would have to be subtracted from the railroads' cost of moving the same freight.

Accident Analysis Approach - In this study, HERS is used to calculate highway accident costs for the incremental traffic. These costs reflect the specific traffic and design characteristics of individual highway sections. Railroad accident costs are calculated using accident rates for rail movements on the Norfolk Southern.

Accident-related costs consist of three primary categories: property damage, injury, and fatality. Because of data limitations, the environmental and social costs of hazardous materials accidents are not addressed in this study. However, property damage, injury, and fatality costs are estimated for all types of accidents, including those involving hazardous materials.

For purposes of consistency, the same fatality and injury costs are applied to both modes. These unit costs are estimated by the National Safety Council (NSC) and represent the average costs of fatal and nonfatal unintentional injuries. NSC recommends the use of "comprehensive

[18]The base year for this study is 1998, the latest year for which verified data and cost factors are available for all key inputs. The HERS reports describe conditions at the beginning of the period. These are the values used in the fixed capacity analysis.

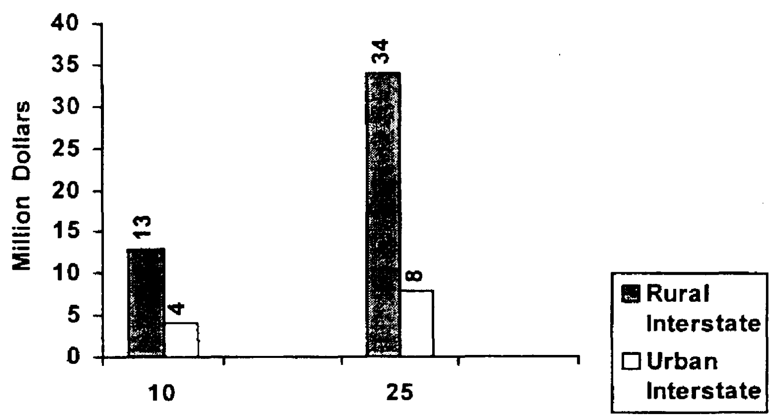
costs" for purposes of benefit-cost analysis.[19] Comprehensive costs include economic costs plus a measure of the value of "lost quality of life." The economic components of motor-vehicle injury and fatality costs include wage and productivity losses, medical expenses, and administrative expenses.[20] However, these estimates do not include the "value of a person's natural desire to live longer or to protect the quality of one's life;" i.e., someone's willingness to pay for improved safety. This value has been estimated through empirical studies of what people actually pay to reduce their safety and health risks. According to NSC, comprehensive accident costs can be interpreted as "the maximum amount society should spend to prevent a statistical death or injury."

A two-step accident analysis process is followed for rail and truck: (1) estimate annual accidents, fatalities, and injuries for the incremental traffic and (2) multiply the annual events by the applicable unit cost per accident, fatality, or injury. The highway accident rates used in HERS reflect the type of highway section and mix of highway vehicles. Railroad accident costs are based on distances traveled in Virginia.

Results of Base-Year Highway Impact Analysis

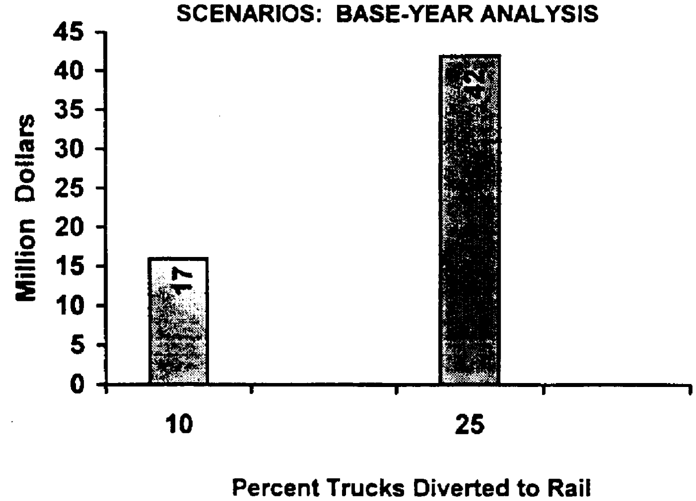
The projected changes in travel-time and vehicle-operating costs for the base year are shown in Exhibits 9 and 10. In Exhibit 9, costs are shown by highway functional class. Exhibit 10 shows total values for both rural and urban sections of I-81. Each figure shows the estimated reduction in travel-time and vehicle-operating cost caused by the hypothetical removal of combination trucks from the base-year (1998) traffic stream. Projected cost savings are shown for 10 and 25 percent reductions in combination truck travel. A reduction of 10 percent resulting from highway diversion appears, based on other studies, to be a reasonable expectation. The 25 percent diversion represents a ceiling which would be reached only under the most ideal conditions.

Exhibit 9
REDUCTION IN TRAVEL-TIME AND VEHICLE OPERATING COSTS FOR I-81 SCENARIOS: BASE-YEAR ANALYSIS



[19] This description of comprehensive costs is paraphrased from: *Injury Facts, 1999 Edition*, National Safety Council.
[20] Wage and productivity losses include the value of wages, fringe benefits, household production, and travel delay. Medical expenses include ambulance and helicopter transport costs.

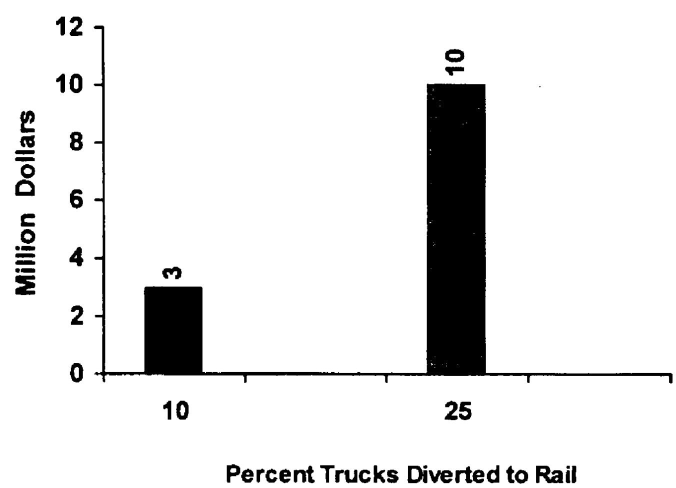
Exhibit 10
TOTAL REDUCTION IN TRAVEL-TIME AND VEHICLE OPERATING COSTS FOR I-81 SCENARIOS: BASE-YEAR ANALYSIS



As Exhibit 9 shows, removing 10 percent of the combination truck traffic from I-81 will reduce annual vehicle-operating and travel-time costs by approximately $13 million on rural sections and $4 million on urban sections. Removing 25 percent of the combination truck traffic from I-81 will reduce annual vehicle-operating and travel-time costs by approximately $34 million on rural sections and $8 million on urban sections.

Exhibit 11 shows the net projected change in accident costs for the base year. In this chart, the estimated increase in rail accident cost has been deducted from the estimated reduction in highway crash cost. As the chart shows, removing 10 percent of the combination truck traffic from I-81 will reduce annual accident costs by approximately $3 million. Removing 25 percent of the combination truck traffic from I-81 will reduce annual accident costs by approximately $10 million.

Exhibit 11
NET REDUCTION IN ACCIDENT COSTS FOR I- SCENARIOS: BASE-YEAR ANALYSIS



<u>Pavement Marginal Costs</u> - With the exception of studded-tire wear, automobile traffic has little effect on pavements (Exhibit 6). The deterioration of pavements is primarily a function of truck axle loads and environmental forces. Thus, a reduction in truck traffic will reduce future resurfacing and/or reconstruction costs.

The marginal pavement costs and truck user fees are generalized estimates developed using the marginal pavement cost factors shown in Exhibit 6. The marginal pavement costs of truck travel will vary with the net and gross weights of the containers and chassis used, the distribution of truck weights among axle groups, the distribution of empty and loaded movements on sections of I-81, and the structural characteristics of pavement sections. Truck registration and special fees will vary with assessed vehicle values and many other factors.

Roughly 76 percent of the incremental truck-miles of travel occur on rural sections of I-81. Based on the heavy truck factors shown in Exhibit 6, the weighted-average marginal pavement cost is approximately 19 cents per truck-mile.

The removal of trucks from I-81 will significantly reduce truck user fees. A precise estimate of the reduction in user fees depends upon state registration and special fees, which are based on vehicle values, registered weights, and other factors. A preliminary estimate suggests that all federal and state user fees -- including motor fuel taxes, heavy truck user fees, and vehicle and tire excise taxes -- are just less than 14 cents per truck-mile. Thus, the loss in truck revenues will be less than the reduction in marginal pavement cost equating to approximately 5 cents per truck-mile.

Using the applicable percentages of the base year and forecast truckloads in Exhibits 3 and 4, respectively, the cost of pavement impacts which could be avoided range from a low of $4.1 million at 10 percent diversion, to $10.3 million at 25 percent as shown in Exhibit 12.

Exhibit 12
MARGINAL PAVEMENT IMPACTS

	ESTIMATED COSTS AVOIDED	
	Diversion Percentage	
	10	25
	($ Millions)	
Base Year	$4.1	$10.3

<u>Results of Future Year Highway Impact Analysis</u>

In the process of conducting the analysis, it became apparent that capacity improvements were going to have to be made to I-81 with or without diversions of truck traffic to rail. The question then became one of how much the diversions might impact implementation of the improvements.

<u>HERS Improvement Logic</u> - The highway improvements considered by HERS consist of resurfacing or pavement reconstruction, possibly combined with some type of widening and/or alignment improvement. The only options considered by HERS in the I-81 analysis are resurfacing, possibly combined with some type of widening.

HERS simulates improvements based on minimum tolerable conditions or deficiency levels. The primary conditions or deficiency levels that trigger improvements in the I-81 analysis are: the volume-to-capacity (v/c) ratio and the present serviceability rating (PSR) of a pavement. The resurfacing PSR triggers a resurfacing improvement. The possible combinations of improvements are listed below. In the I-81 simulations, all lanes are added at normal cost.

- **Major Widening** – The addition of lanes to an existing highway. If lanes are added in excess of the widening feasibility code, they are added at high cost. Otherwise, lanes are added at normal cost. This type of improvement includes the resurfacing of existing lanes and other minor work such as shoulder and drainage work.
- **Minor Widening** - This improvement is similar to major widening except that the added width yields wider lanes or shoulders, but no additional lanes.
- **Resurfacing with Shoulder Improvements** - The overlay of existing pavement plus the widening of shoulders to design standards if feasible, or the complete reconstruction of shoulders to provide additional strength. A minor amount of additional right-of-way may be acquired.
- **Resurfacing** - The overlay of existing pavement including bringing the shoulders up to grade. Minor drainage work also is included.

<u>I-81 Application</u> - In the I-81 analysis, HERS was instructed to use four five-year funding periods. During each period, HERS analyzed the entire set of sample sections to identify improvements that might be warranted. For each section, HERS identified *deficiencies* as well as appropriate improvements to address these deficiencies. HERS then used benefit-cost analysis to determine which of the potential improvements to implement.

HERS uses a complex benefit-cost procedure. The benefits include highway user, agency, safety, and environmental benefits. Highway user benefits include potential savings in: (1) vehicle-operating costs, (2) travel-time costs, and (3) safety costs. Highway agency benefits include savings in capital improvement and routine maintenance costs. HERS can also estimate benefits from reduced vehicle emissions, but a separate analysis was conducted for this study effort as explained later.

HERS recognizes a highway section's need for improvement by comparing its characteristics to deficiency levels. HERS utilizes three deficiency indicators: DL (deficiency level); SDL (serious deficiency level); and UL (unacceptable level). The roles of these three indicators in the improvement-selection procedure are:

- If the DL for a particular characteristic (e.g., v/c ratio) is violated, HERS will analyze the benefits and costs of potential improvements that will correct this condition. If the resulting benefit/cost ratio of an improvement is high enough, it may be selected.

- If the SDL for a particular characteristic of a section is violated, then only improvements that correct this condition are evaluated by the HERS benefit-cost analysis procedure.
- If the UL for a particular characteristic is violated, then an improvement that corrects this condition is selected automatically. The benefit-cost ratio for the improvement is considered only if a limiting constraint is imposed (e.g., not enough funds are available).

In the I-81 simulations, the HERS default v/c ratio was used as an unacceptable condition level. No funding constraint was applied. Thus, HERS automatically simulated the addition of lanes when the forecasted section v/c ratio dropped below the default value during the current or subsequent funding period. In the I-81 simulations, HERS was instructed to implement no improvement unless the benefit/cost ratio was at least 1.0.

When considering pavement options, HERS decides whether resurfacing is appropriate based upon the PSR at the beginning of the funding period. When considering widening options, HERS may select both an "add lanes" option and, if appropriate, the "widen lanes" option. If the capacity of a section is expected to violate the UL during the expected design life for a pavement improvement being considered, a capacity improvement option is treated as a required accompaniment to that pavement improvement. As noted earlier, the Major Widening improvement includes the resurfacing of existing lanes.

It is important to note that the HERS I-81 analysis did not include a funding constraint. The result is a pure needs analysis. Whenever the v/c ratio or the resurfacing PSR is expected to be violated for a highway section, HERS implements the improvement with the greatest benefit-cost ratio. However, the benefit-cost ratio must be greater than or equal to 1.0.

The analysis revealed that the diversion of trucks did delay or negate improvements over the analysis period. At the 10 percent truck diversion level, the cost of improvements over the period was $350 million less and at the 25 percent level, $960 million less (see Appendix D).

<u>Air Quality</u>

Finally, the removal of trucks from I-81 will reduce energy consumption. The traffic shift will also affect emissions of certain air pollutants. HERS can be used to model automotive emissions. However, detailed train movements, forecasts of future railroad emissions, and other data, including the results of train simulations over the proposed route(s), would be needed to model rail emissions. Therefore, purposes of this study effort, a more general approach is used.

Based on a 1991 report by the Federal Railroad Administration[21] (FRA), Class 1 railroad/over-the-road fuel efficiencies were as follows:

[21] *Rail vs. Truck Fuel Efficiency*: US DOT, FRA, by Abacus Technology Corporation, April 1991, p. 7-4.

MODE	FUEL EFFICIENCY RANGE (Ton-Miles/Gal)
Double-Stack Train	243 - 350
Trailer-on-Flatcar (TOFC) Train	196 - 327
Van Trailer (Truck)	131 - 163

Assuming that one half of the diverted trucks move as containers in double-stack trains and one half move in piggyback (TOFC) trains, the average fuel efficiency would be 279 Ton-miles per gallon (TM/gal). The over-the-road truck with a van semi-trailer averages 147 TM/gal.

Emissions contribute to air pollution and have significant health and environmental impacts. NO_x is a major component of smog and acid rain. NO_x contributes to the formation of secondary PM, which causes headaches and lung inflammation among others, and environmentally, reduced visibility and deterioration of buildings.

The ratios were used to compute estimated emissions using rates prescribed for locomotives manufactured between 1973 and 2001 (Environmental Protection Agency Tier 0), and maximum standard heavy duty tractors manufactured in 1998 and later years. Although the locomotive standards are to change at least two more times during the analysis period (Tier 1, 2002 – 2004, and Tier 2, after 2004), Tier 0 standards were selected as it takes a while for new locomotives to make up a significant portion of the railroad's fleet, and also it was felt Tier 0 would be more comparable with existing truck standards. The change in emissions so computed at the different diversion percentages are shown below in Exhibit 13.

Exhibit 13
DIVERSION POLLUTANT DECREASES

POLLUTANT	TONS			
	1998		2020	
	10%	25%	10%	25%
HC	200.9	502.3	323.3	808.4
CO	2813.0	7,032.5	4,527.3	11,318.3
NO_X	(97.7)	(244.2)	(157.2)	(393.0)
PM	(13.39)	(33.5)	(21.5)	(53.8)

The emission volumes were next converted to monetary values using HERS default values. The results are revealed in Exhibit 14 and are also included in the benefit-cost analysis.

Exhibit 14
DIVERSION POLLUTANT COST SAVINGS

POLLUTANT	COST ($000)			
	1998		2020	
	10%	25%	10%	25%
HC	$484.4	$1,211.0	$779.6	$1,949.0
CO	121.0	302.4	194.7	486.7
NO_X	(318.5)	(796.2)	(512.6)	(1,281.5)
PM	(33.4)	(83.4)	(53.7)	(134.2)
Net	$253.5	$633.8	$408.0	$1,020.0

<u>Caveat</u> - Railroads pay a 4.3-cent tax per gallon of fuel. This revenue stream becomes part of the U.S. general fund and is not available for highway improvements. Nevertheless, this revenue contribution should be recognized in some manner in a user fee-infrastructure cost comparison.

Benefit-Cost Analysis

The benefit-cost analysis is conducted as a present value analysis. The approach recognizes that a dollar at some future date is not worth what it is today. All values are expressed in terms of constant dollars (1998) and appear in the analysis over time in the year that they occur.

<u>Term of Analysis</u> – The analysis period is the same as the project analysis, 22 years. The 22 years run from 1998 (the date of most of the base data) to 2020 (the date of the forecast data).

<u>Discount Rate</u> – All values are discounted at an annual rate of 4.33 percent. This is the appropriate rate used by the Federal Railroad Administration in its Local Rail Freight Assistance Program. The rate equals the cost of money to the federal government less the effects of inflation.

<u>Analysis Logic</u> – The primary objective of this study is to determine if the diversion of truck traffic to rail will impact the need for improvements to I-81, and if so, to what extent. The initial approach to this determination was to compute (using HERS) the value of road user delays, accident costs, pavement damage, and environmental impacts over the analysis period holding the capacity on I-81 constant. It became apparent that the deterioration in service levels and resulting impacts on I-81 users, using forecast volumes, was so great that it was unrealistic to consider that capacity would not be added during the analysis period.

It was then decided to permit the HERS performance model to run unconstrained and add capacity as warranted. In this process, the model used four five-year funding periods and examined projected traffic over time.

HERS Results – The demand, as seen by the model without any diversion of trucks, was of a magnitude that it added capacity (see Appendix D) in the first funding period and continued to do so each succeeding five-year period. It was assumed for analysis purposes that funding occurred at the end of each funding period.

Two additional HERS runs were made with 10 percent and 25 percent diversion of trucks (dry vans traveling over 500 miles) to determine the relative impact on I-81 needs. The runs revealed that the diversions did indeed impact I-81 improvements as determined by HERS.

HERS Values – The HERS model computes widening and resurfacing needs and associated costs (Virginia specific) over time. These values were used in the present value analysis. For the initial four years of the analysis period, however, prior to roadway improvements, the difference in roadway impacts with and without truck diversion was input as benefits (costs avoided). The remainder of the analysis assumes that roadway user and accident impacts do not increase as improvements are made as needed. Similarly, pavement impacts are not claimed as HERS also resurfaces as needed. Environment impacts are claimed throughout the period, however, as they were not included in the HERS analysis.

Present Value Benefits – The value of benefits determined by HERS became input for the present value analysis (see Appendices E and F) in the year incurred. The resulting present value at the 10 percent diversion level is $388.9 million. At the 25 percent level, the present value of benefits equates to $995.8 million.

Present Value Costs – The appropriate cost for this analysis is the estimated cost of the NS improvements. The cost estimate advanced by NS is at the top of a range of potential improvements to that route. At the 10 percent diversion level, the resulting number of trains created by the diversion do not warrant the level of improvements for which the costs were estimated. In addition, the potential use of other routes in combination with the Shenandoah (I-81) Route should also be considered. As stated earlier, NS improvements should be redefined and costs estimated accordingly.

Summary – Without the cost side of the ratio, a true benefit-cost analysis cannot be completed. The present value of the benefits does, however, indicate a level of contribution toward a project that would be justified from a public-benefit perspective.

The HERS analysis, however, results in an ideal situation and with no funding constraints, results in improvements being made as soon as justified by its internal benefit-cost analysis. In addition, the HERS analysis considers resurfacing needs while looking ahead at capacity needs. In this process it also evaluates and implements the most cost-effective combination of resurfacing and lane additions. In this manner needs are determined at a faster rate than a pure engineering capacity analysis as conducted for the *I-81 Improvement Studies* would indicate. In addition, practical considerations such as the lead time for all of the steps in actual project implementation, including funding, would not permit completion of such an idealistic schedule. The analysis would best be performed after a realistic roadway improvement schedule is crafted, and railway improvements are tailored more to actual demand considering a full range of routing options.

CONCLUSIONS/RECOMMENDATIONS

Based on the data collected and analyses conducted in this study, the following conclusions have been reached and the following recommendations are made regarding the shifting of highway traffic to rail in the I-81 Corridor.

Conclusions

1. Both cost estimates evaluated in the study, railway and I-81 improvements, were found to be reasonable, but both are based on conceptual/preliminary plans and therefore are order-of-magnitude estimates which need refinement if the proposal is further evaluated.

2. Improvements for railway capacity and speed increases should be re-evaluated considering anticipated diversion and the potential to use alternate routes in conjunction with the Shenandoah Route.

3. Based on studies presented to the Surface Transportation Board and based on NS estimates of "truck competitive" service, the potential to divert 10 percent of I-81 "divertible truck traffic" to rail appears to be a reasonable expectation with rail improvements. In the final analysis, actual capture rates will depend on NS marketing and service.

4. The diversion of truck traffic to rail will impact the timing of capacity improvements to I-81 based on the HERS analysis. As neither the NS proposal nor the 1998 I-81 studies provide an improvement timetable (other than overall timeframes), it is not possible to compare improvement schedules and analysis impacts.

5. In addition to the delay of I-81 capacity improvements, there are also incremental benefits relating to decreases in highway user costs, safety costs, pavement maintenance expenses, and air quality considerations.

Recommendations

1. It is recommended that the Commonwealth of Virginia fully consider proposals advanced to divert highway traffic to rail transportation. The analyses conducted for this study effort indicate the potential for significant public benefits exists.

2. It is further recommended that a number of the elements of this study be reviewed with more detailed data or data gathered with improved techniques, which will permit more refined analyses. These elements would include intermodal market areas (some of the analysis zones contained in the data used in this study cover very broad geographic areas); roadway truck counts and classifications (which also impact forecasts); simulations of fuel consumption and (particulate generation); simulations

of railway operating speeds and capacity needs, and infrastructure costs and improvement schedules.

3. A multi-state analysis encompassing the total range of the proposed project should be considered.

APPENDICES

APPENDIX A

2000 SESSION

SENATE JOINT RESOLUTION NO. 55

Requesting the Secretary of Transportation to expand the scope of her study on the desirability and feasibility of establishing additional intermodal transfer facilities (House Joint Resolution No. 704 (1999)) to include the potential for shifting Virginia's highway traffic to railroads.

Agreed to by the Senate, February 15, 2000
Agreed to by the House of Delegates, March 8, 2000

WHEREAS, safety is a primary goal of the Commonwealth's transportation program; and

WHEREAS, many of the Commonwealth's interstate highways are experiencing an erosion of safety as the result of staggering increases in traffic; and

WHEREAS, one acute example of this situation is Interstate Route 81, whose design intended the facility to carry no more than 15 percent of its total traffic volume as truck traffic, but whose current traffic is made up of as much as 40 percent trucks; and

WHEREAS, widening Interstate Route 81 alone is estimated to cost in excess of $3 billion and take at least 10 years to complete, with similar improvements to other interstate highways with high traffic volumes costing comparable amounts and requiring no less time; and

WHEREAS, it may be both desirable and feasible in the short term to alleviate excessive volumes of traffic on Interstate Route 81 and other interstate highways in Virginia to seek to shift traffic on our highways to trains on our railroads; now, therefore, be it

RESOLVED by the Senate, the House of Delegates concurring, That the Secretary of Transportation be requested to expand her study on the desirability and feasibility of establishing additional intermodal transfer facilities (House Joint Resolution No. 704 (1999)) to include the potential for shifting Virginia's highway traffic to railroads. The request to conduct this study shall be contingent upon the availability of funding and assistance from private industry or other sources.

The Department of Transportation and the Department of Rail and Public Transportation shall assist the Secretary in the conduct of the study. Other agencies of the Commonwealth shall provide assistance to the Secretary, upon request.

The Secretary of Transportation shall complete her work in time to submit her findings and recommendations to the Governor and the 2001 Session of the General Assembly as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents.

APPENDIX B

HOUSE JOINT RESOLUTION NO. 704

Requesting the Secretary of Transportation to study the desirability and feasibility of establishing additional intermodal transfer facilities.

Agreed to by the House of Delegates, February 9, 1999
Agreed to by the Senate, February 23, 1999

WHERREAS, through the mechanism of the Inland Port at Front Royal, Virginia is able to collect truck-haul containerized freight at the Inland Port in sufficient quantities to transport it in unit trains directly to the Ports of Hampton Roads, not only holding down costs paid by the shipper, but also eliminating a substantial number of trucks from the overcrowded long-haul highways of eastern Virginia; and

WHEREAS, by establishing other facilities in Virginia and working cooperatively with other states to encourage the establishment of similar facilities within their boundaries, a network of intermodal transfer facilities might be established that could prove useful in reducing heavy truck traffic on other long-haul highways in the Commonwealth, particularly Interstate Route 81; and

WHEREAS, additional intermodal transfer facilities need not necessarily handle only cargoes with a seaport or river port as their origin or destination, nor would unit trains linking these facilities necessarily be limited to transporting containers typically used in maritime commerce, but might employ a variety of "piggy-back" container, trailer, or semitrailer configurations; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That the Secretary of Transportation be requested to study the desirability and feasibility of establishing additional intermodal transfer facilities. The Department of Transportation and the Department of Rail and Public Transportation shall assist the Secretary in the conduct of the study. Other agencies of the Commonwealth shall provide assistance to the Secretary, upon request.

The Secretary shall complete her work in time to submit her findings and recommendations to the Governor and the 2001 Session of the General Assembly as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents.

Appendix C
Interstate 81 Improvements Study
Costs as of September 1, 1998

Milepost		Study	Improvement Costs			
From	To	Area	Roadway	Structure	R/W	Total
0	7		Under construction - Cost includes R/W & construction			78,986,098
7	22	1	54,350,000	46,767,718	2,937,000	104,054,718
22	72	2	272,404,100	61,424,200	37,472,200	371,300,500
72	83	3	208,445,000	43,775,000	101,962,000	354,182,000
83	116	4	254,427,000	71,375,000	26,269,000	352,071,000
116	118		Under construction - Cost includes R/W & construction			61,639,515
118	163	5	392,480,184	77,467,545	38,326,000	508,273,729
163	180	6	122,761,000	22,158,800	5,645,000	150,564,800
180	229	7	381,180,000	92,612,000	3,765,000	477,557,000
229	264	8	268,925,000	66,778,000	25,432,000	361,135,000
254	305	9	260,887,000	105,000,000	14,415,000	380,302,000
305	324	10	170,000,000	53,000,000	16,000,000	239,000,000
Total for Study Areas			$2,385,859,284	$640,358,263	$272,223,200	$3,298,440,747
Total including Projects Under Construction						$3,439,066,360

Notes:

1. Study Area 3 is the I-81 / I-77 overlay area. This study is ongoing and [costs] may be reduced
2. Projected costs for preliminary engineering, right-of-way and construction are based on preliminary studies as of September 1, 1998. These costs will be refined during preparation of design plans.

Appendix D
HERS SUMMARY

Virginia I81 HERS Analysis

Roadway Improvements with Future AADT = VDOT 2020 AADT; Future AADT Year = 2018
v/c Ratio = HERS default values for all effected functional classes and terrains.
VMT in base year = 3.998 billion

	Funding Period 1		
	Base Case	10% Diversion	25% Diversion
Lane Miles Added	1,024	677	343
Lane Miles Improved			
Widening	1,745	1,222	694
Resurfacing	419	611	788
Total Miles Improved	2,164	1,833	1,482
Cost of Improvements (millions of dollars)			
Widening	784	553	320
Resurfacing	105	131	175
Total Improvement Cost	889	684	495
VMT End of Period	4,982	4,784	4,498

	Funding Period 2		
	Base Case	10% Diversion	25% Diversion
Lane Miles Added	528	513	379
Lane Miles Improved			
Widening	924	898	773
Resurfacing	1,928	1,593	1,249
Total Miles Improved	2,852	2,491	2,022
Cost of Improvements (millions of dollars)			
Widening	784	603	407
Resurfacing	256	227	190
Total Improvement Cost	1,040	830	597
VMT End of Period	6,103	5,697	5,108

	Funding Period 3		
	Base Case	10% Diversion	25% Diversion
Lane Miles Added	144	345	251
Lane Miles Improved			
Widening	248	634	517
Resurfacing	2,749	2,203	1,756
Total Miles Improved	2,997	2,837	2,273
Cost of Improvements (millions of dollars)			
Widening	200	414	299
Resurfacing	379	331	241
Total Improvement Cost	579	745	540
VMT End of Period	7,220	6,621	5,713

	Funding Period 4		
	Base Case	10% Diversion	25% Diversion
Lane Miles Added	13	2	75
Lane Miles Improved			
Widening	38	6	207
Resurfacing	2,973	2,833	2,142
Total Miles Improved	3,011	2,839	2,349
Cost of Improvements (millions of dollars)			
Widening	59	8	128
Resurfacing	444	391	295
Total Improvement Cost	503	399	423
VMT End of Period	8,342	7,535	6,321

	Overall Analysis Period		
	Base Case	10% Diversion	25% Diversion
Lane Miles Added	1,711	1,538	1,048
Lane Miles Improved			
Widening	2,957	2,760	2,192
Resurfacing	8,071	7,242	5,936
Total Miles Improved	11,028	10,002	8,128
Cost of Improvements (millions of dollars)			
Widening	1,828	1,579	1,155
Resurfacing	1,186	1,081	902
Total Improvement Cost	3,014	2,660	2,057
VMT Change over Analysis Period	4,344	3,537	2,323

Appendix E
BENEFIT-COST ANALYSIS
10% Diversion Scenario
($ Millions)

Year	User Savings	Accident Savings	Pavement Savings	Emission Savings	Improvement Savings	Total Benefits	Present Value Benefits
1998	16.0	3.0	4.1	0.253		23.353	23.353
1999	20.1	3.5	4.2	0.260		28.154	26.985
2000	24.3	4.1	4.3	0.267		32.959	30.280
2001	28.4	4.6	4.4	0.274		37.765	33.255
2002				0.281	205	205.281	173.266
2003				0.288		0.288	0.233
2004				0.295		0.295	0.229
2005				0.302		0.302	0.225
2006				0.309		0.309	0.220
2007				0.316	210	210.316	143.612
2008				0.323		0.323	0.212
2009				0.331		0.331	0.207
2010				0.338		0.338	0.203
2011				0.345		0.345	0.199
2012				0.352	(166)	(165.648)	(91.508)
2013				0.359		0.359	0.190
2014				0.366		0.366	0.186
2015				0.373		0.373	0.181
2016				0.380		0.380	0.177
2017				0.387	104	104.387	46.652
2018				0.394		0.394	0.169
2019				0.401		0.401	0.165
2020				0.408		0.408	0.161
Totals	**88.8**	**15.3**	**17.1**	**7.6**	**353.0**	**481.8**	**388.9**

Note: Disc Rate used= 4.33%

Appendix F
BENEFIT-COST ANALYSIS
25% Diversion Scenario
($ Millions)

Year	User Savings	Accident Savings	Pavement Savings	Emission Savings	Improvem Savings	Total Benefits	Present Value Benefits
1998	42.0	10.0	10.3	0.634		62.934	62.934
1999	51.4	10.9	10.6	0.652		73.506	70.455
2000	60.7	11.8	10.9	0.669		84.078	77.244
2001	70.1	12.7	11.1	0.687		94.650	83.348
2002				0.704	394	394.704	333.146
2003				0.722		0.722	0.584
2004				0.739		0.739	0.573
2005				0.757		0.757	0.563
2006				0.774		0.774	0.552
2007				0.792	443	443.792	303.038
2008				0.809		0.809	0.530
2009				0.827		0.827	0.519
2010				0.845		0.845	0.508
2011				0.862		0.862	0.497
2012				0.880	39	39.880	22.030
2013				0.897		0.897	0.475
2014				0.915		0.915	0.464
2015				0.932		0.932	0.454
2016				0.950		0.950	0.443
2017				0.967	80	80.967	36.186
2018				0.985		0.985	0.422
2019				1.002		1.002	0.412
2020				1.020		1.020	0.401
Totals	**224.2**	**45.5**	**42.9**	**19.0**	**956.0**	**1,287.5**	**995.8**

Note: Disc Rate used= 4.33%