Developing a Testbed for Evaluating the Impacts of Truck Performances on Surrounding Traffic

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(Abstract)

The high percentage of trucks combined with the mountainous terrain along the I-81 corridor in the state of Virginia has resulted in significant capacity reduction and delay increases. Different alternatives are being considered in order to alleviate the capacity impacts of trucks along I-81. These alternatives may include adding lanes along grade sections, reducing grade through a re-alignment of the interstate, considering alternate modes for transporting goods, or even reducing the number of trucks on the interstate during peak periods.

The evaluation of these alternative measures requires a sophisticated evaluation tool that not only captures the dynamics of trucks as they travel along grades, but also accurately captures the formation of shockwaves behind these trucks. This project demonstrates the effectiveness of the INTEGRATION model as such an evaluation tool through the modeling of a 30-mile segment of I-81 between Roanoke and Christiansburg.

Initial simulation results indicate that trucks experience delays that exceed light vehicle delays by as much as 18%. The results obtained showed that the 100 lb/hp truck was the most economical. The 100 lb/hp truck gave the best average travel time followed by the 200 lb/hp, combined, and 300 lb/hp trucks, which were represented by an increase that ranged from 16% to 63% for the AM peak traffic, and 26% to 120% for the PM peak. There were a total of 8085 vehicles discharged during the AM peak as opposed to the 10060 vehicles that were discharged during the PM peak, a 24% increase over the AM peak.

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Chapter 1 - Introduction

1.0 Report Objective and Layout

This report describes the development of a testbed for evaluating the impacts of truck performance on surrounding traffic. It also shows how simulation can be used as an effective tool for capturing vehicle and network performances in terms of capacity, average travel time, fuel consumption and emissions, vehicle stops, and delays, all due to the dynamics of traffic.

The first section of this report is the introduction, which gives a brief description of the current situation of trucks and the need for simulation. The next section, Chapter 2, reviews some previous work concerning trucks and their effect on traffic flow and safety with different truck mixes. Chapter 3 illustrates how the various truck characteristics (e.g. vehicle's power, weight, weight on tractive axle, frontal area, transmission efficiency), pavement characteristics (e.g. rolling resistance), and location (e.g. altitude) affect their performance on a highway. It also validates the INTEGRATION model by comparing its performance curves to the HCM performance curves since INTEGRATION was the simulation software used. Chapter 4 describes the section of I-81 used for the testbed and how the geometric characteristics of the highway were used to develop the I-81 simulation network. Chapter 5 uses the mainline and ramp volumes to create the origin-destination input file which was used to load the network. Some sensitivity analysis was later performed by loading the network with cars only, cars together with 100 lb/hp, 200 lb/hp, and 300 lb/hp trucks, and a combination of cars and the three different types of trucks mentioned above. These results are presented in Chapter 6. The last and final chapter, Chapter 7, gives some conclusions and recommendations.

1.1 Background

The United States trucking industry is one of the leading contributors to the US economy. Since 1980, trucks have transported at least 25% of all freight, while railroads have transported 33%. Trucks are also responsible for transporting 40.5% of all intercity tonnage which helps contribute to the $22.8 billion in federal taxes paid in 1999 (Fitch, 1994).

Today, studies show that the U.S. transportation industry will carry 13.2 billion tons of freight and generate $547.7 billion in revenue by the year 2006, according to a study conducted by one of the nation’s leading economic research firms, Standard & Poor’s DRI, for the American Trucking Associations (ATA) Foundation (Truckline, 1998).

DRI’s "U.S. Freight Transportation Forecast...to 2006" predicts that a three- to five-percent annual rise in international trade will help drive a 30-percent increase over 1996 revenues of $420.2 billion and a 21% increase over the 1996 volume of 10.9 billion tons. Airfreight and intermodal rail shipments while accounting for 3.2 percent and 1.3 percent, respectively, of the freight-transportation market will see the greatest increases due to the faster growth in the commodities that are moved by containerized and intermodal shipments over bulk commodities, such as coal, primary metal products, and crude oil. The change in the commodity mix also will put trucking at the top of the growth chart as it continues to dominate freight movement in the U.S. (Truckline, 1998).

Additional forecasts over the next 10 years by DRI predict that the trucking industry’s share of the nation's freight bill will continue at nearly 82 percent in 2006 with $446.2 billion in gross revenues, marking a 29-percent increase over 1996 revenues of $346 billion. Trucking's share of freight volume will increase from 60 percent to 63 percent over the same period rising 25.9 percent, from 6.5 billion tons to 8.2 billion tons (Truckline, 1998).

1.2 Need for Simulation

With the increase in the number of trucks traveling on U.S. interstate highways, and the capacity implications that results from these trucks, there is a need for evaluation tools that can quantify the capacity reductions and delay increases that result from these trucks. These tools can be utilized in order to identify any bottlenecks within the roadway system and can be utilized to evaluate proposed enhancement to the existing roadway system. For example, on I-81 in the southwestern part of Virginia, the use of simulation can be extremely beneficial in order to evaluate improvements on critical sections along steep grades.

Furthermore, simulation evaluates the impact of increased demands (especially in the case of trucks) on the overall delay. This project shows how different mixes of trucks and grades affect travel time and other measures of effectiveness including delay, fuel consumption, and emissions. For instance, the use of the different vehicle combinations such as passenger cars, light trucks, and heavy trucks can have a larger impact on the freeway capacity than the case where only heavy trucks travel with passenger cars. The reason that the former case could operate at a lower capacity is because it could involve lighter trucks overtaking heavier trucks which would lead to reductions in capacity for the passenger cars (Demarchi et al., 1999). One way of capturing this reduction in capacity is through the use of simulation. The performance of the trucks used in this project will be characterized by their power, which is given as weight-horsepower ratio (lb/hp). This performance standard has been recommended by the Bureau of Public Roads in their house document #354, commonly referred to as the BPR size and weight report (Fitch, 1994). The simulation software used to carry out the evaluations was INTEGRATION (Van Aerde et al., 1997).

Chapter 2 - Literature Review

2.0 Truck Review

The impacts of trucks on highways have increasingly affected highway capacity. Trucks cover a particularly wide range of vehicles, from lightly loaded farm vehicles to the most heavily loaded coal, timber, and gravel haulers. Individual trucks will have widely varying operational characteristic based on how heavily they are loaded.

The analysis procedures for these trucks are found in the truck performance curves in the Highway Capacity Manual (HCM; TRB, 1994). The typical truck found in the traffic stream is the 200 lb/hp, but the 1994 HCM Special Report also provides information on light (100 lb/hp) and heavy trucks (300 lb/hp).

The term "trucks" usually refers to one or more of the following vehicle classifications: pickup trucks, single unit (straight trucks), bobtails (tractor without trailer), and a combination (tractor pulling a semitrailer or multitrailer). Although the definition for trucks varies among states, the term "trucks" in this report will be used to refer to the 100lb/hp, 200lb/hp, and 300lb/hp ratio trucks.

Facilities dominated by heavy farm trucks, gravel haulers, or similar vehicles would have an average weight-to-horsepower ratio in the 300 and 400 lb/hp range. The HCM analysis procedure for trucks generally assumes the characteristics of the typical truck (200 lb/hp) in the traffic stream, and applies these characteristics to all trucks in the traffic stream (HCM). This method is somewhat incomplete for two reasons. First, it assumes the truck population to be homogenous. Second, it does not consider the delay to the surrounding traffic. Both factors result in an underestimation of the impacts of trucks on the capacity and delay of the system.

2.1 Effects of Mixed Vehicle Travel

It is known that the presence of vehicles other than passenger cars in the traffic stream affects flow in two ways:

- Such vehicles are larger than passenger cars, and therefore occupy more roadway space than passenger cars, and
- The operating capabilities of such vehicles (acceleration, deceleration, maintenance of speed, etc.) are generally more inferior to those of passenger cars; when introduced to the traffic stream, these different performance capabilities lead to the formation of gaps in the traffic stream which cannot be readily filled by passenger cars.

The second impact is particularly significant on long sustained upgrades, on which trucks may be forced to slow considerably, thereby creating extremely large gaps in the traffic stream. Because of this, roadway space is used far less efficiently than by a traffic stream composed only of passenger cars. The second impact becomes more evident when trucks start overtaking one another as they travel along grades.

Since the completion of the interstate highway system, total traffic and large truck volumes have increased steadily. During certain periods on some freeway corridors, large truck volumes may approach or exceed that of passenger vehicles. Increase in total traffic and percentage of trucks in the traffic mix increase the probability and severity of adverse impacts related to mixed vehicle travel (Hoel and Vidunas, 1997).

2.2 Safety

The need for the modeling of trucks on I-81 has also stemmed from a safety point of view. The increased truck traffic, particularly on the Interstate system, has raised considerable concern about highway safety and capacity. Crashes involving automobile/truck conflicts have increased awareness among transportation officials and the traveling public and have focused attention on conflicts between automobile travel and freight movement over the same facility. In crashes involving cars and trucks, the mass difference between the two vehicle types put the occupants of the lighter vehicle at greater fatality risk. Furthermore, crashes involving trucks often block traffic, resulting in travel delays and monetary loss (Hoel and Vidunas - VDOT, 1997).

Chapter 3 - Truck Dynamic Model

3.0 Introduction of Model

The truck dynamic model that is utilized in this report is a second-order motion model that computes the vehicle's maximum acceleration based on its instantaneous speed (Demarchi et al., 1999). The objective of this section is to illustrate how the various truck characteristics (e.g. vehicle's power, weight, weight on tractive axle, frontal area, transmission efficiency), pavement characteristics (e.g. rolling resistance), and location (e.g. altitude) affect their performance on a highway. This section also validates the INTEGRATION model by comparing its performance curves to the HCM performance curves since INTEGRATION was the tool used to model the trucks on I-81. The motion model that is described in this section is validated against the HCM curves for conditions where the HCM approach is applicable.

The objective of this chapter is to describe a first-degree motion model that was developed in order to capture vehicle acceleration constraints. The motion model is sensitive to the vehicle weight, its power, the vehicle's frontal area, the pavement's rolling resistance, and the section grade. Furthermore, the proposed motion model has been incorporated within the INTEGRATION microscopic simulation and traffic assignment model in order to provide a comprehensive evaluation tool that captures vehicle-to-vehicle interaction, vehicle-to-control interaction, and vehicle dynamics (Demarchi et al., 1999).

3.1 Vehicle Tractive and Resistance Forces

A vehicle's ability to accelerate, decelerate, and negotiate a grade is a function of a number of factors including the vehicle weight and engine power. The engine power provides the torque that is required to drive the vehicle's axle, which in turn rotates the vehicle's wheels and generates a tractive force between the vehicle tires and the road surface. In order for the vehicle to accelerate, the tractive force magnitude must exceed all resistance forces. Equations (1) to (4) show the forces and total resistance that act on the vehicle during motion.

$$F_t = 3600\eta \frac{P}{V} \tag{1}$$

$$F_{\max} = 9.8066 \mathrm{W}_{\mathrm{t}a} \mu \tag{2}$$

$$F = \min(F_t, F_{\max}) \tag{3}$$

Where:
P: engine power (kW)
V: speed (km/h)
η: transmission efficiency
F_{max}: maximum tractive force (N)
W_{ta}: vehicle weight on tractive axle (kg)
μ: friction coefficient

$$R = c_1 C_d C_h A V^2 + 9.8066 C_r (c_2 V + c_3) \frac{W}{1000} + 9.8066 W i \tag{4}$$

Where:
R_a: air drag resistance (N)
c_1: coefficient that accounts for air density and units conversion ($c_1 = 0.047285$)
C_d: air drag coefficient
A: frontal area (m^2)
V: speed (km/h)
C_h: altitude coefficient
H: altitude (m)
R_r: rolling resistance (N)
C_r: rolling coefficient
c_2, c_3: rolling resistance constants
W: vehicle weight (kg)
V: speed (km/h)
R_g: grade resistance (N)
i: grade magnitude

In order to develop an expression for the acceleration, the second-order motion model must first determine typical truck parameters (vehicle weight, speed, frontal area, rolling coefficient, grade magnitude, air drag coefficient, etc.) from literature. The second step was to extract from the HCM performance curves the truck parameters that correspond to the curves. These estimated parameters were then compared to those from the literature to ensure validity.

The expression for the vehicle acceleration was given as shown in Equation (5), where the coefficients K_0, K_1, K_2, K_3, and K_4, when $F<F_{max}$, are as follows:

$$a = K_0 \frac{1}{V} + K_1 V^2 + K_2 V + K_3 + K_4 \tag{5}$$

$$K_0 = 3600\eta \frac{P}{W} \tag{6}$$

$$K_1 = -\frac{c_1 C_d C_h A}{W} \tag{7}$$

$$K_2 = -0.0098066 c_2 C_r \tag{8}$$

$$K_3 = -0.0098066 c_3 C_r \tag{9}$$

$$K_4 = -9.8066 i \tag{10}$$

The coefficients K_0, K_1, K_2, K_3, and K_4 were computed by performing a regression analysis on the normalized acceleration (dependant variable) and speed (independent variable).

3.2 Impacts of Grades and Model Validation

This section demonstrates how the grades provide a major resistance force and how large grade resistance at higher upgrades results in equilibrium speeds that decrease as a function of the grade magnitude.

The model was validated against HCM performance curves by incorporating it into INTEGRATION. This was done by applying the model to the three HCM typical trucks, namely: the heavy truck (300 lb/hp), the average truck (200 lb/hp), and the light truck (100 lb/hp). Curves for heavy and light trucks can be found only in the 1985 HCM version. The later versions of the HCM only provide curves for the average truck (Demarchi et al., 1999). The results of these comparisons are shown below, Figures 3.1, 3.2, and 3.3.

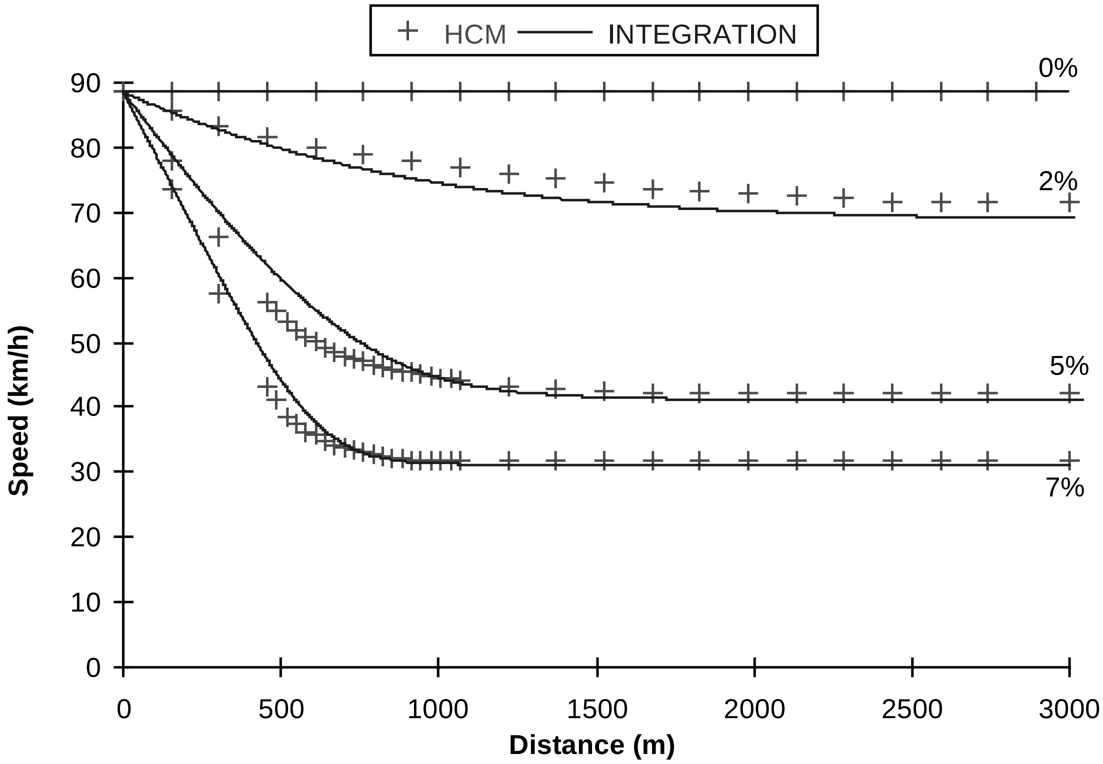

Figure 3.1. 200 lb/hp truck deceleration curves - INTEGRATION versus HCM

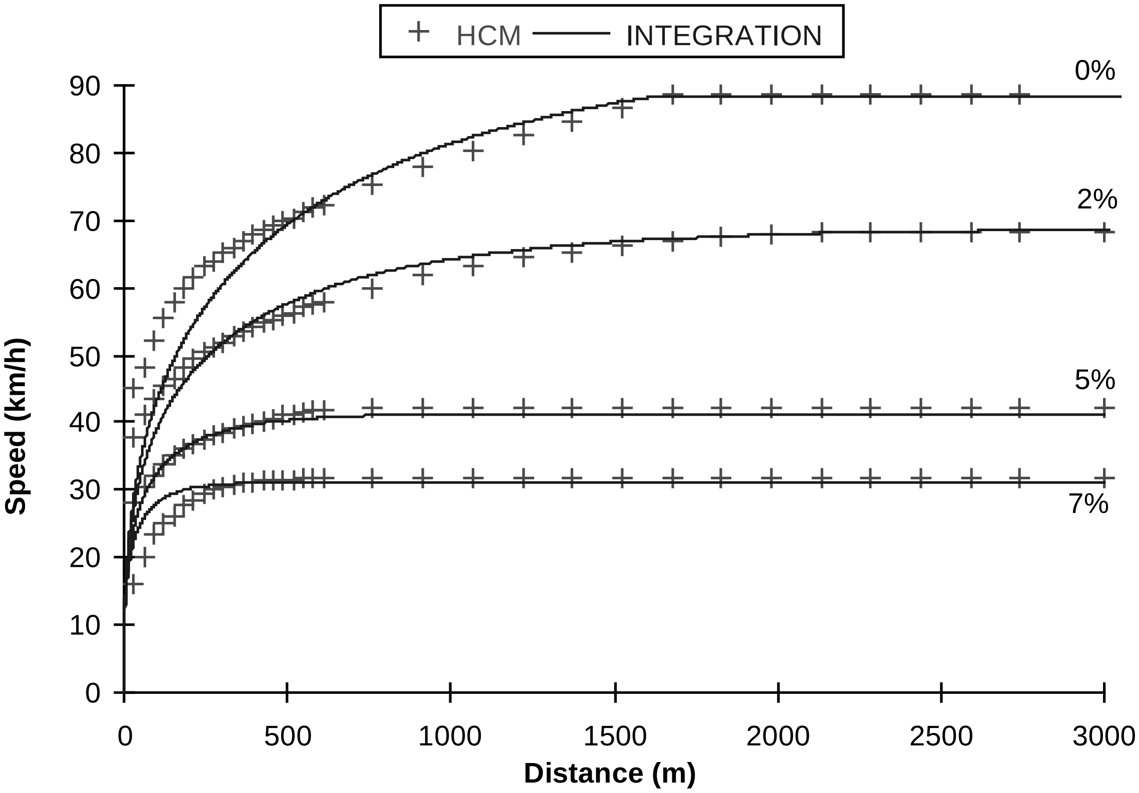

Figure 3.2. 200 lb/hp truck acceleration curves – INTEGRATION versus HCM

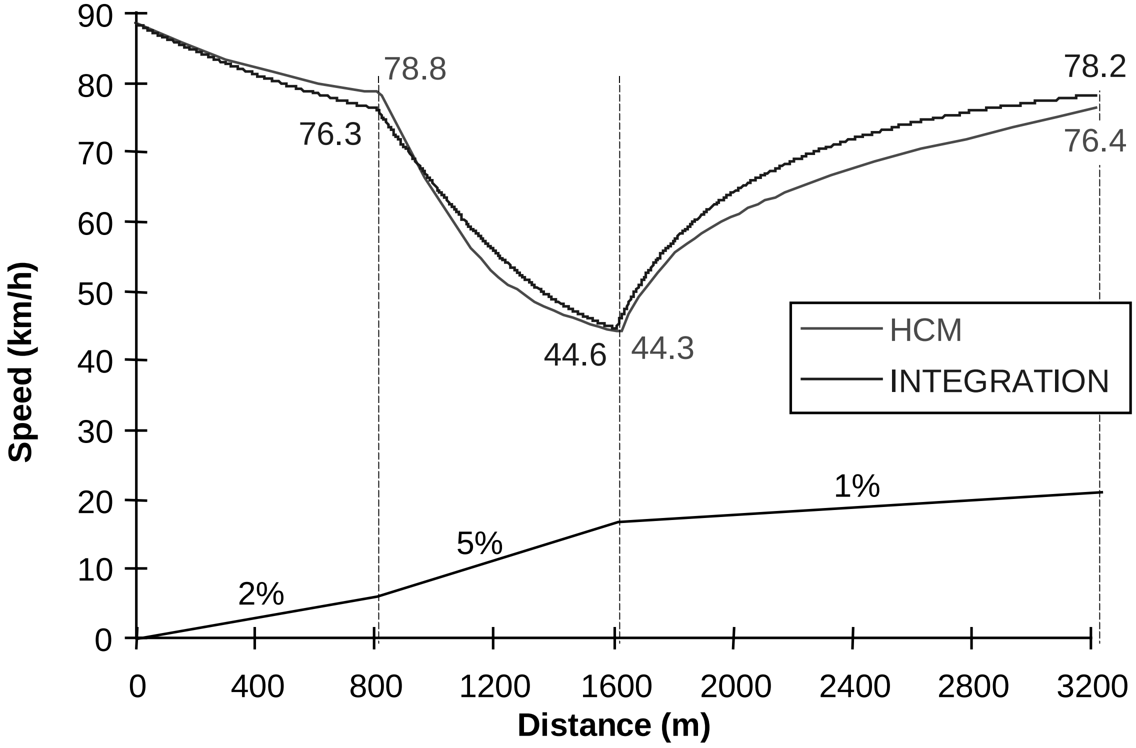

Figure 3.3. Composite grade comparison – INTEGRATION versus HCM

In conclusion, the curves above show a very good fit between the HCM and INTEGRATION results. Figure 3.2.1 illustrates for the same grades how the simulated and HCM performance curves compare. Again, the performance curves appear to be similar except when the vehicle is accelerating as it initially negotiates the grade. These differences are most probably caused by the lack of accuracy in generating these points from the HCM performance curves, as was previously discussed. Another point to note is that unlike the HCM curves, the simulation results always produce identical equilibrium speeds for both the acceleration and deceleration curves (Figure 3.3; Demarchi et al., 1999).

CHAPTER 4 - Development of I-81 Simulation Network

4.0 Overview of Method

This chapter will examine the development of the I-81 network. It will describe the section of highway that was utilized for evaluation purposes, as well as the sources of data that were utilized. This chapter illustrates how simulation using the INTEGRATION software, together with QUEENSOD, can be utilized to evaluate the performance of a highway. The evaluations are conducted utilizing data that were provided by the Virginia Department of Transportation (VDOT) and traffic flow counts that were provided by HDR Engineering. These counts were classified by time-of-day and vehicle type.

In order to carry out the evaluations, the network was first developed by coding it into INTEGRATION. The next phase was to create an origin-destination matrix, using QUEENSOD, which served as the traffic volume input file, one of the input files for INTEGRATION. After the network was coded and the various data were incorporated, the simulation was carried out using different peak volumes, that is, AM-peak, mid-day peak, and PM-peak. The results of those simulations were then utilized to demonstrate how the 100 lb/hp, 200 lb/hp, 300 lb/hp, and a combination of all trucks affected the traffic flow on an interstate highway.

The following section describes the section of I-81 that was utilized for evaluation purposes. The second section describes the construction of the simulation network for the modeled section. The third section focuses on the estimation of the origin-destination matrix and the organization of the input volumes that were used as the input source.

4.1 Description of I-81 Section

The section of I-81 that was modeled was a 30-mile section that ran from the Route 460 interchange in Christiansburg to the I-581 interchange in Roanoke, Figure 4.1. This section of road is a four-lane limited access rural and urban interstate highway which was constructed in the early 1960s. The terrain is mostly rolling and mountainous in this corridor. This corridor has several important functions. As part of a major interstate highway, it provides the region with an important transportation link to other economic production centers and marketers in the eastern United States. The corridor also services commuter traffic and provides access to the Roanoke central business district from the outlying counties, and serves commuters traveling between Roanoke and the Christiansburg/Blacksburg areas. This region has a significant amount of tourist attractions. Consequently, there are large volumes of tourist traffic and recreation vehicles using the Interstate 81 corridor to access the state parks and recreation facilities.

As a result of its varied uses, the corridor is characterized by heavy truck volumes in addition to congestion caused by commuter work trips and tourist traffic.

The rolling terrain that distinguishes the region presents long upgrades which further complicate the congestion in the corridor. Additionally, the heavy truck traffic effectively uses up the capacity of the facility during peak hours.

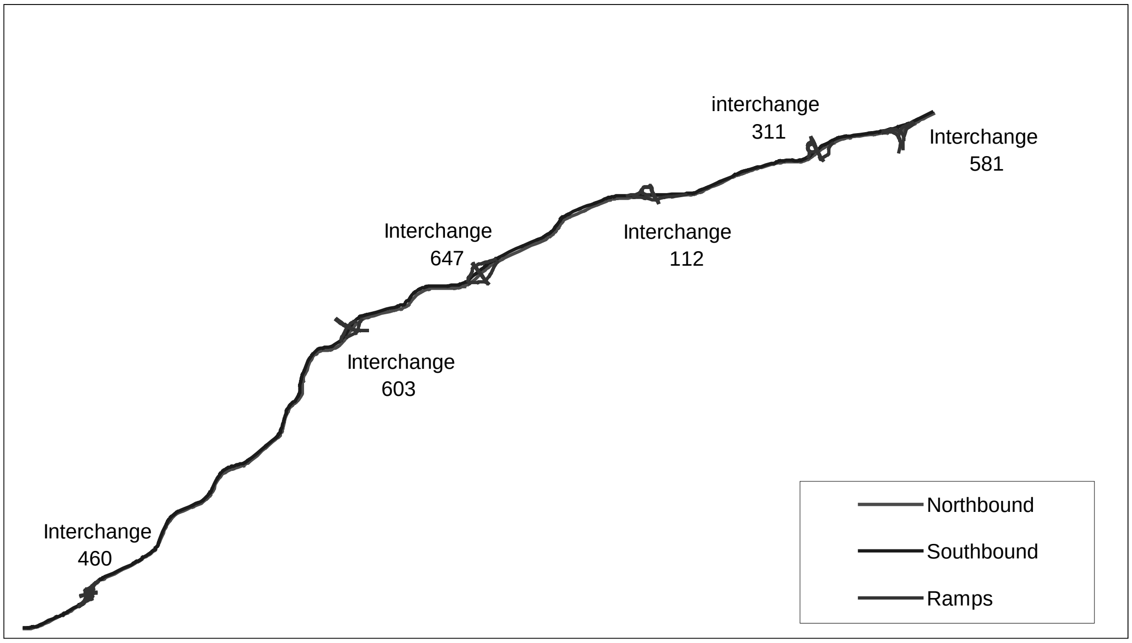

Figure 4.1. Schematic showing mainline and ramps

Although there are currently seven interchanges in the study area, only six of these interchanges were coded because the data files that were provided by VDOT did not include the seventh interchange, as illustrated in Figure 4.1. These interchanges were initially constructed to serve the rural areas, but with the development of the neighboring towns and cities, they have since been updated to suit the traffic pattern.

The Average Daily Traffic (ADT) on this section of road ranges from about 25,337 with a directional split of about 30/70 northbound/southbound (NB/SB) between Route 460 and the 603 interchange, to 50,409 with a directional split of 60/40 (NB/SB) between Route 311 and the I-581 interchange. Approximately 25% and 27% of trucks were observed at the route 460 and I-581 interchanges, respectively. Table 4.1 shows the traffic data for that section of road and indicates an increase in the percentage of trucks for 1992 and 1996.

Table 4.1. Traffic data for 1992 and 1996

From Rte.	To Rte.	1990 ADT	1996 ADT	Directional Split (NB/SB)	1992 % Trucks	1996 % Trucks
11/460	603	31170	25337	30/70	26	25
603	647	31595	38566	50/50	26	38
647	112	32330	35782	60/40	26	37
112	311	38160	45324	60/40	25	38
311	220/581	45610	50409	60/40	22	27

4.2 Source of Data

The data that were utilized for this project came from two major sources. The first source was the set of plans and profiles that was provided by VDOT. The second source was the traffic count data by vehicle type and time-of-day. Both the ramp and main line volumes were received from HDR Engineering.

4.3 Coding of Network

The initial stage in the coding of the I-81 network included the organization of information from the set of plans and profiles into a spreadsheet that would further be used for generating the input file for INTEGRATION. This was done by recording all the geometric data, such as the PC, PI, PT, δ, L, and R, to develop an x-y coordinate system that would be used as the basis for the network, links and nodes. Figure 4.2 shows the location of the geometric data on a simple curve. The network was created using an Excel macro that utilized the horizontal and vertical geometric data to create the coordinates for the nodes. This method was repeated for both the northbound and southbound directions. Tables 4.2 and 4.3 illustrate a subset of horizontal curves that were utilized to generate the x-y coordinate system, and describe each of the fields and their input format, respectively.

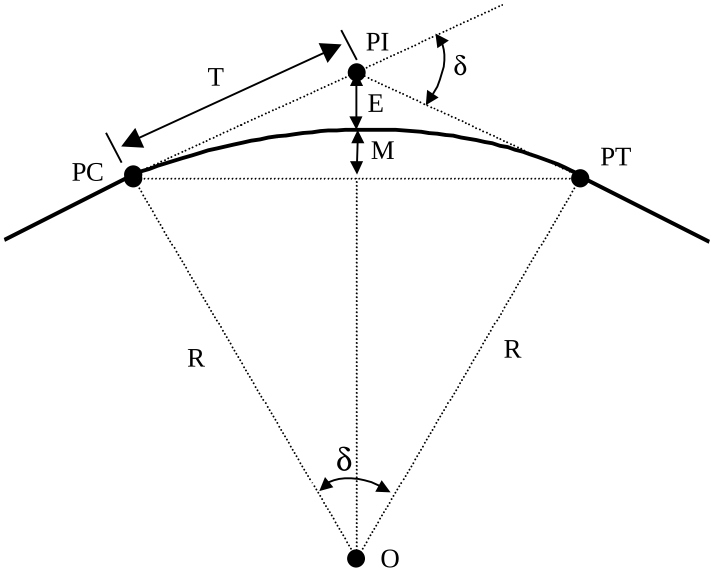

Figure 4.2. Diagram showing geometric data

Where:

PC: Point of curvature
PI: Point of intersection
PT: Point of tangency
L: Length of curve

E: External distance
PM: Middle ordinate
PT: Tangent length
δ: Degree of curve

Table 4.2. Input data for generating the X-Y coordinate system

PI (ft)		PT (ft)		δ (degrees/minutes/seconds)			R (ft)	Dir of curve	L (ft)
1076	62.38	1088	24.67	23	58	22	5639.58	L	2359.62
1122	37.01	1126	71.11	4	22	39	11369.16	L	868.62
1154	30.33	1160	66.39	34	9	4	2201.83	L	1312.40
1183	3.29	1192	32.88	-37	26	35	2954.79	R	1930.97
1248	47.47	1255	43.74	7	1	36	11369.16	L	1394.30
1275	63.19	1283	63.03	34	4	20	2774.79	L	1650.09
1323	51.00	1333	71.62	-42	57	26	2864.79	R	2147.86
1378	19.41	1390	76.55	39	20	8	3819.72	L	2622.37
1420	52.17	1431	99.66	-49	9	14	2864.79	R	2457.70
1449	24.45	1457	40.18	24	52	12	3819.72	L	1658.00
1511	49.03	1517	70.68	35	21	26	2083.48	L	1285.72
1547	31.19	1555	43.17	-33	27	51	2864.79	R	1673.21
1567	58.27	1574	52.89	43	58	12	1909.86	L	1465.67
1591	88.07	1601	58.61	-19	36	15	5729.58	R	1960.42
1632	34.15	1642	53.16	-55	50	0	2291.83	R	2233.33
1663	75.67	1678	15.99	45	49	5	3819.72	L	3054.54
1707	58.12	1714	49.41	-40	19	31	2053.61	R	1445.35

Table 4.3. Description of columns for the horizontal input data

Data	Descriptio	Input	Conventio
Curve	curve	–	–
PC	initial point	stacks +	distance ◁length between stacks
PI	intermediate	stacks +	
PT	end point	stacks +	
δ	angle	° ' "	negative for clockwise positive for counterclockwise
R	radius	distance (ft)	–

Tables 4.4 and 4.5 show a sample input file for the vertical data, and a description of each field and the input format, respectively.

Table 4.4. Input data for grade profile

Point	Station (stack)		grade (%)
1	1064	65.05	
2	1075	60.00	0.880
3	1111	50.00	2.540
4	1127	20.00	-0.960
5	1146	50.00	0.640
6	1173	20.00	-1.498
7	1194	0.00	0.994
8	1276	50.00	-4.000
9	1305	50.00	-3.129
10	1328	50.00	3.993
11	1356	0.00	2.260
12	1386	0.00	-2.883
13	1428	50.00	-3.736
14	1453	0.00	4.000
15	1487	20.00	-3.940

Table 4.5. Description of each column in the vertical data input sheet

Data	Description	Input format	Convention
Point	Node identification	–	–
Stack point	Stack point	Stack + distance	distance < length between stacks
Grade	Grade magnitude	%	positive for upgrades negative for downgrades

The next phase dealt with the coding of the ramps at the interchanges. This task was a little more tedious since the ramps were first digitized from the plan set to obtain another set of coordinates. These coordinates were then converted to the coordinate system of the mainline using simple algebra. After all the interchanges were put in place, a second macro was utilized to connect the ramps to the mainline. One thing that must be noted is that no acceleration lanes were coded into the network. Also, there were no climbing lanes due to the lack of information on the plans that were used. Figure 4.3 through Figure 4.8 show a diagram of each interchange that was coded.

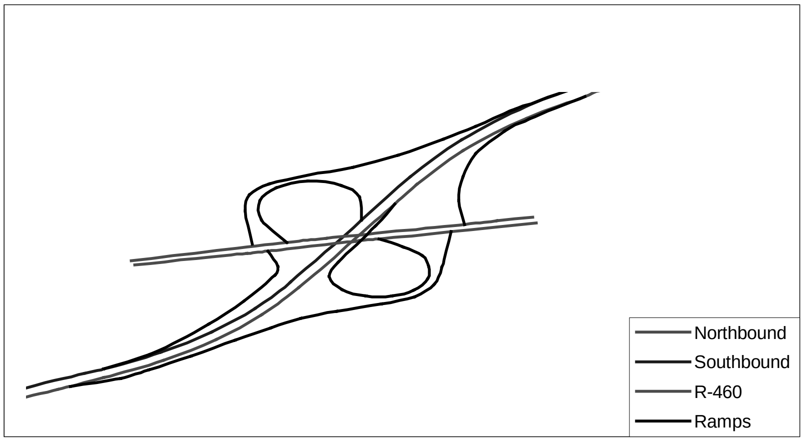
Northbound
Southbound
R-460
Ramps

Figure 4.3. 460 interchange

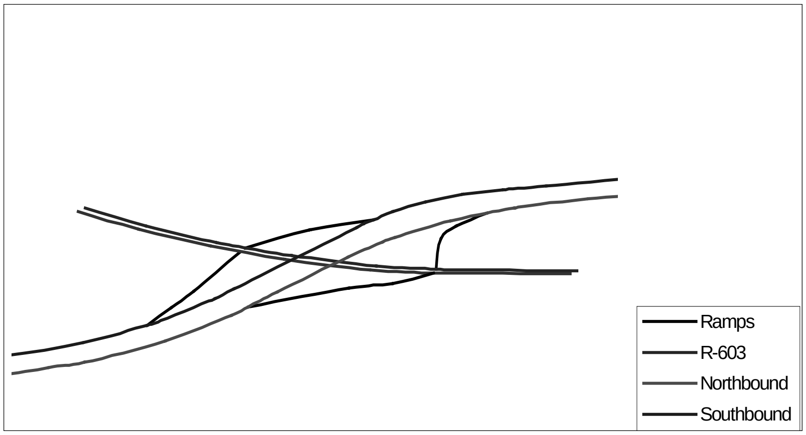
Ramps
R-603
Northbound
Southbound

Figure 4.4. 603 interchange

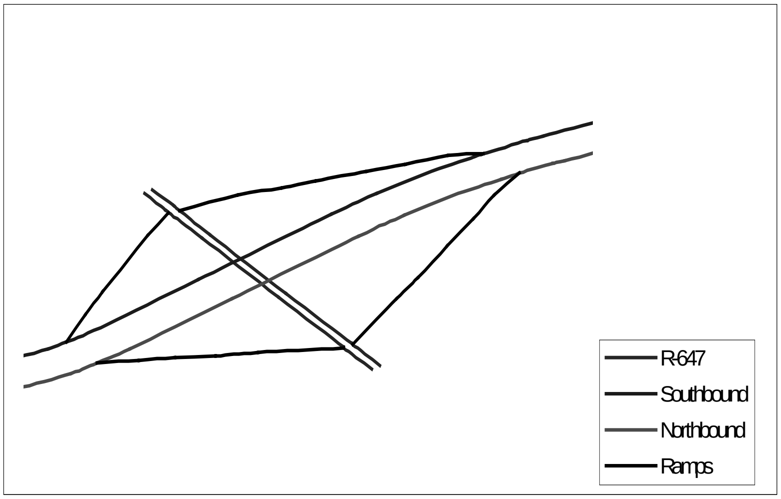
R-647
Southbound
Northbound
Ramps

Figure 4.5. 647 interchange

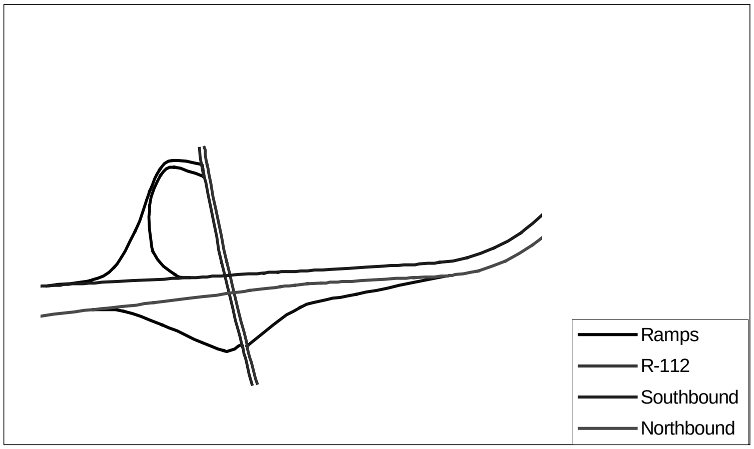
Ramps
R-112
Southbound
Northbound

Figure 4.6. 112 interchange

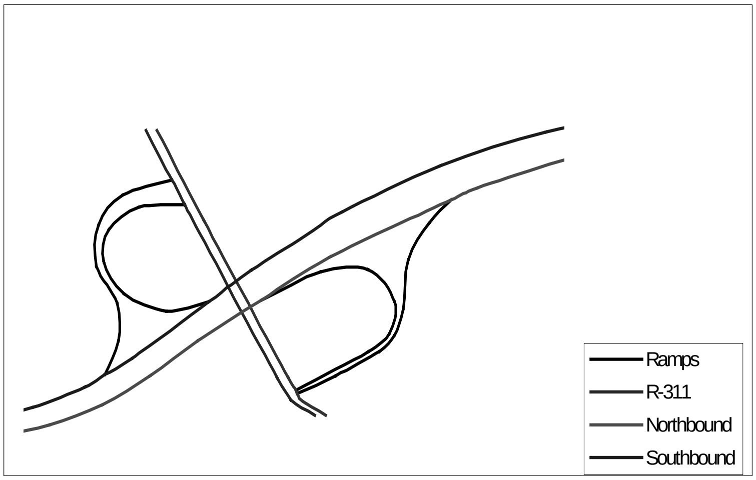
Ramps
R-311
Northbound
Southbound

Figure 4.7. 311 interchange

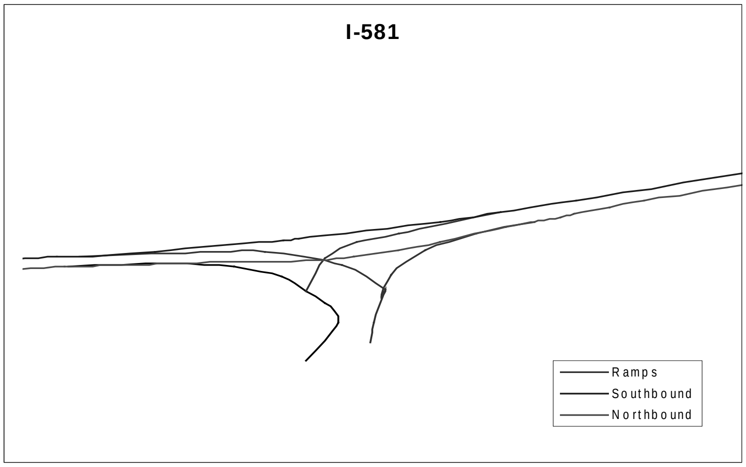
I-581
Ramps
Southbound
Northbound

Figure 4.8. 581 interchange

The first is interchange 460. It is a partial cloverleaf, which consists of four ramps, two on and two off, serving Route 460, a four-lane highway, running from West Virginia to Petersburg, Virginia. The next is interchange 603, which is a diamond interchange that also consists of two on-ramps and two off-ramps. Unlike Route 460, it is a two-lane county road that acts as a feeder road to Route 460 and I-81. The third interchange is interchange 647. It is a two-lane secondary road that feeds into I-81 from the neighboring county. Route 112 interchange is a partial diamond interchange; it has the same number of ramps as the previous interchanges. Route 112 is a Virginia primary road that connects Route 460 to Route 220. The fifth interchange is the Route 311 interchange. It is a partial cloverleaf with two on-and-off ramps. Route 311 is a Virginia byway that connects I-81 to I-64. The last interchange is the 581/220 interchange. This is a three-leg directional interchange that runs directly into and out of I-81. Route 581 is actually an interstate that runs through the city of Roanoke and continues into North Carolina as Route 220.

The next stage included the generation of the input file for INTEGRATION (node file, link file, and grade file) using the second macro. This macro used the coordinates and the grade profile generated by the first macro to create these files.

The links were created based on the geometry of the highway. For instance, the start and end node of each link had to correspond to the grade and curvature of the actual highway. Also, the first vertical stack (that is, the initial point of the highway) was made lower or equal to the PC stack of the first curve. The last vertical point stack, corresponding to the end of the highway, was made higher or at least equal to the PT stack of the last curve (Figure 4.9). Also, each curve length was divided into four minor links and then all short links were deleted (links less than 100 feet). If there was a grade change between two consecutive horizontal points, the link was divided into two links at the grade change.

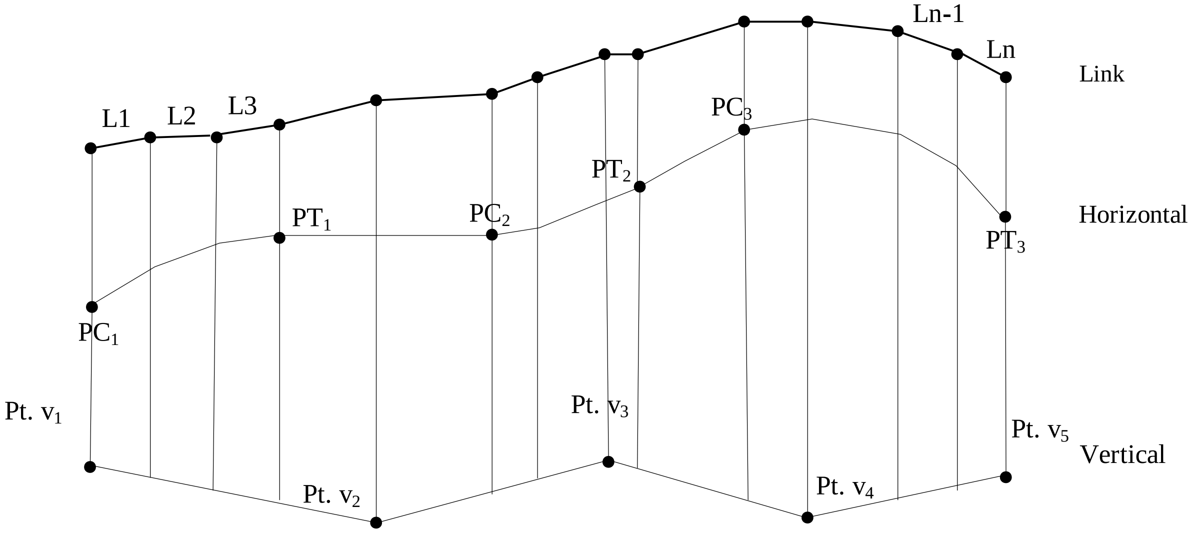
Ln-1
Ln
Link
L1
L2
L3
PC$_3$
PT$_2$
PT$_1$
PC$_2$
Horizontal
PT$_3$
PC$_1$
Pt. v$_1$
Pt. v$_3$
Pt. v$_5$
Vertical
Pt. v$_2$
Pt. v$_4$

Figure 4.9. Diagram showing links from horizontal and vertical geometric data

A sample of the output files can be seen in Tables 4.6, 4.7, 4.8, and 4.9. A total of 592 nodes and 604 links were generated.

Table 4.6. Sample Node File for INTEGRATION

592	0.2	0.4			
1	1	1	1	-1	0
27	1.6	1.03	4	0	0
28	2.19	1.12	4	0	0
29	2.77	1.28	4	0	0
30	3.33	1.49	4	0	0
31	5.42	2.42	4	0	0
32	6.01	2.69	4	0	0
33	6.21	2.78	4	0	0
34	6.41	2.87	4	0	0
35	6.61	2.97	4	0	0
36	6.8	3.07	4	0	0
37	7.02	3.19	4	0	0

Table 4.7. Description of fields in the node file

Line	Field	Description
1	1	Title
2	1	Number of nodes
	2	Scale factor applied to X-coordinates
	3	Scale factor applied to Y-coordinates
3	1	Unique node identification number
	2	X coordinate of node location
	3	Y coordinate of node location
	4	Node type identifier
	5	Macro zone cluster number
	6	Information availability indication

Table 4.8. Sample link file for INTEGRATION

Title- I-81 Link file																				
604	1	1	1	1	1															
1	1	27	0.18	100	2000	2	0	50	80	0	0	0	0	0	0	0	0	0	0	0
2	27	28	0.18	100	2000	2	0	50	80	0	0	0	0	0	0	0	0	0	0	0
3	28	29	0.18	100	2000	2	0	50	80	0	0	0	0	0	0	0	0	0	0	0
4	29	30	0.18	100	2000	2	0	50	80	0	0	0	0	0	0	0	0	0	0	0
5	30	31	0.7	100	2000	2	0	50	80	0	0	0	0	0	0	0	0	0	0	0
6	31	32	0.2	100	2000	2	0	50	80	0	0	0	0	0	0	0	0	0	0	0
7	32	33	0.07	100	2000	2	0	50	80	0	0	0	0	0	0	0	0	0	0	0
8	33	34	0.07	100	2000	2	0	50	80	0	0	0	0	0	0	0	0	0	0	0
9	34	35	0.07	100	2000	2	0	50	80	0	0	0	0	0	0	0	0	0	0	0
10	35	36	0.07	100	2000	2	0	50	80	0	0	0	0	0	0	0	0	0	0	0
11	36	37	0.08	100	2000	2	0	50	80	0	0	0	0	0	0	0	0	0	0	0
12	37	38	0.48	100	2000	2	0	50	80	0	0	0	0	0	0	0	0	0	0	0
13	38	39	0.02	100	2000	2	0	50	80	0	0	0	0	0	0	0	0	0	0	0
14	39	40	0.06	100	2000	2	0	50	80	0	0	0	0	0	0	0	0	0	0	0

Table 4.9. Default values used on the link file

Line	Field	Description	Default	Unit
1	1	Title		
2	1	Number of links in file	604	
	2-6	Scale factor for link length, free-speed, saturation flow rate, speed at capacity, and density respectively	-	-
3	1	Unique link identification number	-	-
	2	Identification number of node upstream of link	-	-
	3	Identification number of node downstream of link	-	-
	4	Link length	-	-
	5	Free speed	100	km/h
	6	Saturation flow rate per lane	2000	vphpl
	7	Number of lanes	2	-
	8	Vehicle speed variability factor	0	-
	9	Speed at capacity	50	km/h
	10	Jam density	80	v/km/lane
	11-21	-	0	-

The default values used were values that were typical for an interstate such as I-81. For instance, the speed limit of 100 km/h was chosen because it approximated the existing speed limit of 65 mph on I-81. The other parameters, such as the saturated flow rate, speed at capacity, and jam density, were values obtain from the HCM for an interstate with the given geometric characteristics.