ESTIMATING THE OFF-NETWORK PRESENCE OF STAA DIMENSIONED VEHICLES ON NORTH CAROLINA ROADWAYS USING CMV CRASH DATA, 2001-2005

Work Performed in Support of
NCDOT Research Project 2007-14 (Task B)

By

Ronald G. Hughes, Ph.D.
Program Director
Visual Analytics, Modeling, and Simulation (VAMS)

Jeremy Scott, M.S.
Research Associate
Spatial Data, GIS Research and Training

Greg Ferrara, M.A.
Program Manager
Spatial Data, GIS Research and Training

NORTH CAROLINA STATE UNIVERSITY
Institute for Transportation Research and Education
Centennial Campus

Raleigh, North Carolina

May 2008

Technical Report Documentation Page

1. Report No. FHWA/NC/2007-14	2. Government Accession No.	3. Recipient's Catalog No.
4. Estimating the Off-Network Presence of STAA Dimensioned Vehicles on North Carolina Roadways Using CMV Crash Data, 2001-2005		5. Report Date May 6, 2008
7. Author(s) Ronald G. Hughes, Jeremy Scott, Greg Ferrara		8. Performing Organization Report No.
9. Performing Organization Name and Address NC State University Institute for Transportation Research and Education		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address North Carolina Department of Transportation Research and Analysis Group 1 South Wilmington Street Raleigh, North Carolina 27601		13. Type of Report and Period Covered Final Report *September 1, 2006 to August 31, 2007* 14. Sponsoring Agency Code
Supplementary Notes:		

16. Abstract

The present study used commercial motor vehicle (CMV) crash data from NCDOT's Traffic Engineering Accident Analysis System (TEAAS) to infer the presence and relative extent of STAA dimensioned vehicles operating beyond the 3-mile buffer of the present STAA Truck Network in North Carolina. STAA dimensioned vehicles include trailers 53ft or greater in length and double trailers. STAA routes in NC constitute only about 8 percent of all state-maintained roadway miles. The data showed that approximately 87 percent of all large truck crashes took place on STAA network roads during the period 2001-2005. While only 13 percent of large truck involved crashes took place on roads 'off' the network, the likelihood of any given off-network crash involving a fatality was twice that of a crash taking place on the network. Off network crashes involving large trucks are problematic for reasons other than safety, especially in metropolitan areas where operations, irrespective of crash involvement, are associated with traffic delays (due to the maneuvering/turning requirements of larger vehicles) and infrastructure damage. The report provides GIS 'maps' of each of the eight NCSHP troop areas, the network and its 3-mile buffer and the location and severity of all large truck-involved crashes reported as taking place 'off' the network. The report also provides a detailed description of the attributes of off-network crashes for 2001-2005 for each NCSHP troop. Several criteria were explored as a means for ranking troop areas in terms of need for STAA improvements. The report also identifies specific off-network routes at the county and troop levels having the highest numbers of crashes per mile. Recommendations are provided for 'next steps' as well as a plan for technology transfer and implementation.

17. Key Words *STAA Truck Network, truck crashes, 53ft trailers, doubles, Geographic Information System (GIS), TEAAS, crash severity, non-STAA high crash routes*	18. Distribution Statement		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 78	22. Price

Table of Contents

Technical Report Documentation Page 1
Tables and Figures 3
Disclaimer 4
Acknowledgements 5
Summary 6
2008 Attorney General's Re-interpretation of STAA guidelines: 8
Cross-referencing for NCDOT 'divisions', NCSHP 'troops and NC counties: 9
COUNTIES by NCSHP 'TROOPS' 10
COUNTIES by NCDOT 'DIVISIONS' 12
Chapter 1: Introduction 14
1.1 The Objective of the Present Study 19
Chapter 2: Methodology 21
2.1 Create the STAA Truck Network 21
2.2 Create the 3-mile buffer 22
2.3 Locate off-network truck crashes 22
2.4 Analysis 22
I: Merit-Based Prioritization by Troop 23
II: Summary Statistics by Route and County 23
III: Geographic Analysis 23
Chapter 3: Results and Conclusions 26
3.1 Spatial Distributions of Off-Route Crashes at Troop Level 26
3.2 Characterizing Attributes of Off-Network Crashes 28
3.3 Alternative Strategies for Prioritizing Improvement 28
Chapter 4: Discussion 74
4.1 Toward a Method for Prioritizing the Need for Improvement 74
4.2 The Enforcement Alternative 75
4.3 Responsibility of the Vehicle Manufacturing Community 76
Chapter 5: Prioritized Recommendations by Agency 77
Appendix A 83
Appendix B 88

Tables and Figures

Table 1: Two lane road mileage in NC 16
Table 2: Clear roadway widths for NC bridges 17
Table 3: Summary attributes for each of the 8 troops 27
Table 4: Measure of Merit = AxB 29
Table 5: Measure of Merit = AxBxC 29
Table 6: Attributes of off-network crashes: Troop A 31
Table 7: Attributes of off-network crashes: Troop B 37
Table 8: Attributes of off-network crashes: Troop C 43
Table 9: Attributes of off-network crashes: Troop D 49
Table 10: Attributes of off-network crashes: Troop E 55
Table 11: Attributes of off-network crashes: Troop F 60
Table 12: Attributes of off-network crashes: Troop G 65
Table 13: Attributes of off-network crashes: Troop H 70

Figure 1: North Carolina National Truck Network for STAA Vehicles 14
Figure 2: STAA dimension vehicles 15
Figure 3: Off-tracking of 48 ft and 53 ft trailers 15
Figure 4: Lane encroachment example 18
Figure 5: Growth of truck traffic 18
Figure 6: One-fifth traffic delays caused by trucks 19
Figure 7: Cluster Analysis: Linear distance vs Areal distance 24
Figure 8 : Robustness of the STAA Network 27
Figure 9: Troop A Off-Network High Crash Rate Routes 30
Figure 10: Troop B Off-Network High Crash Rate Routes 36
Figure 11: Troop C Off-Network High Crash Rate Routes 42
Figure 12: Troop D Off-Network High Crash Rate Routes 48
Figure 13: Troop E Off-Network High Crash Rate Routes 54
Figure 14: Troop F Off-Network High Crash Rate Routes 59
Figure 15: Troop G Off-Network High Crash Rate Routes 64
Figure 16: Troop H Off-Network High Crash Rate Routes 69

Disclaimer

Acknowledgements

Kevin Lacy, P.E.
State Traffic Engineer
North Carolina Department of Transportation

Mr. Tony Wyatt, P.E. & P.T.O.E.
Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation

LC. Smith, Director
Geographic Information Systems (GIS)
North Carolina Department of Transportation

Marilyn Graham, Terry Norris, and Jonathan Broom
North Carolina Department of Transportation
Imaging, Mapping, and Graphics Group

Fred Rosendahl
Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation

Major Jaime Hatcher
North Carolina State Highway Patrol (NCSHP)
Director, Motor Carrier Enforcement Administration

Captain George, E. Gray, Jr.
North Carolina State Highway Patrol
Director, Motor Carrier Safety Assistance Program (MCSP)

Captain Mark Nichols
North Carolina State Highway Patrol (NCSP)
Motor Carrier Enforcement
Size and Weight Office

1Sgt Hank Whitmire
North Carolina State Highway Patrol (NCSHP)
Motor Carrier Enforcement
Size and Weight Office

Darrell Jernigan, Chair
Commercial Motor Vehicles Working Group
North Carolina Governor's Executive Committee on Highway Safety

Summary

The present study addresses the presence of commercial motor vehicle (CMV) involved crashes in North Carolina which took place off (i.e., beyond the 3-mile buffer) the truck network established by the Surface Transportation Assistance Act (STAA). All crash data were obtained from the North Carolina Department of Transportation's Traffic Engineering Accident Analysis System (TEAAS). The data used in the study were for the period, CY2001-CY2005. Since it was not possible to reliably differentiate STAA 'dimensioned' vehicles using the trailer length field of the DMV-349 crash report form (due to large number of inaccurate or missing data), the dataset used for the analysis is confounded by the presence of trailers with trailer lengths (e.g., 48 ft) permissible 'off-network.'

The analysis was conducted within ITRE's Truck Crash GIS Data Base environment. The Truck Crash GIS website is available on line at http://vams.itre.ncsu.edu/truckcrash/. The first task involved coding the STAA truck crash network into GIS, including the 3-mile buffer permitted on either side of STAA routes. This coding was performed using information on the extent of the STAA network from the NCDOT and from roadway files provided in the NCDOT Linear Referencing System (LRS). "Maps" were generated for each of the eight North Carolina State Highway Patrol (NCSHP) troop areas, A-H. In each case, CMV-involved off-network crashes were color coded for level of injury severity. Tabular data were also generated for each NCSHP troop area documenting the attributes of the off-network crashes (e.g., type of crash, class of roadway, roadway configuration, type of signal control present, etc.).

Attempts were made to 'cluster' off-route crashes in an effort to permit NCDOT and NCSHP motor carrier enforcement personnel to better 'focus' on specific areas of off-route crash activity. Initial efforts at clustering were done on the basis of (subjective) visual inspection. Several alternative quantitative methods were also explored – all of which were limited in their present form in terms of their ability to effectively cluster events taking place along linear (as opposed to area) features (e.g.,. a roadway).

In an effort to produce a product with more spatial specificity, the extent to which a specific route warranted increased focus was approached by documenting the linear exposure (number of miles) of a route, the counties through which the route passed, and a measure of crash rate for the route derived by dividing the number of reported crashes for the five year period by the length of the route within a particular county. Also presented were the total number of roadway miles in the county and the percentage of total roadway miles covered by STAA routes. These highlighted routes and the associated data were presented to the motor carrier enforcement section of the NCSHP for its review.

The results of the report are timely inasmuch as the Office of the Governor was receiving complaints at the time from farmers (in counties such as Wayne County) who

were being ‘ticketed’ in their efforts to get agricultural products to market using acceptable routes. To the extent that these complaints were essentially complaints of ‘restricted access,’ they were also unwarranted in that the farming community was, under its own volition, choosing to transport its products using a vehicle/trailer class (53ft) prohibited by the STAA regulations and refusing to take available, although more circuitous, routes between farm and marketplace. Even a cursory review of the STAA crash maps, by county, shows there to be a great deal of variation in the extent to which currently designated STAA routes provide the largest commercial vehicle configurations with needed access to commercial destinations.

Does the use of non-STAA approved routes by STAA dimensioned truck configurations constitute a safety problem? The present data indicate that the percentage of all off-network CMV-involved crashes involving a fatality was approximately 3.1 percent. This compared to 1.5 percent for crashes occurring on STAA routes. Does the off-network presence of over-weight, non-STAA compliant vehicles constitute a threat to the infrastructure (i.e., accelerated damage to roadways, increased stress on bridges, etc.)? While the present report provides no documentation of the comparative likelihood of overweight trucks on/off the STAA network, it is clear that an 80,000 pound vehicle produces more stress on roads that are designed to less than interstate standards. In separate research efforts directed toward the development of a ‘vulnerability index’ for prioritizing size and weight enforcement efforts on facilities characterized by traffic demand, structural condition of the facility (e.g, a bridge), and pavement condition, it is clear that off-network infrastructure is more ‘vulnerable’ than that which constitutes the current USDOT designated STAA network.

In short, the present study used crash data to infer the presence and relative extent of non-STAA vehicles operating beyond the 3-mile buffer of the present STAA Truck Network in North Carolina. The data showed that approximately 87 percent of all large truck crashes took place on 7.5 percent of the states roads during the period 2001-2005. The remainder of all large truck crashes (approximately 13 percent) took place on 92 percent of the state’s roads (i.e., those roads not included on the network). That means that large truck operations are being confined in large part to STAA network roadways. Compliance means significant differences in truck exposure on STAA and non-STAA routes, with the result being that large truck crashes per mile on STAA routes are orders of magnitude greater than large truck crashes per mile on non-STAA routes. However, to the extent that non-STAA routes are less well equipped by design and construction to handle large trucks, the likelihood of a fatal large truck crash off the network was, according to the data, approximately twice that of a fatal large truck crash on the network.

Bottom Line: While STAA compliance is inferred to be good, the limited number of STAA routes has the effect of channelizing larger than 48 foot trailer truck traffic onto congested corridors where truck crash rates are orders of magnitude higher than those for off-network roads. Low off-network crash rates do not imply increased safety for large trucks, inasmuch as fatality rates off-network were twice that of those for on-network. Furthermore, the study warrants a closer, county by county examination of the data to identify limitations of the current network in terms of providing commercial vehicles adequate ‘access’ to reach their final destinations. A good case in point is Wayne County where US 70 is the only STAA route in the entire county, providing limited access to Goldsboro from areas to the north and south of Goldsboro.

2008 Attorney General’s Re-interpretation of STAA guidelines:

Concurrent with Statewide TACT (Targeting Aggressive Cars and Trucks) efforts, in the time period following the submission of the final report for the current study (January & February 2008), significant efforts by the NC Retailers Association and NC Trucking Association were made to the State Legislature and the Governor’s Office to grant increased access to additional routes. As a result of these efforts and research into North Carolina’s Truck Network legislation, the Secretary of Crime Control and Public Safety and the Secretary of Transportation formally requested a ruling from the Office of the State Attorney General clarifying the “literal” interpretation of which routes 53ft trailers should be statutorily eligible to travel.

The two letters found in Appendix B provide the published opinion/interpretation of the Attorney General on this issue. The ruling of the Attorney General had the effect of designating all Federal Aid Primary (FAP) routes (as effective in 1991) as being statutorily eligible for 53 foot long trailers. The newly added routes (blue lines) did not, however, affect or extend access to the operation of double (twin) trailers. The opinion was issued independent of other sections of G.S. 20-115 without consideration of the geometry, number of lanes, and control of access criteria that the USDOT required in authorizing North Carolina’s truck network.

No in-depth engineering review of the safety and/or operational ramifications likely to be associated with this ruling was performed prior to the issuance of this ruling. However, NCDOT and the NCSHP were able to designate certain routes as being “under study” with the February 28, 2008 publishing of North Carolina’s Interim Truck Network map. The NCDOT, the NC State Highway Patrol, and the NCSU Institute for Transportation Research and Education (ITRE) have conducted preliminary observations of 53 foot trailer traffic on select routes added to the Network as the result of this ruling. These observations and engineering investigations and recommendations are continuing as this report nears publication.

Cross-referencing for NCDOT ‘divisions’, NCSHP ‘troops and NC counties:

The present study was conducted within the framework of NCSHP ‘troops’ inasmuch as truck safety and enforcement tools and actions directed toward off-network truck behavior have traditionally been the responsibility of the Motor Carrier Enforcement section of the NC State Highway Patrol. However, to the extent that implications for roadway improvements are contained within the recommendations of the study, the following tables are provided that enable the reader to cross reference by county, NCSHP troop, or NCDOT division.

COUNTIES by NCSHP 'TROOPS'

COUNTY	NCDOT DIVISION	HP DISTRICT	HP TROOP
Beaufort	2	1	A
Bertie	1	2	A
Camden	1	3	A
Carteret	2	8	A
Chowan	1	3	A
Craven	2	6	A
Currituck	1	3	A
Dare	1	9	A
Gates	1	2	A
Hertford	1	2	A
Hyde	1	4	A
Jones	2	7	A
Lenoir	2	7	A
Martin	1	5	A
Pamlico	2	6	A
Pasquotank	1	3	A
Perquimans	1	3	A
Pitt	2	5	A
Tyrrell	1	4	A
Washington	1	4	A
Bladen	6	5	B
Brunswick	3	6	B
Columbus	6	5	B
Cumberland	6	1	B
Duplin	3	4	B
Harnett	6	8	B
New Hanover	3	6	B
Onslow	3	3	B
Pender	3	4	B
Robeson	6	7	B
Sampson	3	2	B

COUNTY	NCDOT DIVISION	HP DISTRICT	HP TROOP
Durham	5	7	C
Edgecombe	4	1	C
Franklin	5	4	C
Granville	5	7	C
Greene	2	5	C
Halifax	4	1	C
Johnston	4	6	C
Nash	4	1	C
Northampton	1	1	C
Vance	5	4	C
Wake	5	3	C
Warren	5	4	C
Wayne	4	2	C
Wilson	4	5	C
Alamance	7	5	D
Caswell	7	4	D
Chatham	8	1	D
Guilford	7	4	D
Lee	8	1	D
Orange	7	5	D
Person	5	4	D
Randolph	8	6	D
Rockingham	7	3	D
Cabarrus	10	6	E
Davidson	9	1	E
Davie	9	3	E
Forsyth	9	4	E
Montgomery	8	2	E
Rowan	9	3	E
Stanly	10	2	E
Stokes	9	4	E
Surry	11	5	E
Yadkin	11	5	E

COUNTY	NCDOT DIVISION	HP DISTRICT	HP TROOP
Alexander	12	4	F
Alleghany	11	2	F
Ashe	11	2	F
Burke	13	1	F
Caldwell	11	3	F
Catawba	12	5	F
Iredell	12	4	F
Lincoln	12	5	F
Watauga	11	3	F
Wilkes	11	2	F
Avery	11	1	G
Buncombe	13	4	G
Cherokee	14	6	G
Clay	14	6	G
Graham	14	6	G
Haywood	14	5	G
Henderson	14	3	G
Jackson	14	5	G
Macon	14	6	G
Madison	13	1	G
McDowell	13	2	G
Mitchell	13	1	G
Polk	14	3	G
Rutherford	13	2	G
Swain	14	6	G
Transylvania	14	3	G
Yancey	13	1	G
Anson	10	3	H
Cleveland	12	4	H
Gaston	12	1	H
Hoke	8	6	H
Mecklenburg	10	5	H
Moore	8	6	H
Richmond	8	2	H
Scotland	8	2	H
Union	10	3	H

COUNTIES by NCDOT ‘DIVISIONS’

COUNTY	NCDOT DIVISION	HP DISTRICT	HP TROOP
Bertie	**1**	**2**	**A**
Camden	**1**	**3**	**A**
Chowan	**1**	**3**	**A**
Currituck	**1**	**3**	**A**
Dare	**1**	**9**	**A**
Gates	**1**	**2**	**A**
Hertford	**1**	**2**	**A**
Hyde	**1**	**4**	**A**
Martin	**1**	**5**	**A**
Pasquotank	**1**	**3**	**A**
Perquimans	**1**	**3**	**A**
Tyrrell	**1**	**4**	**A**
Washington	**1**	**4**	**A**
Northampton	**1**	**1**	**C**
Beaufort	2	1	A
Carteret	2	8	A
Craven	2	6	A
Jones	2	7	A
Lenoir	2	7	A
Pamlico	2	6	A
Pitt	2	5	A
Greene	2	5	C
Brunswick	3	6	B
Duplin	3	4	B
New Hanover	3	6	B
Onslow	3	3	B
Pender	3	4	B
Sampson	3	2	B
Edgecombe	4	1	C
Halifax	4	1	C
Johnston	4	6	C
Nash	4	1	C
Wayne	4	2	C
Wilson	4	5	C

COUNTY	NCDOT DIVISION	HP DISTRICT	HP TROOP
Durham	5	7	C
Franklin	5	4	C
Granville	5	7	C
Vance	5	4	C
Wake	5	3	C
Warren	5	4	C
Person	5	4	D
Bladen	6	5	B
Columbus	6	5	B
Cumberland	6	1	B
Harnett	6	8	B
Robeson	6	7	B
Alamance	7	5	D
Caswell	7	4	D
Guilford	7	4	D
Orange	7	5	D
Rockingham	7	3	D
Chatham	8	1	D
Lee	8	1	D
Randolph	8	6	D
Montgomery	8	2	E
Hoke	8	6	H
Moore	8	6	H
Richmond	8	2	H
Scotland	8	2	H
Davidson	9	1	E
Davie	9	3	E
Forsyth	9	4	E
Rowan	9	3	E
Stokes	9	4	E

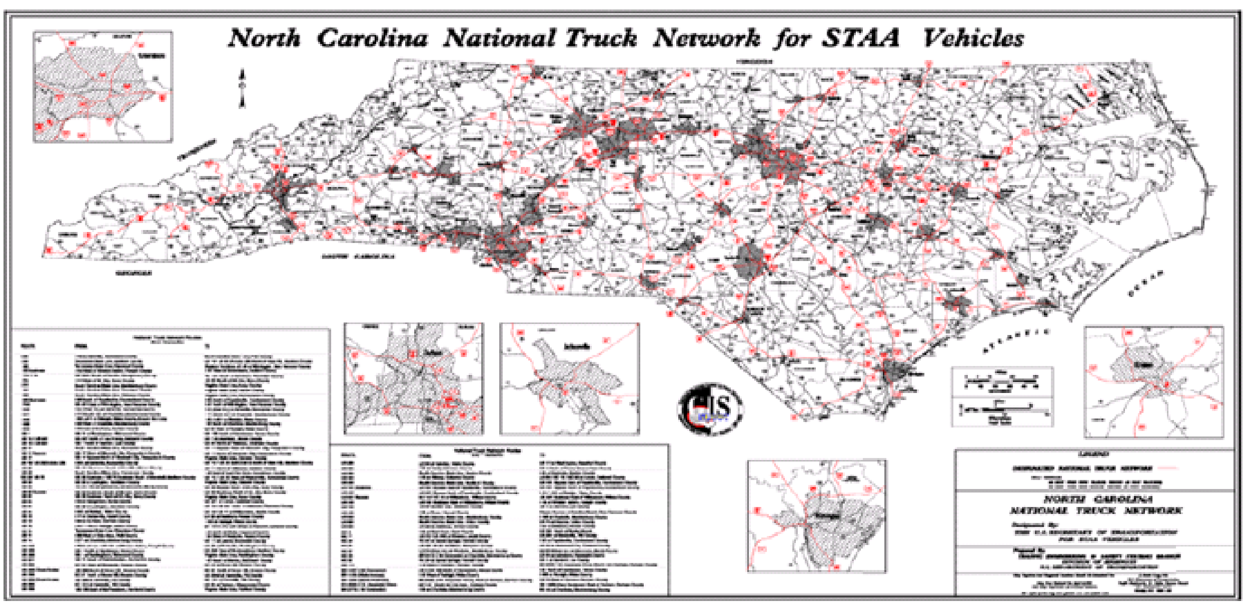
COUNTY	NCDOT DIVISION	HP DISTRICT	HP TROOP
Cabarrus	10	6	E
Stanly	10	2	E
Anson	10	3	H
Mecklenburg	10	5	H
Union	10	3	H
Surry	11	5	E
Yadkin	11	5	E
Alleghany	11	2	F
Ashe	11	2	F
Caldwell	11	3	F
Watauga	11	3	F
Wilkes	11	2	F
Avery	11	1	G
Alexander	12	4	F
Catawba	12	5	F
Iredell	12	4	F
Lincoln	12	5	F
Cleveland	12	4	H
Gaston	12	1	H
Burke	13	1	F
Buncombe	13	4	G
Madison	13	1	G
McDowell	13	2	G
Mitchell	13	1	G
Rutherford	13	2	G
Yancey	13	1	G
Cherokee	14	6	G
Clay	14	6	G
Graham	14	6	G
Haywood	14	5	G
Henderson	14	3	G
Jackson	14	5	G
Macon	14	6	G
Polk	14	3	G
Swain	14	6	G
Transylvania	14	3	G

Chapter 1: Introduction

At the request of the NC Department of Transportation (NCDOT), the North Carolina State University (NCSU) Institute for Transportation Research and Education (ITRE) undertook the task of 'mapping' the involvement of selected classes of commercial motor vehicles in crashes taking place beyond the permissible 3-mile 'buffer' of the STAA truck network in North Carolina.

The STAA 'network' of roads was originally established as part of the Surface Transportation Assistance Act of 1982. The intent of the legislation (NC statute included as Attachment A) was to restrict the operation of certain classes of commercial motor vehicles (CMVs) to roads identified as part of the network. The classes of commercial motor vehicles affected by this legislation include tractors pulling double trailers (twins), and tractors pulling single trailers 53 ft or greater in length. The legislation also limits the maximum width of a trailer to 102 in.

What is the 'truck network'?



The STAA 'truck network' map can be accessed on line at:
http://www.ncdot.org/it/gis/graphics/STAA_main.pdf

Figure 1: North Carolina National Truck Network for STAA Vehicles

Over time, as population has grown and the demand upon trucking to deliver necessary goods and services has expanded geographically, the STAA network (and the ability of state Departments of Transportation to expand the network) has become unable to support the infrastructure demands of larger vehicles. The 53 foot trailer, for instance, is reportedly rapidly becoming the industry preferred trailer of choice (versus the older

48 foot trailer), even though the 48 ft trailer remains the 'design vehicle' for most state Departments of Transportation design efforts.

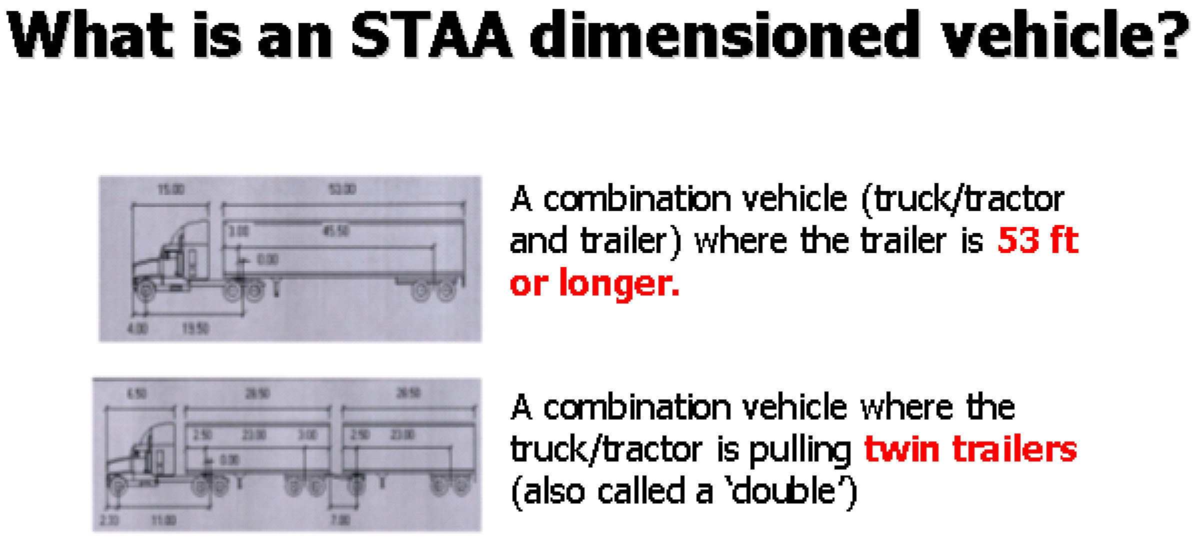


Figure 2: STAA dimension vehicles

Longer vehicles, such as the tractor and 53 ft trailer, encounter operational difficulty on many curves and at intersections. "Off tracking" is an operational phenomenon that refers to the fact that the "track" (or path) of the rear tandem axle of a trailer does not follow the track of the steering axle. The result is that the rear axle and truck body track a smaller radius than the steering axle. Examples of off-tracking are shown in the turning movements represented in the figures below for 48 ft and 53 ft trailers.

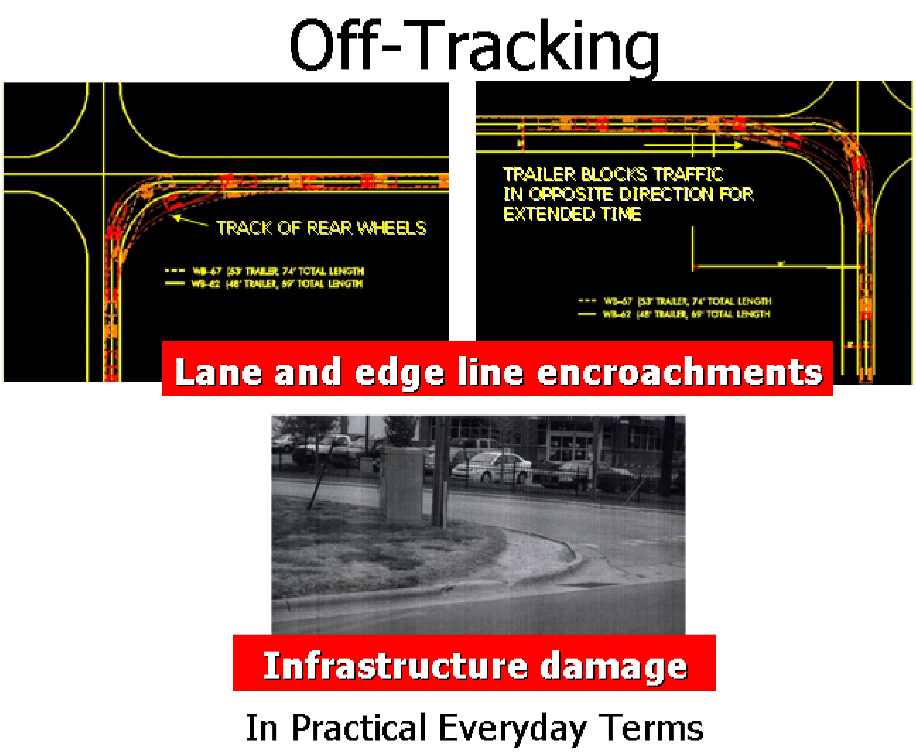


Figure 3: Off-tracking of 48 ft and 53 ft trailers

Overall roadway width and lane width are clearly important variables when it comes to the operational suitability of large vehicles. The following tables illustrate the problem in North Carolina.

Table 1 provides data on two (2) lane road mileage in North Carolina. As can been seen in the table, approximately 73,500 miles (or 94 percent) of the State's overall 78,000 miles of State Maintained roads ARE TWO (2) LANE ROADS. AND, approximately 78%, or 57,500 miles of North Carolina's two (2) lane roads are less than 21 feet wide (lanes with a nominal width of just over 10 feet).

Total Two (2) Lane Road Mileage in North Carolina			
(Source: MLI 1 Road Inventory, NCDOT Roadway Inventory Unit)			
Total Surface Width (in feet)	**Number of Miles**	**Cumulative Number**	**Cumulative Percent**
<16	3376	3376	5%
16	4187	7563	10%
17	240	7803	11%
18	22213	30016	41%
19	497	30513	42%
20	27151	57664	78%
21	391	58055	79%
22	4847	62902	86%
23	254	63156	86%
24	6164	69320	94%
>24	4163	73483	100%
Total Miles	73483		
2-Lane Roadway Classifications	**Mileage (Approx)**		
US Routes	3317		
NC Routes	7451		
Secondary Roads	62715		

Table 1: Two lane road mileage in NC

Consider now the increase in risk for a 102 inch wide vehicle (the nominal width of most tractor trailers) when traveling in a less than 10 foot wide travel lane when the edge line of the travel line is defined by the side rails of a bridge.

Table 2 provides information on clear roadway widths for North Carolina bridges.

Clear Roadway Widths for North Carolina Bridges

(Source: NCDOT Bridge Maintenance Unit)

Clear Roadway Width (in feet)	Number of Structures	Cumulative Number	Cumulative Percent	Interstate	US	NC	SR	City
<16	688	688	6%	0	1	21	666	0
16.1-17.9	513	1201	11.08%	0	0	6	507	0
18.0-19.9	2240	3441	31.73%	0	1	26	2213	0
20.0-21.9	374	3815	35.18%	3	27	42	302	0
22.0-23.9	616	4431	40.87%	1	13	48	554	0
24.0-25.9	3112	7543	69.57%	5	63	188	2853	3
26.0-27.9	547	8090	74.61%	8	54	136	344	5
28.0-29.9	1774	9864	90.97%	137	356	311	950	20
30.0-31.9	532	10396	95.88%	6	65	81	377	3
32.0-33.9	141	10537	97.18%	2	33	40	64	2
34.0-35.9	306	10843	100.00%	7	56	83	156	4

Table 2: Clear roadway widths for NC bridges

The data show that at the time of this report (from the NCDOT Bridge Maintenance Unit) that North Carolina has over 3,400 bridges that are less than 20 feet in total clear roadway width. Roughly 5 percent of these are located on numbered NC highways. That means that a 102 inch wide vehicle, when perfectly centered in the travel lane, has only 9 inches of clearance between the center line on its left and the edge line of the roadway on its right. Given that the mirrors of large tractor trailers typically extend from one to two feet beyond this, it is clear that 10ft travel lanes are not sufficient for these large vehicles.

We have not yet addressed the effects of horizontal curvature and the ability of longer vehicles to remain centered into the travel lane (i.e., the problem of off-tracking) and the increased risk of vehicle intrusions over the center line and/or the damage done to infrastructure by intrusions over the edge line or beyond the paved extent of the roadway.

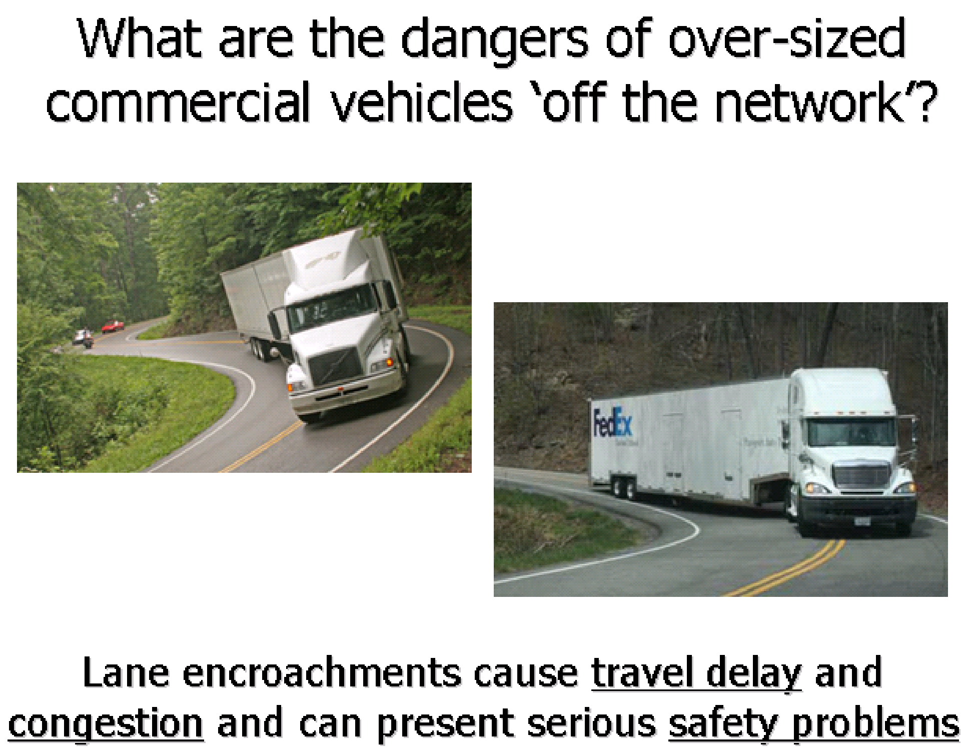


Figure 4: Lane encroachment example

Clearly the operation of over-length vehicles on roadways not designed to support such lengths (and/or their greater loads) can cause safety problems as well as accelerated damage to the infrastructure.

Is the current situation likely to improve over time? **Not likely.**

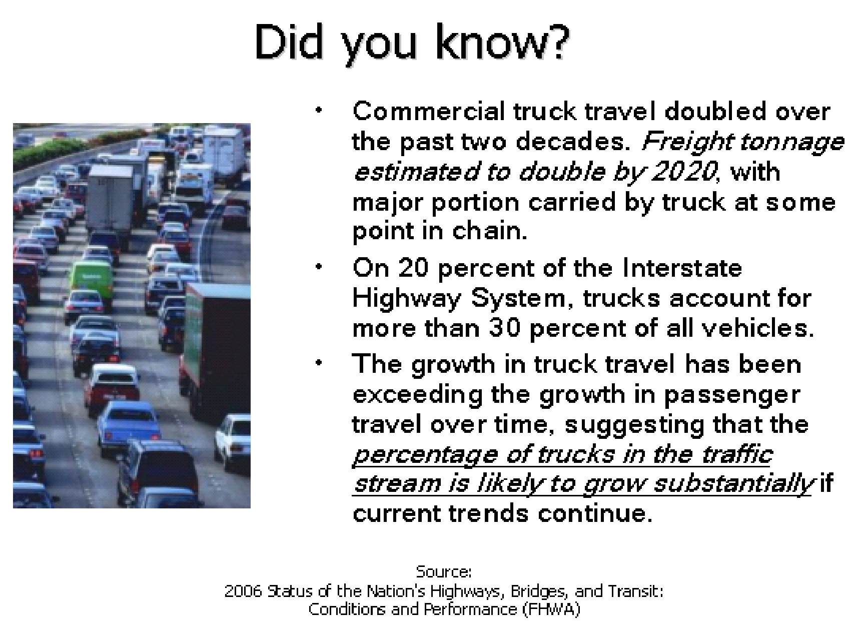


Figure 5: Growth of truck traffic

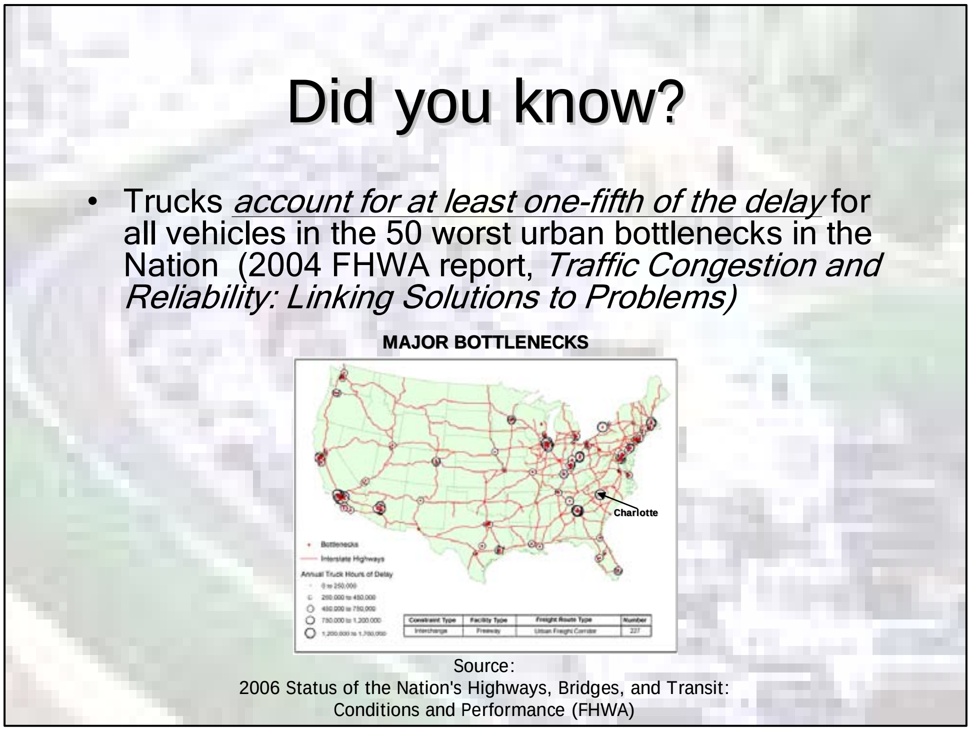


Figure 6: One-fifth traffic delays caused by trucks

The information contained in these figures suggests not, especially in our state's heavily populated areas defining the 'crescent' (the 'Triangle,' the 'Triad,' and the greater Charlotte-Mecklenburg area). In these areas, congestion may be the greater concern (i.e., than safety) in that while the Charlotte-Mecklenburg area experiences the highest numbers of CMV-involved crashes, the majority of these involve only minor injuries and/or 'property damage only.' Charlotte is already cited as being one of the 50 worst urban bottlenecks in the Nation, with trucks said to account for at least one fifth of the delay for all vehicles.

1.1 The Objective of the Present Study

To obtain an estimate of the extent to which these larger vehicles are operating on North Carolina roadways off the network that was established for their legal operation. The NCDOT requested that crash data for theses types of vehicles be examined over a multi-year period (2001-2005). While not a 'count' per se of the frequency of off-network operations, the crash data serve as an 'indicator' of off-network 'presence' for these classes of vehicles. It was further requested that this analysis be conducted within the GIS (Geographic Information System) framework of ITRE's GIS truck crash database for North Carolina (http://vams.itre.ncsu.edu/truckcrash/). The methodology used for this examination is described in the Methodology section of the report.

The intent of the present effort was to provide the NCDOT with data which could be used in establishing prioritized needs for the geo-specific improvement of the existing STAA infrastructure in North Carolina (or additions to that infrastructure) and to better be able to support the commercial motor vehicle travel needs of the industry and the populations that it support.

Chapter 2: Methodology

The following discussion outlines the steps used to create the final products for this study. It is hoped that the methodology described will provide a general guide for replication of the steps used in the process.

The objective of the GIS component of this study was two-fold:

1. Identify the locations of STAA dimensioned truck crashes occurring more than the permissible three mile distance from the STAA Truck Network (TN).

2. Identify and prioritize segments of the statewide road network to accommodate increased heavy truck traffic for either improving the existing road infrastructure or for possible inclusion in the future STAA TN.

2.1 Create the STAA Truck Network

The first step to locate truck crashes more than three miles from the STAA TN was to create a truck network, in the GIS framework, that met two specific requirements. First, the TN needed to match the time frame of the truck crash data, and second the TN needed to have spatially coincident features with the NCDOT's Linear Referencing System (*LRS*).

In order to match the time frame of the truck crash data (2001-2005), the 2005 STAA TN needed to be used. However, the existing 2005 STAA TN did not have spatially coincident geometry with the LRS. This was due to the fact that they were not developed using the same source data. To fix this, a 'new' 2005 STAA network was created.

The following steps outline the process used to create the new 2005 STAA TN:

1. Overlay the 2005 TN layer on the 2006 *LRS*
2. Select all 2006 *LRS* features that match the 2005 TN
3. Save selected 2005 features of 2006 *LRS* as new 2005 TN layer

It should be noted that as parts of the truck network are removed and/or new sections added, crashes that occurred on the network the previous year will appear to be off the network the following year. An example of this is in the Wilmington area. In 2006, the truck network was modified to force truck traffic to the north of Wilmington onto Interstate 140. Prior to 2006, truck traffic traveled south of Wilmington along US 17. Therefore, truck crash incidents prior to 2006 may appear to be 'off-network' based on the current iteration of the truck network.

2.2 Create the 3-mile buffer

The second step was to prepare the data for selecting truck crash incidents that occurred more than three miles from the TN. To accomplish this, a linear buffer of the *LRS* was created.

This 3-mile buffer was created by generating a "network" using the Network Analyst extension inside of ESRI's ArcGIS 9.2 desktop package. The network buffer differed from a traditional linear buffer in that it measured the distance traveled along roads rather than simply by perpendicular distances from the truck network.

The following steps were used to generate the three mile buffer:

1. A Network Dataset feature class was created from the *LRS*. This resulted in a node or "junction" layer that consisted of all vertices found in the LRS. The Network Dataset was created using the following steps:
    a. Create a file geodatabase
    b. Create a Feature Dataset
    c. Import LRS into new Feature Dataset
    d. Create new Network Dataset from LRS
2. *LRS* Network Dataset nodes that intersected the TN were extracted to a new TN node layer. These were used as 'facilities' for creating the three mile buffer.
3. Lastly, the Solve program inside of the Network Analyst extension was used to create 1, 2, and 3-mile service areas (buffers) from each facility.

2.3 Locate off-network truck crashes

Oversized truck crashes (greater than 53' long and 102" wide) more than three miles from the TN were located. However, it was soon discovered that the sample size of these oversized truck crashes was too small to identify meaningful patterns. Approximately 40% of these truck crash records had inaccurate or no trailer length data. Therefore, the scope of the project was expanded to include all large trucks. Three classes of large trucks were included in the study: Tractor/Semi-Trailer; Doubles; Unknown Heavy Trucks. All large truck crash incidents that did not intersect the 3-mile buffer were deemed to be off-network incidents.

2.4 Analysis

Three methods were employed in analyzing the data. First, we explored the methods of developing multiplicative (joint) functions based upon crash frequency. Second, we calculated the percent of off-network crashes, and the percent of fatal and/or injury crashes by route and county. The first two methods produced comparable results and are presented in the next section. Lastly, we explored various geographic analysis methods and how they could/should be applied to this study.

I: Merit-Based Prioritization by Troop

At the broadest scale, a “merit-based” priority ranking was developed to assist the NCDOT in prioritizing roads for improvement or inclusion in the TN. The intent of this metric was to prioritize road improvement/TN at the troop level of geography. This metric was developed based on the assumption that the 'need for improvement' is a joint (multiplicative) function of (a) the percent of off-network crashes in the troop and (b) the percent of crashes involving fatal and/or non-fatal injuries. This process was applied to data for each of eight troop areas (A-H). One might also want to prioritize these data further in order to come up with a prioritized statewide list. We felt that to do so should be left up to the NCDOT.

II: Summary Statistics by Route and County

Within each troop, summary statistics were calculated for specific routes (i.e. US-64). The purpose of this metric was to provide a quick reference by route, by which totals could be easily and quickly referenced. Only routes having fifteen or more crashes were included in the tables. The number ‘fifteen’ was chosen purely for convenience in that it generally resulted in a manageable number of routes for further consideration. Crashes per mile were calculated from crash and mileage totals for each route. Additionally, percent fatal, non-fatal and property damage only were tabulated for each route. These totals are presented for each county spanned by the route.

III: Geographic Analysis

Scale is one of the most important factors in geospatial analysis. By examining data and analysis results at various scale levels, a better understanding of the phenomena at hand can be gained. Better understanding translates to higher confidence levels for making well informed decisions. For the purposes of this study, the scale of analysis was limited to the troop level of geography. Because geographic size for each troop varied, this scale was generally within the range of 1:700,000 to 1:250,000.

a.) Visual Inspection

The off-network crash data were graphically analyzed at the troop level by creating plots showing the STAA routes and 3-mile buffer. Individual crash points were superimposed on the images and were differentiated by level of injury severity.

The data alone do, by themselves, provide a ready means to prioritize needed improvements either at the troop and/or the actual roadway level. However, several alternative strategies were investigated as a means to provide a more 'focused' geographic examination of the data.

Defining clusters of off-network crashes based purely upon subjective visual inspection, while easy to accomplish, lacks the objective reliability/repeatability associated with a more 'algorithmic' (i.e., computational) approach. In an effort to obtain a more computationally reliable method, we looked at several algorithms to provide some degree of statistical rigor to apparent visual patterns discovered during the mapping process.

b.) Clustering Methods

Several software packages were used to explore the possibility of identifying statistically significant 'clusters' of crash locations. Most of these out of the box routines share a common shortfall in that they do not consider the unique spatial attributes of points that lie along linear features (i.e., roadways). While a 'cluster' identified in this manner might be sufficient to aid an engineer or a planner in initially focusing on an 'area' for closer investigation, they do not focus on 'roadways' per se, but rather points within that 'area.'

This is an important consideration. Crashes that have close geographic proximity to each other (i.e. "as the crow flies") may not be as close when measured by distance traveled along a road. Truck crashes are implicitly dependent on the road network. To exclude the road network from analysis efforts could result in an inaccurate decision tool for prioritization efforts.

For example, in A (Figure 7), points have been accurately grouped into two distinct clusters (one on the north side of the river and the other on the south side of the river). However, in B, all four points would have been grouped into a single cluster, independent of the road network. Although this produces a valid cluster, it does not support the decision needs for this study.

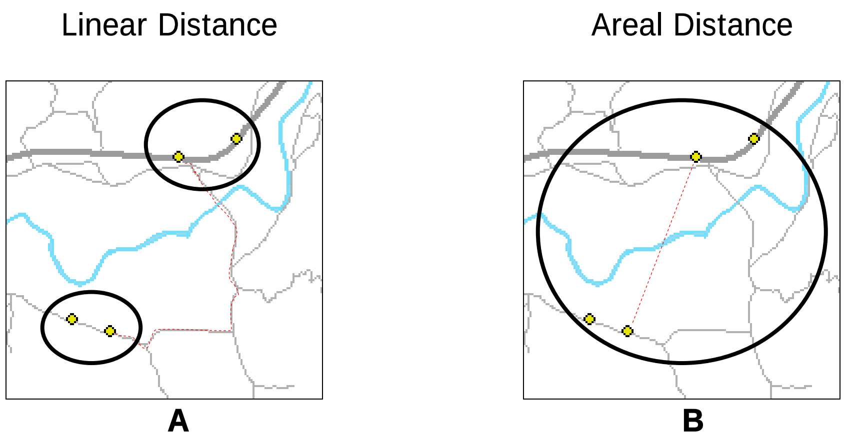


Figure 7: Cluster Analysis: Linear distance vs Areal distance

i.) <u>ArcGIS 9.2</u>

Several 'out of the box' methods for performing cluster and hot spot analysis were explored using ESRI's ArcGIS Spatial Statistics tool set. A method was attempted to include the linear distance component into both the cluster (Anselin Local Morans I) and hot spot (Getis-Ord Gi*) analysis tools. The cluster analysis tool was used to identify areas where truck crashes occurred at higher rates than would be expected by random distribution. This was accomplished by the following steps:

1. Calculate shortest drive distance between crash locations and assign this value to each of the points.
2. Run the cluster analysis algorithm, weighted by drive distance.

This method did not produce satisfactory results. When comparisons were made with visible groupings of crash points, the ArcGIS results were deemed suspect.

ii.) <u>CrimeStat III</u>

This software was used to apply a hierarchical clustering technique to the off-network crash points. Although this software has the capability of including linear features when generating hierarchical clusters, the software crashed repeatedly. Contact was made with the software developer to try to fix the problem. Possible solutions to the problem proved unsuccessful.

iii.) <u>FHWA GIS Safety Analysis Tools 4.0</u>

This is an ArcGIS 9.x toolbar that permits focused attention on a particular area and uses several types of analysis tools. However, this tool did not permit the generation of clusters or hot spots to the entire dataset. The user was required to define a particular route, segment or distance from a user defined point.

In summary, efforts of identifying statistically significant 'clusters' of crash locations weighted by distance along the road network produced unsatisfactory results. A more thorough investigation is recommended and would likely be very useful in the context of this and other related studies.

Chapter 3: Results and Conclusions

The results of the present analysis into the off-network presence of STAA dimensioned vehicles are presented in the following tables and figures. The figures provide visual evidence of the presence of off-network activity inferred from reported crashes involving tractors pulling single trailers 48ft or greater in length, tractors pulling twin trailers (doubles), and other ‘unknown heavy vehicles.’ The crash data are from the years 2001-2005. The images have been created from the NCSU/ITRE GIS Truck Crash Website and supporting databases.

3.1 Spatial Distributions of Off-Route Crashes at Troop Level

The data shown in the figures are presented by NCSHP ‘troops’ (lettered A thru H). Each figure provides a list of the individual counties within that particular troop. Each figure also contains a legend indicating the symbology used to distinguish different roadway types and different levels of crash injury severity.

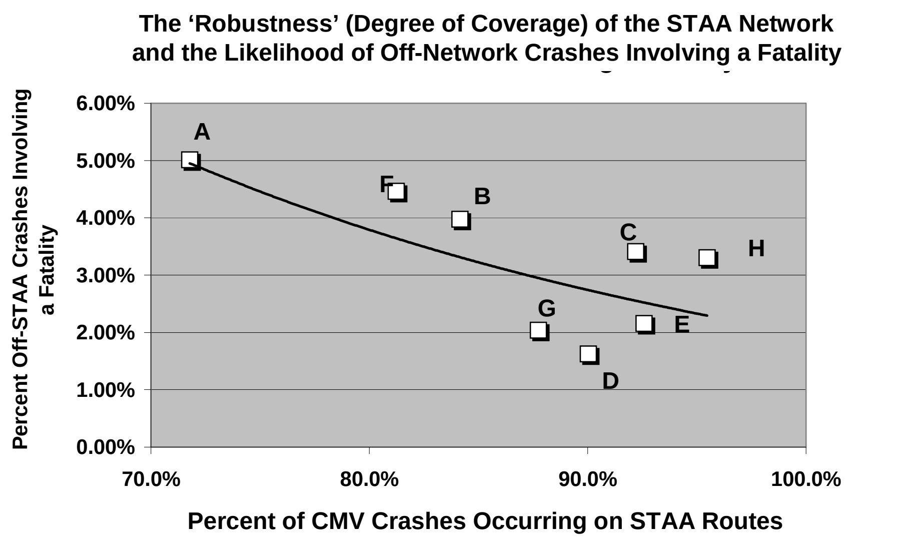
The following table provides summary data for each of the eight NCSHP troop areas. The table contains data on the number of reported highway miles in the troop, the number of STAA miles (derived from NCDOT LRS data), the total number of CMV-involved crashes in the troop, the number of crashes that occurred on STAA routes and those that occurred ‘off’ STAA routes. The table also provides data on the levels of injury severity associated with off-network crashes. A comparison not shown in the table is that between the average likelihood of a heavy truck being involved in a fatal crash statewide (irrespective of on/off network) and that of a heavy truck ‘off’ the network being involved in a fatal crash. The data show that, on average, 1.5 percent of statewide heavy truck crashes are fatal. The percentage of fatalities increases to 3.1 when examining off-network truck crash incidents. The likelihood of an off-network truck crash incident resulting in a fatality is more than double that of an on-network incident.

The figure immediately below the first table is an attempt to conceptualize the potential safety impact off the STAA network. The figure plots the percentage of off-network crashes involving one or more fatalities as a function of a measure indicating the percentage of total troop roadway miles that are designated as ‘truck network’ miles. The data for each NCSHP troop has been identified. What the figure shows is that as the percentage of STAA miles increases in a troop area, the likelihood of a dimensioned vehicle crash involving a fatality ‘decreases.’ In other words, as more of an area’s roads become suitable for large truck traffic, the frequency of fatalities off the network decreases (most likely the result of shifting large trucks to the network).

The result is actually quite ‘intuitive’ in that the ‘risk’ of a fatal truck involved crash is recognized to be higher on the classes of roadway not designated as part of the network (i.e., NC and US-numbered highways, local and secondary roads, etc.).

TROOP	Total State-Maintained Roadway Miles	Total STAA Network Miles	Total CMV-Involved Crashes (All Roads)	Number and Percent Off-Network Crashes		Percent Fatal	Percent Non-Fatal Injury	Percent PDO
A	9018.3	653	2477	699	28%	5%	64%	31%
B	12150	1065	4763	755	16%	4%	73%	23%
C	14239.6	1352.6	8659	675	8%	3%	59%	38%
D	9911.3	715.5	5558	554	10%	2%	47%	51%
E	9958.6	779.7	4998	371	7%	2%	57%	41%
F	8904.5	323.6	3345	628	19%	4%	49%	47%
G	10025.5	707.6	3207	393	12%	2%	39%	59%
H	9095.8	768.8	9352	424	5%	3%	52%	45%

Table 3: Summary attributes for each of the 8 troops



The more capable the STAA network is at capturing CMV crashes, the lower the likelihood that any given off-network crash will involve a fatality

Figure 8 : Robustness of the STAA Network

The remaining figures show off-network high crash rate routes for each NCSHP troop area for the period 2001-2005. For each troop, the figure contains a map and a table. The map displays the following: off-network high crash rate routes; off-network truck crash incidents differentiated by level of injury severity; the truck network; and the 3-mile buffer. The table displays the summary statistics explained in the methodology section above.

3.2 Characterizing Attributes of Off-Network Crashes

We have also attempted to characterize the major attributes of off-network crashes using data from the NCDMV-349 crash report form. We have selected from among what are considered to be the major attributes of interest. Remember, that these are the attributes of a dataset where the only vehicle classes represented are combination vehicles, double/twin trailers, and other undifferentiated heavy trucks. Remember too that these crashes all took place off-network, typically on NC and US-numbered roadways, local and secondary routes.

Some of the more common types of crashes are ‘rear end, slow or stop’; ‘side-swipe, same direction’; ‘angle’; and ‘fixed object’. For the most part they occurred on roads with little or no access control, and little or no means of traffic control other than signs and pavement markings. Many of these roads are typically 2-lane, undivided roadways. Knowing that the design standards for these roads are less than those applied to Interstate roadways, one also can assume reduced lane widths, higher degrees of vertical and horizontal curvature, and possible sight distance restrictions. As with most crashes, visibility is more often than not ‘clear,’ and roadway conditions are reported as ‘dry’ at the time of the crash. A very low percentage of crashes are reported as having alcohol or speed involvement. Most are reported as having taken place in ‘rural’ versus ‘urban’ environments. The ratio of interstate to intrastate carriers was about 6:4.

3.3 Alternative Strategies for Prioritizing Improvement

Following the figures presenting the GIS ‘maps’ of off-network crashes and the associated data on the attributes of off-network crashes at each troop level, we turn to the results of preliminary/exploratory investigations of alternative methods for prioritizing the need for improvement, first at the troop level, and subsequently in terms of specific routes/areas within each troop.

First, at the troop level, we explored alternative methods for generating a ‘measure of merit’ based strictly upon crash frequency and crash severity indices.

The first assumes that the 'need for improvement' is a joint (multiplicative) function of (a) the percent of off-network crashes in the troop and (b) the percent of crashes involving fatal and/or non-fatal injuries. The product would generate a 'measure of merit' which could then be used to prioritize individual troops. Here we have simply computed the measure of merit for each troop relative to the 'worst' troop (in this case Troop A).

Shown below are two possible rationales for computing a relative *measure of merit.*

Troop	% Crashes Off-Network A	% Fatal and Non-Fatal Injuries Off-Network B	Measure of Merit AxB	Normalized Relative to Troop A	Priority for Improvement
A	28%	69%	0.1932	1.000	Level 1
B	16%	77%	0.1232	0.638	Level 2
F	19%	53%	0.1007	0.521	
D	10%	51%	0.051	0.264	Level 3
C	8%	62%	0.0496	0.257	
G	12%	41%	0.0492	0.255	
E	7%	59%	0.0413	0.214	
H	5%	55%	0.0275	0.142	Level 4

Table 4: Measure of Merit = AxB

An alternative method would be to give consideration to the frequency of off-network crashes in addition to their percent occurrence. Here we have simply added an additional column to the data above. The result below shows that the ranking of troops is unchanged, although some re-grouping might be possible within the Level 2 and Level 3 categories.

Troop	Freq Off Network Crashes A	% Crashes Off-Network B	% Fatal and Non-Fatal Injuries Off-Network C	Measure of Merit AxBxC	Normalized Relative to Troop A	Priority for Improvement
A	699	28%	69%	135.05	1.000	Level I
B	755	16%	77%	93.02	0.689	Level 2
F	628	19%	53%	63.24	0.468	
D	554	10%	51%	28.25	0.209	Level 3
C	675	8%	62%	33.48	0.248	
G	393	12%	41%	19.34	0.143	
E	371	7%	59%	15.32	0.113	Level 4
H	424	5%	55%	11.66	0.086	

Table 5: Measure of Merit = AxBxC

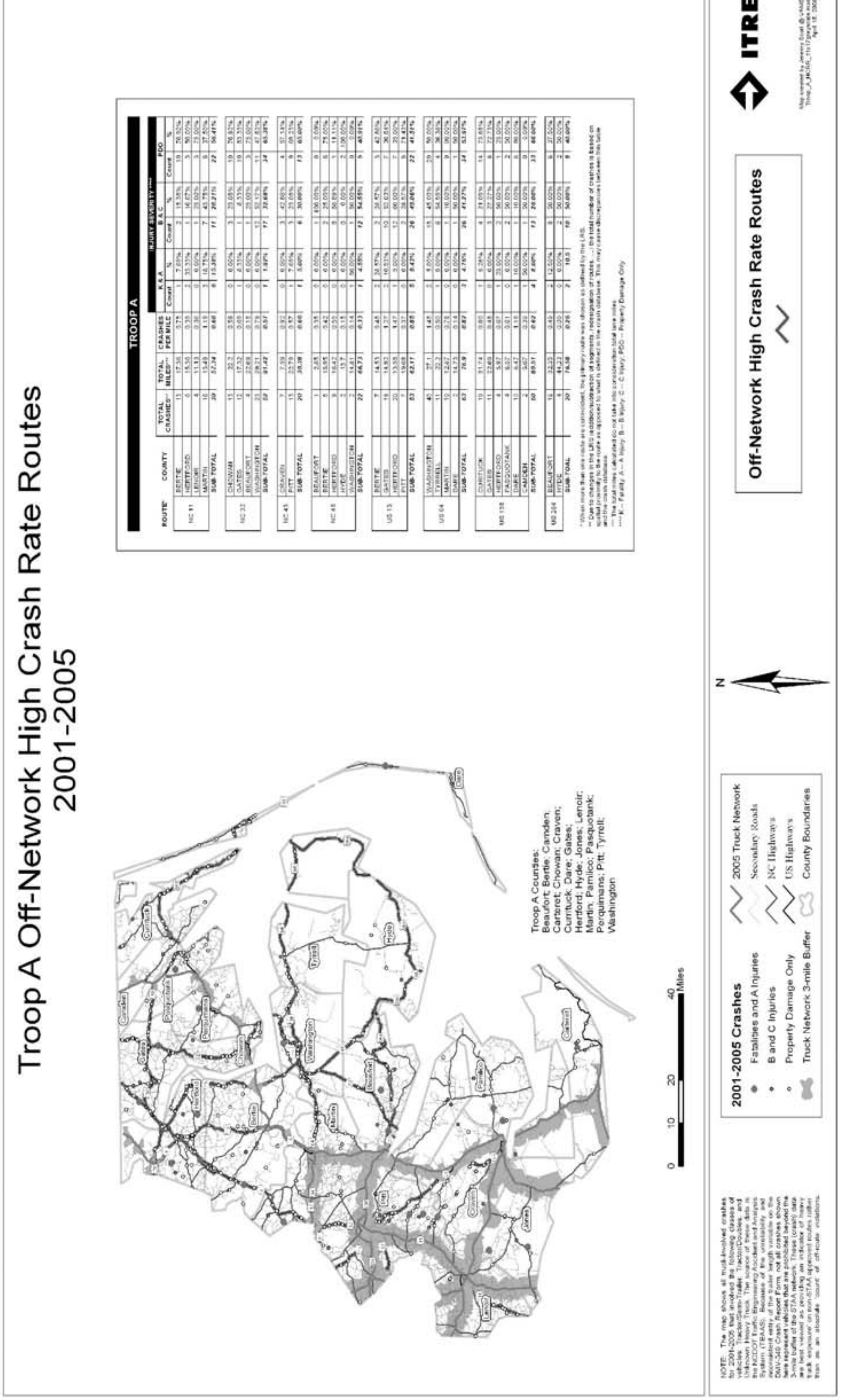


Figure 9: Troop A Off-Network High Crash Rate Routes

Table 6: Attributes of off-network crashes: Troop A

Frequency Distribution of County Name

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
BEAUFORT	48	6.9	48	6.9
BERTIE	63	9.0	111	15.9
CAMDEN	7	1.0	118	16.9
CARTERET	17	2.4	135	19.3
CHOWAN	21	3.0	156	22.3
CRAVEN	34	4.9	190	27.2
CURRITUCK	33	4.7	223	31.9
DARE	27	3.9	250	35.8
DUPLIN	1	0.1	251	35.9
GATES	58	8.3	309	44.2
GREENE	1	0.1	310	44.3
HERTFORD	72	10.3	382	54.6
HYDE	8	1.1	390	55.8
JONES	15	2.1	405	57.9
LENOIR	16	2.3	421	60.2
MARTIN	55	7.9	476	68.1
PAMLICO	10	1.4	486	69.5
PASQUOTANK	35	5.0	521	74.5
PERQUIMANS	5	0.7	526	75.3
PITT	70	10.0	596	85.3
TYRRELL	15	2.1	611	87.4
WASHINGTON	85	12.2	696	99.6
WAYNE	3	0.4	699	100.0
Total	699	100.0		

Frequency Distribution of Accident Type

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
D	378	54.1	378	54.1
F	32	4.6	410	58.7
I	289	41.3	699	100.0
Total	699	100.0		

Frequency Distribution of Alcohol Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
No	680	97.3	680	97.3
Yes	19	2.7	699	100.0
Total	699	100.0		

Frequency Distribution of A-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	660	94.4	660	94.4
1	33	4.7	693	99.1
2	6	0.9	699	100.0
Total	699	100.0		

Frequency Distribution of B-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	595	85.1	595	85.1
1	93	13.3	688	98.4
2	9	1.3	697	99.7
3	1	0.1	698	99.9
4	1	0.1	699	100.0
Total	699	100.0		

Frequency Distribution of C-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	499	71.4	499	71.4
1	145	20.7	644	92.1
2	41	5.9	685	98.0
3	8	1.1	693	99.1
4	1	0.1	694	99.3
5	2	0.3	696	99.6
6	1	0.1	697	99.7
7	1	0.1	698	99.9
9	1	0.1	699	100.0
Total	699	100.0		

Frequency Distribution of Crash Type

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ANGLE	69	9.9	69	9.9
ANIMAL	26	3.7	95	13.6
BACKING UP	20	2.9	115	16.5
FIXED OBJECT	55	7.9	170	24.3
HEAD ON	19	2.7	189	27.0
JACKKNIFE	13	1.9	202	28.9
LEFT TURN, DIFFERENT ROADWAYS	41	5.9	243	34.8
LEFT TURN, SAME ROADWAY	54	7.7	297	42.5
MOVABLE OBJECT	13	1.9	310	44.3
OTHER COLLISION WITH VEHICLE	18	2.6	328	46.9
OTHER NON-COLLISION	18	2.6	346	49.5
OVERTURN/ROLLOVER	42	6.0	388	55.5
PARKED MOTOR VEHICLE	16	2.3	404	57.8
PEDESTRIAN	3	0.4	407	58.2
RAN OFF ROAD - LEFT	13	1.9	420	60.1
RAN OFF ROAD - RIGHT	69	9.9	489	70.0
RAN OFF ROAD - STRAIGHT	1	0.1	490	70.1
REAR END, SLOW OR STOP	82	11.7	572	81.8
REAR END, TURN	19	2.7	591	84.5
RIGHT TURN, DIFFERENT ROADWAYS	11	1.6	602	86.1
RIGHT TURN, SAME ROADWAY	23	3.3	625	89.4
RR TRAIN, ENGINE	1	0.1	626	89.6
SIDESWIPE, SAME DIRECTION	28	4.0	654	93.6
SIDESWIPE,OPPOSITE DIRECTION	45	6.4	699	100.0
Total	699	100.0		

Frequency Distribution of Number Killed

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	667	95.4	667	95.4
1	29	4.1	696	99.6
2	3	0.4	699	100.0
Total	699	100.0		

Frequency Distribution of Month of the Year

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
APR	66	9.4	66	9.4
AUG	70	10.0	136	19.5
DEC	69	9.9	205	29.3
FEB	36	5.2	241	34.5
JAN	53	7.6	294	42.1
JUL	51	7.3	345	49.4
JUN	59	8.4	404	57.8
MAR	56	8.0	460	65.8
MAY	60	8.6	520	74.4
NOV	64	9.2	584	83.5
OCT	66	9.4	650	93.0
SEP	49	7.0	699	100.0
Total	699	100.0		

Frequency Distribution of Road Class

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
LCL	54	7.7	54	7.7
NC	260	37.2	314	44.9
RP	175	25.0	489	70.0
RU	2	0.3	491	70.2
SR	1	0.1	492	70.4
US	207	29.6	699	100.0
Total	699	100.0		

Frequency Distribution of Road Configuration

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ONE-WAY, NOT DIVIDED	6	0.9	6	0.9
TWO-WAY, DIVIDED, POSITIVE MEDIAN BA	4	0.6	10	1.5
TWO-WAY, DIVIDED, UNPROTECTED MEDIAN	40	5.9	50	7.4
TWO-WAY, NOT DIVIDED	624	92.4	674	99.9
UNKNOWN	1	0.1	675	100.0
Total	675	100.0		

Frequency Distribution of Access Control

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
FULL ACCESS CONTROL	22	3.3	22	3.3
NO ACCESS CONTROL	645	95.8	667	99.1
PARTIAL ACCESS CONT	6	0.9	673	100.0
Total	673	100.0		

Frequency Distribution of Rural vs Urban

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
R	667	95.4	667	95.4
U	32	4.6	699	100.0
Total	699	100.0		

Frequency Distribution of Crash Severity

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
A	32	4.6	32	4.6
B	96	13.8	128	18.4
C	161	23.1	289	41.5
K	32	4.6	321	46.1
O	376	53.9	697	100.0
Total	697	100.0		

Frequency Distribution of Speed Indicated

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	674	96.4	674	96.4
Y	25	3.6	699	100.0
Total	699	100.0		

Frequency Distribution of Traffic Control

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
DOUBLE YELLOW LINE, NO PASSING ZONE	216	35.1	216	35.1
FLASHING SIGNAL WITH STOP SIGN	16	2.6	232	37.7
FLASHING STOP AND GO SIGNAL	1	0.2	233	37.8
HUMAN CONTROL	6	1.0	239	38.8
NO CONTROL PRESENT	229	37.2	468	76.0
OTHER	3	0.5	471	76.5
RR CROSSBUCKS ONLY	1	0.2	472	76.6
RR GATE AND FLASHER	1	0.2	473	76.8
STOP AND GO SIGNAL	50	8.1	523	84.9
STOP SIGN	88	14.3	611	99.2
WARNING SIGN	2	0.3	613	99.5
YIELD SIGN	3	0.5	616	100.0
Total	616	100.0		

Frequency Distribution of Day of the Week

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
FRI	108	15.5	108	15.5
MON	138	19.7	246	35.2
SAT	36	5.2	282	40.3
SUN	21	3.0	303	43.3
THU	126	18.0	429	61.4
TUE	131	18.7	560	80.1
WED	139	19.9	699	100.0
Total	699	100.0		

Frequency Distribution of Work Zone Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	681	97.4	681	97.4
Y	18	2.6	699	100.0
Total	699	100.0		

Frequency Distribution of Year _

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
2001	110	15.7	110	15.7
2002	131	18.7	241	34.5
2003	151	21.6	392	56.1
2004	153	21.9	545	78.0
2005	154	22.0	699	100.0
Total	699	100.0		

Frequency Distribution of Interstate/Intrastate

Intrastate	**292**
Interstate	**407**

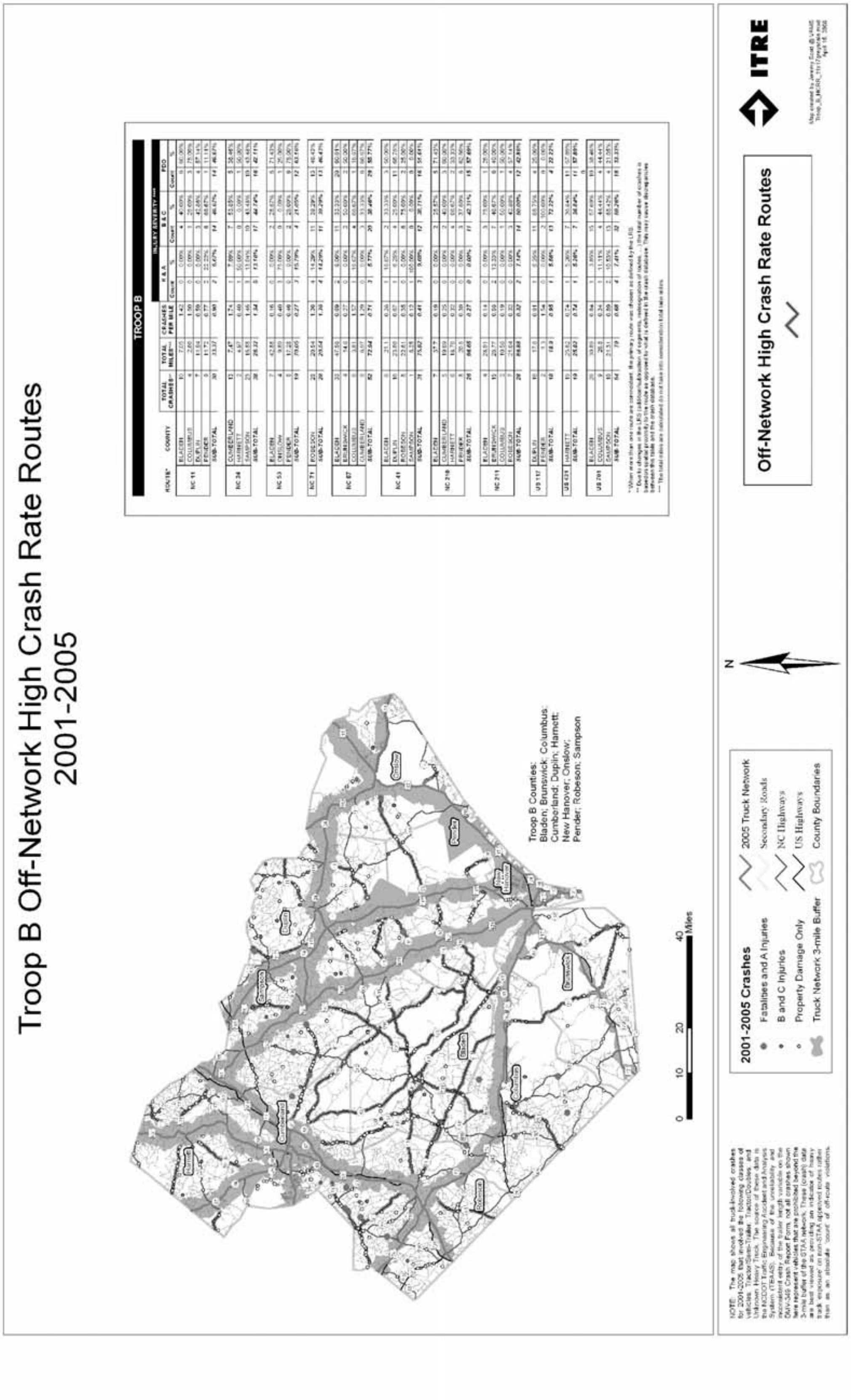


Figure 10: Troop B Off-Network High Crash Rate Routes

Table 7: Attributes of off-network crashes: Troop B

Frequency Distribution of County

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
BLADEN	139	18.4	139	18.4
BRUNSWICK	41	5.4	180	23.8
COLUMBUS	70	9.3	251	33.2
CUMBERLAND	54	7.1	305	40.3
DUPLIN	114	15.1	419	55.4
HARNETT	66	8.7	485	64.2
HOKE	1	0.1	486	64.3
NEW HANOVE	6	0.8	492	65.1
ONSLOW	20	2.6	512	67.7
PENDER	37	4.9	549	72.6
ROBESON	100	13.2	649	85.8
SAMPSON	107	14.2	756	100.0
Total	756	100.0		

Frequency Distribution of Rural vs Urban

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
R	734	97.1	734	97.1
U	21	2.8	756	100.0
Total	756	100.0		

Frequency Distribution of Injury Severity

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
D	369	48.8	370	48.9
F	24	3.2	394	52.1
I	362	47.9	756	100.0
Total	756	100.0		

Frequency Distribution of Month of the Year

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
APR	52	6.9	52	6.9
AUG	71	9.4	123	16.3
DEC	73	9.7	196	25.9
FEB	57	7.5	253	33.5
JAN	70	9.3	323	42.7
JUL	52	6.9	375	49.6
JUN	62	8.2	437	57.8
MAR	68	9.0	505	66.8
MAY	57	7.5	562	74.3
NOV	73	9.7	636	84.1
OCT	60	7.9	696	92.1
SEP	60	7.9	756	100.0
Total	756	100.0		

Frequency Distribution of Day of the Week

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
FRI	121	16.0	121	16.0
MON	156	20.6	277	36.6
SAT	36	4.8	313	41.4
SUN	26	3.4	339	44.8
THU	136	18.0	475	62.8
TUE	139	18.4	614	81.2
WED	141	18.7	755	99.9
Total	756	100.0		

Frequency Distribution of Year

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
2001	139	18.4	139	18.4
2002	141	18.7	280	37.1
2003	152	20.1	432	57.2
2004	164	21.7	596	78.9
2005	159	21.1	755	100.0
Total	755	100.0		

Frequency Distribution of Injury Severity

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
A	28	3.7	28	3.7
B	123	16.4	151	20.1
C	211	28.1	362	48.1
K	24	3.2	386	51.3
O	365	48.5	751	99.9
Total	752	100.0		

Frequency Distribution of Persons Killed

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	731	96.8	731	96.8
1	19	2.5	750	99.3
2	4	0.5	754	99.9
3	1	0.1	755	100.0
Total	755	100.0		

Frequency Distribution of A-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	722	95.6	722	95.6
1	27	3.6	749	99.2
2	5	0.7	754	99.9
4	1	0.1	755	100.0
Total	755	100.0		

Frequency Distribution of B-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	618	81.9	618	81.9
1	115	15.2	733	97.1
2	15	2.0	748	99.1
3	6	0.8	754	99.9
4	1	0.1	755	100.0
Total	755	100.0		

Frequency Distribution of C-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	500	66.2	500	66.2
1	199	26.4	699	92.6
2	38	5.0	737	97.6
3	8	1.1	745	98.7
4	5	0.7	750	99.3
5	3	0.4	753	99.7
6	2	0.3	755	100.0
Total	755	100.0		

Frequency Distribution of Crash Type

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ANGLE	83	11.0	83	11.0
ANIMAL	31	4.1	114	15.1
BACKING UP	25	3.3	139	18.4
FIXED OBJECT	98	13.0	238	31.5
HEAD ON	19	2.5	257	34.0
JACKKNIFE	6	0.8	263	34.8
LEFT TURN, DIFFERENT ROADWAYS	47	6.2	310	41.0
LEFT TURN, SAME ROADWAY	56	7.4	366	48.4
MOVABLE OBJECT	24	3.2	390	51.6
OTHER COLLISION WITH VEHICLE	13	1.7	403	53.3
OTHER NON-COLLISION	10	1.3	413	54.6
OVERTURN/ROLLOVER	60	7.9	473	62.6
PARKED MOTOR VEHICLE	12	1.6	485	64.2
PEDALCYCLIST	1	0.1	486	64.3
PEDESTRIAN	2	0.3	488	64.6
RAN OFF ROAD - LEFT	3	0.4	491	64.9
RAN OFF ROAD - RIGHT	3	0.4	494	65.3
RAN OFF ROAD - STRAIGHT	1	0.1	495	65.5
REAR END, SLOW OR STOP	104	13.8	599	79.2
REAR END, TURN	18	2.4	617	81.6
RIGHT TURN, DIFFERENT ROADWAY	16	2.1	633	83.7
RIGHT TURN, SAME ROADWAY	20	2.6	653	86.4
SIDESWIPE, SAME DIRECTION	43	5.7	696	92.1
SIDESWIPE,OPPOSITE DIRECTION	60	7.9	756	100.0
Total	756	100.0		

Frequency Distribution of Speed Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	733	97.0	733	97.0
Y	22	2.9	756	100.0

Total	756	100.0

Frequency Distribution of Work Zone Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	747	98.8	747	98.8
Y	8	1.1	756	100.0
Total	756	100.0		

Frequency Distribution of Roadway Class

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
LCL	54	7.1	54	7.1
NC	386	51.1	440	58.2
RP	202	26.7	643	85.1
RU	1	0.1	644	85.2
US	112	14.8	756	100.0
Total	756	100.0		

Frequency Distribution of Roadway Configuration

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ONE-WAY, NOT DIVIDED	3	0.4	3	0.4
TWO-WAY, DIVIDED, POSITIVE MEDIAN BA	3	0.4	7	1.0
TWO-WAY, DIVIDED, UNPROTECTED MEDIAN	48	6.6	55	7.6
TWO-WAY, NOT DIVIDED	670	92.4	725	100.0
Total	725	100.0		

Frequency Distribution of Access Control

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
FULL ACCESS CONTROL	24	3.3	25	3.5
NO ACCESS CONTROL	685	95.1	710	98.6
PARTIAL ACCESS CONTROL	10	1.4	720	100.0
Total	720	100.0		

Frequency Distribution of Traffic Control

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
DOUBLE YELLOW LINE, NO PASSING ZONE	232	34.6	232	34.6
FLASHING SIGNAL WITH STOP SIGN	7	1.0	239	35.6
FLASHING STOP AND GO SIGNAL	2	0.3	241	35.9
HUMAN CONTROL	4	0.6	245	36.5
NO CONTROL PRESENT	260	38.7	505	75.3
OTHER	4	0.6	509	75.9
STOP AND GO SIGNAL	44	6.6	553	82.4
STOP SIGN	111	16.5	664	99.0
WARNING SIGN	2	0.3	667	99.4
YIELD SIGN	4	0.6	671	100.0
Total	671	100.0		

Frequency Distribution of Alcohol Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
No	730	96.6	731	96.7
Yes	25	3.3	756	100.0
Total	756	100.0		

Frequency Distribution of Intrastate vs Interstate

Intrastate	**300**
Interstate	**455**

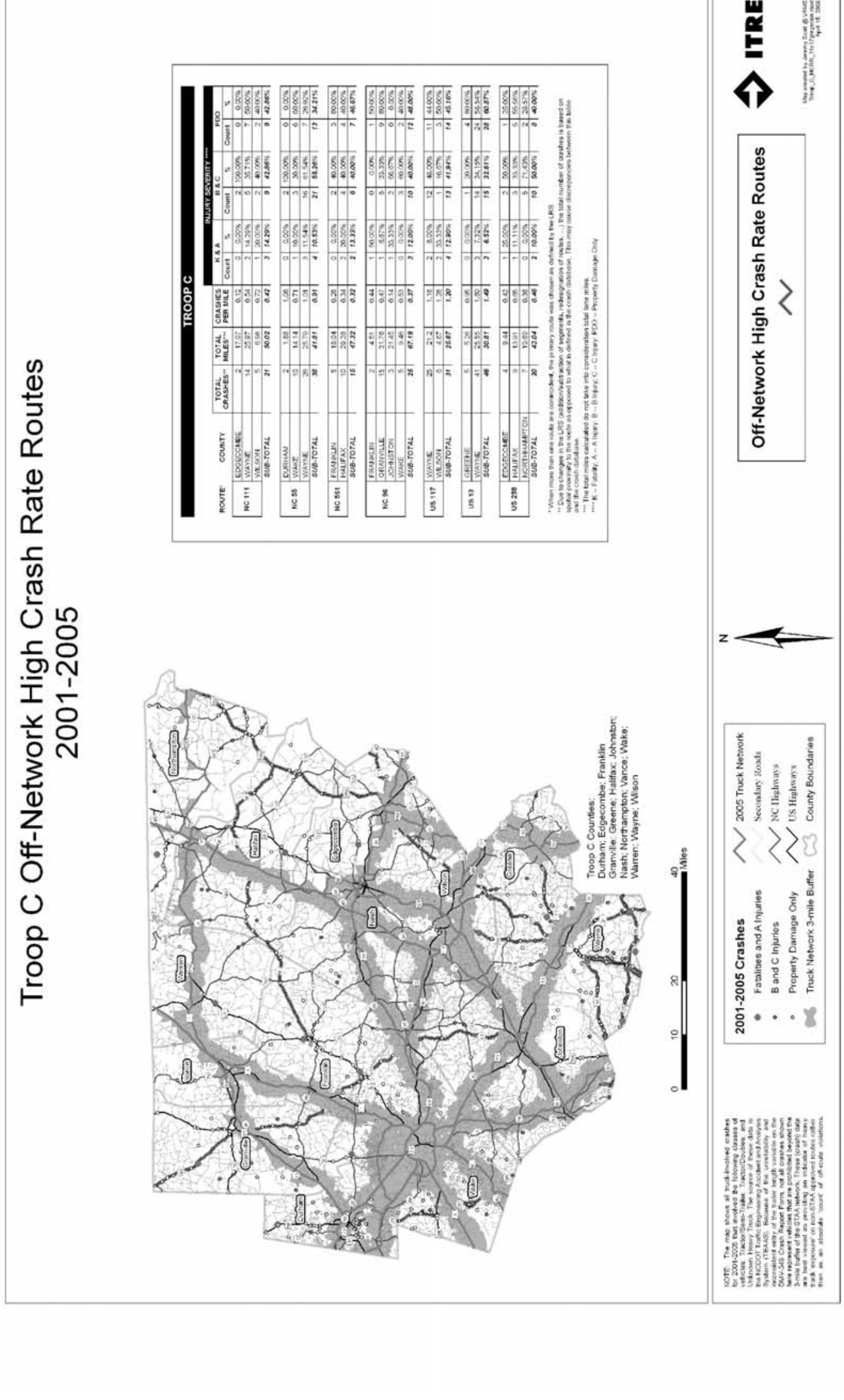


Figure 11: Troop C Off-Network High Crash Rate Routes

Table 8: Attributes of off-network crashes: Troop C

Frequency Distribution of County

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
DUPLIN	1	0.1	1	0.1
DURHAM	47	7.0	48	7.1
EDGECOMBE	30	4.4	78	11.6
FRANKLIN	63	9.3	141	20.9
GRANVILLE	49	7.3	190	28.1
GREENE	14	2.1	204	30.2
HALIFAX	64	9.5	268	39.7
HARNETT	2	0.3	270	40.0
JOHNSTON	37	5.5	307	45.5
NASH	17	2.5	324	48.0
NORTHAMPTON	50	7.4	374	55.4
PITT	1	0.1	375	55.6
SAMPSON	1	0.1	376	55.7
VANCE	4	0.6	380	56.3
WAKE	82	12.1	462	68.4
WARREN	8	1.2	470	69.6
WAYNE	175	25.9	645	95.6
WILSON	30	4.4	675	100.0
Total	675	100.0		

Frequency Distribution of Access Control

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
FULL ACCESS CONTROL	39	5.9	39	5.9
NO ACCESS CONTROL	580	87.9	619	93.8
PARTIAL ACCESS CONTROL	41	6.2	660	100.0
Total	660	100.0		

Frequency Distribution of Accident Type

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
D	375	55.6	375	55.6
F	22	3.3	397	58.8
I	278	41.2	675	100.0
Total	675	100.0		

Frequency Distribution of Alcohol Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
No	656	97.2	656	97.2
Yes	19	2.8	675	100.0
Total	675	100.0		

Frequency Distribution of A Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	649	96.1	649	96.1
1	22	3.3	671	99.4
2	3	0.4	674	99.9
3	1	0.1	675	100.0
Total	675	100.0		

Frequency Distribution of B-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	562	83.3	562	83.3
1	93	13.8	655	97.0
2	16	2.4	671	99.4
3	3	0.4	674	99.9
4	1	0.1	675	100.0
Total	675	100.0		

Frequency Distribution of Crash Type

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ANGLE	83	12.3	83	12.3
ANIMAL	20	3.0	103	15.3
BACKING UP	28	4.1	131	19.4
FIXED OBJECT	86	12.7	217	32.1
HEAD ON	11	1.6	228	33.8
JACKKNIFE	6	0.9	234	34.7
LEFT TURN, DIFFERENT ROADWAYS	36	5.3	270	40.0
LEFT TURN, SAME ROADWAY	49	7.3	319	47.3
MOVABLE OBJECT	11	1.6	330	48.9
OTHER COLLISION WITH VEHICLE	6	0.9	336	49.8
OTHER NON-COLLISION	5	0.7	341	50.5
OVERTURN/ROLLOVER	41	6.1	382	56.6
PARKED MOTOR VEHICLE	25	3.7	407	60.3
PEDALCYCLIST	3	0.4	410	60.7
PEDESTRIAN	2	0.3	412	61.0
RAN OFF ROAD - LEFT	7	1.0	419	62.1
RAN OFF ROAD - RIGHT	33	4.9	452	67.0
RAN OFF ROAD - STRAIGHT	3	0.4	455	67.4
REAR END, SLOW OR STOP	81	12.0	536	79.4
REAR END, TURN	18	2.7	554	82.1
RIGHT TURN, DIFFERENT ROADWAYS	14	2.1	568	84.1
RIGHT TURN, SAME ROADWAY	20	3.0	588	87.1
RR TRAIN, ENGINE	1	0.1	589	87.3
SIDESWIPE, SAME DIRECTION	40	5.9	629	93.2
SIDESWIPE,OPPOSITE DIRECTION	44	6.5	673	99.7
UNKNOWN	2	0.3	675	100.0
Total	675	100.0		

Frequency Distribution of C_INJS

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	494	73.2	494	73.2
1	143	21.2	637	94.4
2	32	4.7	669	99.1
3	4	0.6	673	99.7
4	2	0.3	675	100.0
Total	675	100.0		

Frequency Distribution of Number Persons Killed

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	653	96.7	653	96.7
1	21	3.1	674	99.9
2	1	0.1	675	100.0
Total	675	100.0		

Frequency Distribution of Month

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
APR	70	10.4	70	10.4
AUG	50	7.4	120	17.8
DEC	56	8.3	176	26.1
FEB	53	7.9	229	33.9
JAN	59	8.7	288	42.7
JUL	52	7.7	340	50.4
JUN	56	8.3	396	58.7
MAR	54	8.0	450	66.7
MAY	55	8.1	505	74.8
NOV	52	7.7	557	82.5
OCT	64	9.5	621	92.0
SEP	54	8.0	675	100.0
Total	675	100.0		

Frequency Distribution of Number Lanes

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
1	7	1.1	7	1.1
2	542	81.9	549	82.9
3	16	2.4	565	85.3
4	68	10.3	633	95.6
5	23	3.5	656	99.1
6	4	0.6	660	99.7
8	2	0.3	662	100.0
Total	662	100.0		

Frequency Distribution of Roadway Class

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
LCL	112	16.6	112	16.6
NC	248	36.7	360	53.3
PVA	1	0.1	361	53.5
RP	161	23.9	522	77.3
RU	2	0.3	524	77.6
SR	3	0.4	527	78.1
US	148	21.9	675	100.0
Total	675	100.0		

Frequency Distribution of Roadway Configuration

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ONE-WAY, NOT DIVIDED	10	1.5	10	1.5
TWO-WAY, DIVIDED, POSITIVE MEDIAN BARRIE	11	1.7	21	3.2
TWO-WAY, DIVIDED, UNPROTECTED MEDIAN	62	9.3	83	12.5
TWO-WAY, NOT DIVIDED	581	87.5	664	100.0
Total	664	100.0		

Frequency Distribution of Rural vs Urban

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
R	580	85.9	580	85.9
U	95	14.1	675	100.0
Total	675	100.0		

Frequency Distribution of Injury Severity

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
A	25	3.7	25	3.7
B	102	15.2	127	19.0
C	151	22.5	278	41.5
K	22	3.3	300	44.8
O	370	55.2	670	100.0
Total	670	100.0		

Frequency Distribution of Speed Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	658	97.5	658	97.5
Y	17	2.5	675	100.0
Total	675	100.0		

Frequency Distribution of Traffic Control

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
DOUBLE YELLOW LINE, NO PASSING ZONE	157	25.4	157	25.4
FLASHING SIGNAL WITH STOP SIGN	12	1.9	169	27.3
FLASHING SIGNAL WITHOUT STOP SIGN	4	0.6	173	28.0
FLASHING STOP AND GO SIGNAL	1	0.2	174	28.2
HUMAN CONTROL	4	0.6	178	28.8
NO CONTROL PRESENT	231	37.4	409	66.2
OTHER	4	0.6	413	66.8
RR CROSSBUCKS ONLY	1	0.2	414	67.0
RR GATE AND FLASHER	3	0.5	417	67.5
SCHOOL ZONE SIGNS	2	0.3	419	67.8
STOP AND GO SIGNAL	72	11.7	491	79.4
STOP SIGN	118	19.1	609	98.5
WARNING SIGN	6	1.0	615	99.5
YIELD SIGN	3	0.5	618	100.0
Total	618	100.0		

Frequency Distribution of Day of the Week

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
FRI	124	18.4	124	18.4
MON	136	20.1	260	38.5
SAT	25	3.7	285	42.2
SUN	20	3.0	305	45.2
THU	130	19.3	435	64.4
TUE	125	18.5	560	83.0
WED	115	17.0	675	100.0
Total	675	100.0		

Frequency Distribution of Work Zone Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	671	99.4	671	99.4
Y	4	0.6	675	100.0
Total	675	100.0		

Frequency Distribution of Year

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
2001	125	18.5	125	18.5
2002	133	19.7	258	38.2
2003	139	20.6	397	58.8
2004	136	20.1	533	79.0
2005	142	21.0	675	100.0
Total	675	100.0		

Frequency Distribution of Interstate vs Intrastate

Intrastate	**302**
Interstate	**373**

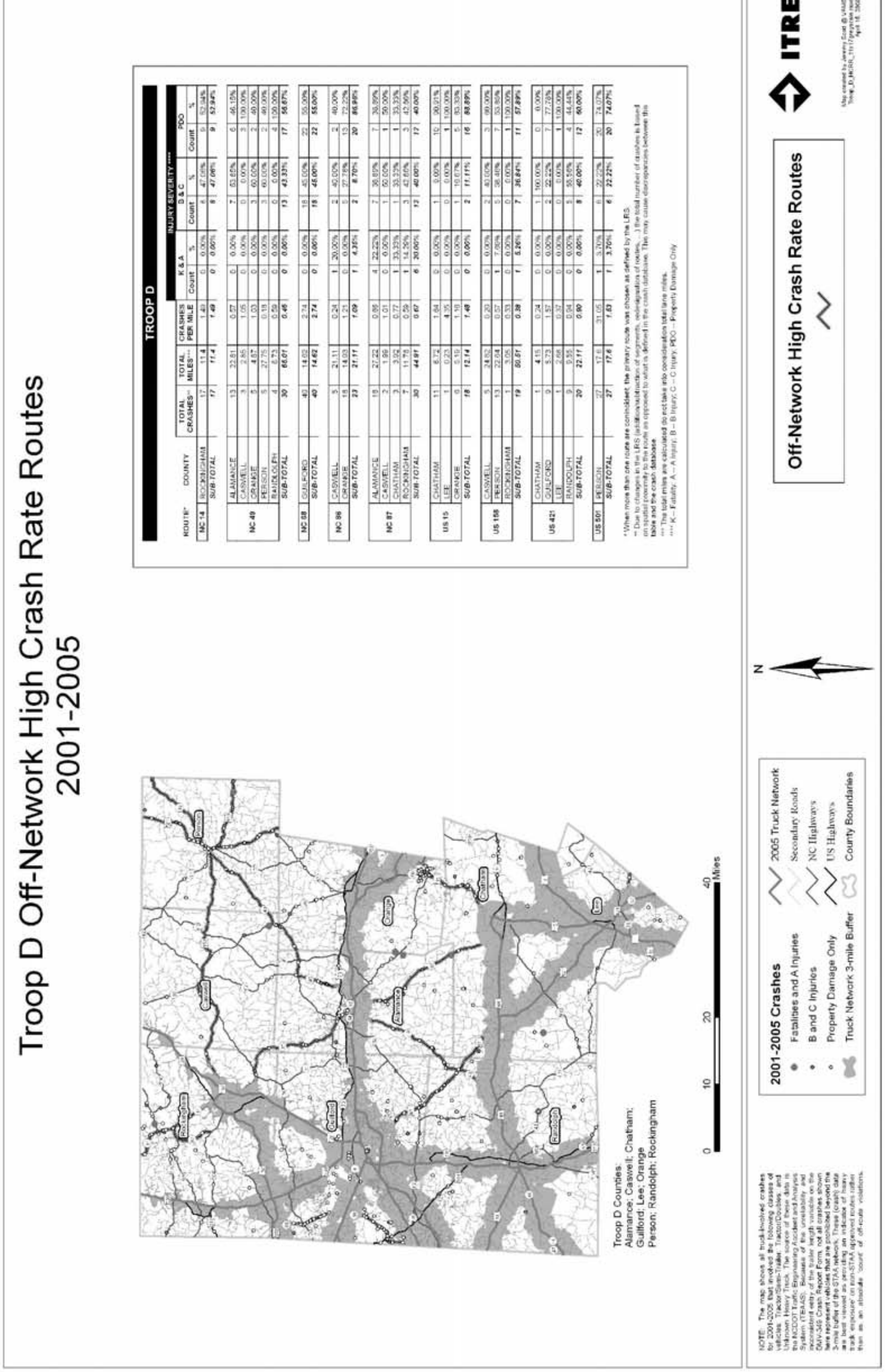


Figure 12: Troop D Off-Network High Crash Rate Routes

Table 9: Attributes of off-network crashes: Troop D

Frequency Distribution of County

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ALAMANCE	60	10.8	60	10.8
CASWELL	17	3.1	77	13.9
CHATHAM	59	10.6	136	24.5
CNTY_NM	1	0.2	137	24.7
GUILFORD	142	25.6	279	50.3
LEE	15	2.7	294	53.0
MOORE	1	0.2	295	53.2
ORANGE	64	11.5	359	64.7
PERSON	65	11.7	424	76.4
RANDOLPH	53	9.5	477	85.9
ROCKINGHAM	78	14.1	555	100.0
Total	555	100.0		

Frequency Distribution of Rural vs Urban

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
R	367	66.1	367	66.1
U	187	33.7	555	100.0
Total	555	100.0		

Frequency Distribution of Injury Severity

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
D	359	64.7	360	64.9
F	9	1.6	369	66.5
I	186	33.5	555	100.0
Total	555	100.0		

Frequency Distribution of Month of the Year

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
APR	42	7.6	42	7.6
AUG	38	6.8	80	14.4
DEC	36	6.5	116	20.9
FEB	34	6.1	150	27.0
JAN	51	9.2	201	36.2
JUL	36	6.5	237	42.7
JUN	50	9.0	287	51.7
MAR	39	7.0	326	58.7
MAY	53	9.5	379	68.3
MNTH	1	0.2	380	68.5
NOV	53	9.5	433	78.0
OCT	63	11.4	496	89.4
SEP	59	10.6	555	100.0
Total	555	100.0		

Frequency Distribution of Day of the Week

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
FRI	85	15.3	85	15.3
MON	112	20.2	197	35.5
SAT	23	4.1	220	39.6
SUN	19	3.4	239	43.1
THU	112	20.2	351	63.2
TUE	100	18.0	451	81.3
WED	103	18.6	554	99.8
WKDAY	1	0.2	555	100.0
Total	555	100.0		

Frequency Distribution of Year

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
2001	95	17.1	95	17.1
2002	123	22.2	218	39.4
2003	113	20.4	331	59.7
2004	118	21.3	449	81.0
2005	105	19.0	554	100.0
Total	554	100.0		

Frequency Distribution of Injury Severity

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
A	10	1.8	10	1.8
B	54	9.8	64	11.6
C	122	22.1	186	33.7
K	9	1.6	195	35.3
O	356	64.5	551	99.8
Total	552	100.0		

Frequency Distribution of Number Killed

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	545	98.4	545	98.4
1	9	1.6	554	100.0
Total	554	100.0		

Frequency Distribution of Number A-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	544	98.2	544	98.2
1	9	1.6	553	99.8
2	1	0.2	554	100.0
Total	554	100.0		

Frequency Distribution of B-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	493	89.0	493	89.0
1	52	9.4	545	98.4
2	6	1.1	551	99.5
3	3	0.5	554	100.0
Total	554	100.0		

Frequency Distribution of C-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	417	75.3	417	75.3
1	110	19.9	527	95.1
2	17	3.1	544	98.2
3	8	1.4	552	99.6
5	2	0.4	554	100.0
Total	554	100.0		

Frequency Distribution of Crash Type

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ANGLE	50	9.0	50	9.0
ANIMAL	15	2.7	65	11.7
BACKING UP	26	4.7	91	16.4
FIXED OBJECT	61	11.0	153	27.6
HEAD ON	9	1.6	162	29.2
JACKKNIFE	4	0.7	166	29.9
LEFT TURN, DIFFERENT ROADWAYS	34	6.1	200	36.0
LEFT TURN, SAME ROADWAY	34	6.1	234	42.2
MOVABLE OBJECT	14	2.5	248	44.7
OTHER COLLISION WITH VEHICLE	11	2.0	259	46.7
OTHER NON-COLLISION	13	2.3	272	49.0
OVERTURN/ROLLOVER	31	5.6	303	54.6
PARKED MOTOR VEHICLE	13	2.3	316	56.9
PEDALCYCLIST	1	0.2	317	57.1
PEDESTRIAN	1	0.2	318	57.3
RAN OFF ROAD - LEFT	2	0.4	320	57.7
RAN OFF ROAD - RIGHT	21	3.8	341	61.4
RAN OFF ROAD - STRAIGHT	1	0.2	342	61.6
REAR END, SLOW OR STOP	92	16.6	434	78.2
REAR END, TURN	12	2.2	446	80.4
RIGHT TURN, DIFFERENT ROADWAYS	6	1.1	452	81.4
RIGHT TURN, SAME ROADWAY	21	3.8	473	85.2
RR TRAIN, ENGINE	1	0.2	474	85.4
SIDESWIPE, SAME DIRECTION	43	7.7	517	93.2
SIDESWIPE,OPPOSITE DIRECTION	38	6.8	555	100.0
Total	555	100.0		

Frequency Distribution of Speed Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	547	98.6	547	98.6
Y	7	1.3	555	100.0
Total	555	100.0		

Frequency Distribution of Work Zone Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	541	97.5	541	97.5
Y	13	2.3	555	100.0
Total	555	100.0		

Frequency Distribution of Road Class

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
LCL	154	27.7	154	27.7
NC	190	34.2	344	62.0
RP	110	19.8	455	82.0
RU	2	0.4	457	82.3
SR	7	1.3	464	83.6
US	91	16.4	555	100.0
Total	555	100.0		

Frequency Distribution of Roadway Configuration

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ONE-WAY, NOT DIVIDED	15	2.8	15	2.8
RD_CONFIG	1	0.2	16	3.0
TWO-WAY, DIVIDED, POSITIVE MEDIAN BA	5	0.9	21	3.9
TWO-WAY, DIVIDED, UNPROTECTED MEDIAN	71	13.1	92	17.0
TWO-WAY, NOT DIVIDED	450	83.0	542	100.0
Total	542	100.0		

Frequency Distribution of Access Control

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ACCESS_CNT	1	0.2	1	0.2
FULL ACCESS CONTROL	43	8.0	44	8.1
NO ACCESS CONTROL	468	86.7	512	94.8
PARTIAL ACCESS CONTROL	28	5.2	540	100.0
Total	540	100.0		

Frequency Distribution of Traffic Control

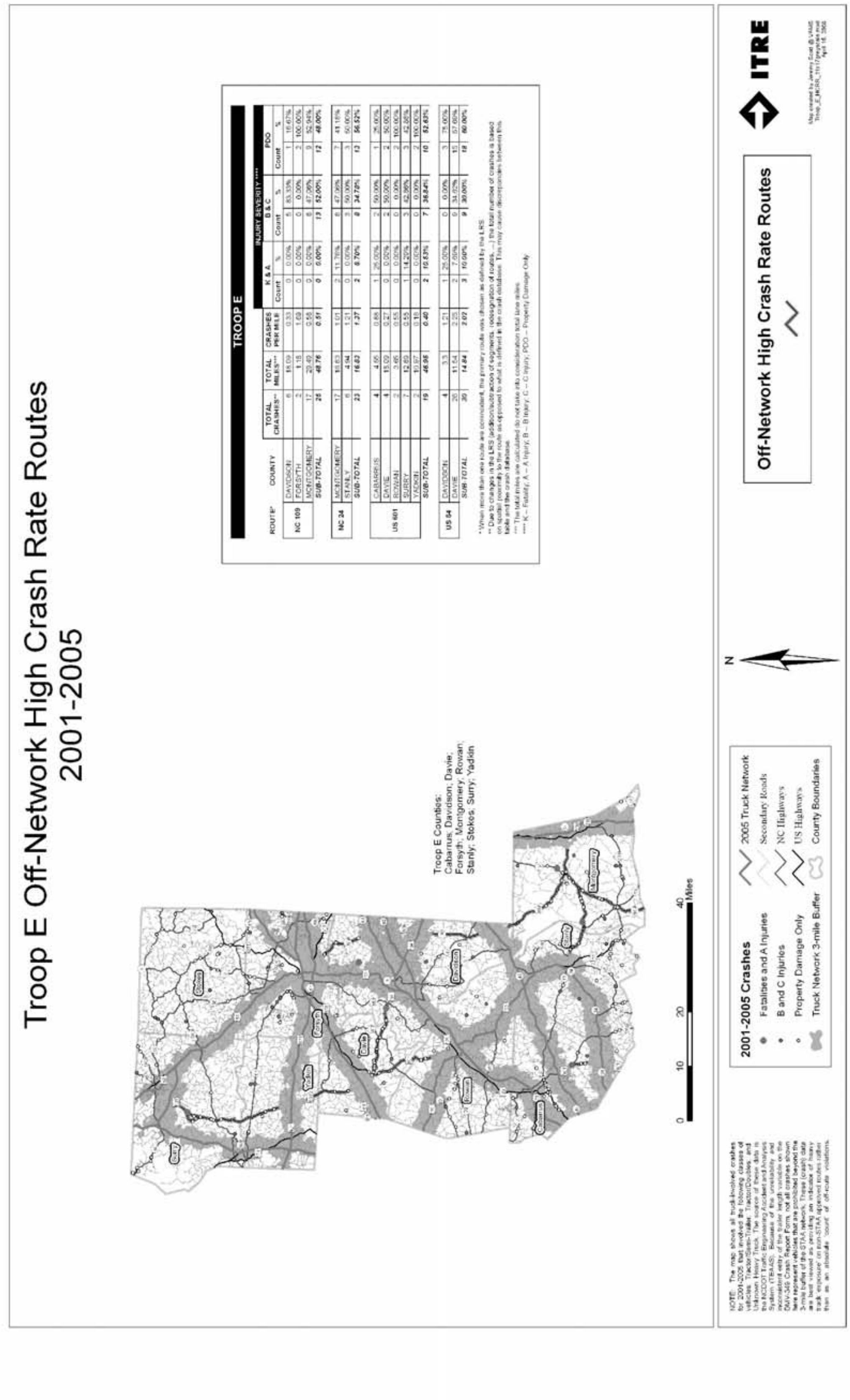
Value	Freq	Percent	Cumulative Freq	Cumulative Percent
DOUBLE YELLOW LINE, NO PASSING ZONE	158	31.1	158	31.1
FLASHING SIGNAL WITH STOP SIGN	5	1.0	163	32.1
FLASHING SIGNAL WITHOUT STOP SIGN	1	0.2	164	32.3
FLASHING STOP AND GO SIGNAL	1	0.2	165	32.5
HUMAN CONTROL	6	1.2	171	33.7
NO CONTROL PRESENT	181	35.6	352	69.3
OTHER	3	0.6	355	69.9
RR CROSSBUCKS ONLY	1	0.2	356	70.1
RR FLASHER	1	0.2	357	70.3
STOP AND GO SIGNAL	94	18.5	451	88.8
STOP SIGN	55	10.8	506	99.6
YIELD SIGN	1	0.2	508	100.0
Total	508	100.0		

Frequency Distribution of Alcohol Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
No	539	97.1	540	97.3
Yes	15	2.7	555	100.0
Total	555	100.0		

Frequency Distribution of Interstate vs Intrastate

Interstate	**321**
Intrastate	**233**



TROOP E

ROUTE*	COUNTY	TOTAL CRASHES**	TOTAL MILES***	CRASHES PER MILE	INJURY SEVERITY **** K & A Count	K & A %	B & C Count	B & C %	PDO Count	PDO %
NC 109	DAVIDSON	6	18.09	0.33	0	0.00%	5	83.33%	1	16.67%
	FORSYTH	2	1.18	1.69	0	0.00%	0	0.00%	2	100.00%
	MONTGOMERY	17	29.49	0.58	0	0.00%	8	47.06%	9	52.94%
	SUB-TOTAL	**25**	**48.76**	**0.51**	**0**	**0.00%**	**13**	**52.00%**	**12**	**48.00%**
NC 24	MONTGOMERY	17	16.83	1.01	2	11.76%	8	47.06%	7	41.18%
	STANLY	6	4.94	1.21	0	0.00%	3	50.00%	3	50.00%
	SUB-TOTAL	**23**	**16.83**	**1.37**	**2**	**8.70%**	**8**	**34.78%**	**13**	**56.52%**
US 601	CABARRUS	4	4.55	0.88	1	25.00%	2	50.00%	1	25.00%
	DAVIE	4	15.09	0.27	0	0.00%	2	50.00%	2	50.00%
	ROWAN	2	3.65	0.55	0	0.00%	0	0.00%	2	100.00%
	SURRY	7	12.69	0.55	1	14.29%	3	42.86%	3	42.86%
	YADKIN	2	10.97	0.18	0	0.00%	0	0.00%	2	100.00%
	SUB-TOTAL	**19**	**46.95**	**0.40**	**2**	**10.53%**	**7**	**36.84%**	**10**	**52.63%**
US 64	DAVIDSON	4	3.3	1.21	1	25.00%	0	0.00%	3	75.00%
	DAVIE	26	11.54	2.25	2	7.69%	9	34.62%	15	57.69%
	SUB-TOTAL	**30**	**14.84**	**2.02**	**3**	**10.00%**	**9**	**30.00%**	**18**	**60.00%**

* When more than one route are coincident, the primary route was chosen as defined by the LRS.
** Due to changes in the LRS (addition/subtraction of segments, redesignation of routes, ...) the total number of crashes is based on spatial proximity to the route as opposed to what is defined in the crash database. This may cause discrepancies between this table and the crash database.
*** The total miles are calculated do not take into consideration total lane miles.
**** K – Fatality; A – A Injury; B – B Injury; C – C Injury; PDO – Property Damage Only

Figure 13: Troop E Off-Network High Crash Rate Routes

Table 10: Attributes of off-network crashes: Troop E

Frequency Distribution of County

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ANSON	2	0.5	2	0.5
CABARRUS	45	12.1	47	12.6
DAVIDSON	28	7.5	76	20.4
DAVIE	49	13.2	125	33.6
FORSYTH	40	10.8	165	44.4
GUILFORD	4	1.1	169	45.4
MONTGOMERY	61	16.4	230	61.8
RANDOLPH	1	0.3	231	62.1
ROWAN	29	7.8	260	69.9
STANLY	44	11.8	304	81.7
STOKES	29	7.8	333	89.5
SURRY	30	8.1	363	97.6
YADKIN	9	2.4	372	100.0
Total	372	100.0		

Frequency Distribution of Rural vs Urban

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
R	317	85.2	317	85.2
U	54	14.5	372	100.0
Total	372	100.0		

Frequency Distribution of Accident Type

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
D	215	58.0	215	58.0
F	7	1.9	222	59.8
I	149	40.2	371	100.0
Total	371	100.0		

Frequency Distribution of Month of the Year

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
APR	44	11.8	44	11.8
AUG	38	10.2	82	22.0
DEC	28	7.5	110	29.6
FEB	34	9.1	144	38.7
JAN	21	5.6	165	44.4
JUL	35	9.4	200	53.8
JUN	35	9.4	235	63.2
MAR	20	5.4	255	68.5
MAY	36	9.7	291	78.2
MNTH	1	0.3	292	78.5
NOV	30	8.1	322	86.6
OCT	23	6.2	345	92.7
SEP	27	7.3	372	100.0
Total	372	100.0		

Frequency Distribution of Day of the Week

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
FRI	66	17.7	66	17.7
MON	60	16.1	126	33.9
SAT	17	4.6	143	38.4
SUN	7	1.9	150	40.3
THU	68	18.3	218	58.6
TUE	75	20.2	293	78.8
WED	78	21.0	371	99.7
WKDAY	1	0.3	372	100.0
Total	372	100.0		

Frequency Distribution of Year

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
2001	77	20.8	77	20.8
2002	63	17.0	140	37.7
2003	73	19.7	213	57.4
2004	92	24.8	305	82.2
2005	66	17.8	371	100.0
Total	371	100.0		

Frequency Distribution of Injury Severity

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
A	9	2.5	9	2.5
B	64	17.4	73	19.9
C	76	20.7	149	40.6
K	7	1.9	156	42.5
O	210	57.2	366	99.7
SEVERITY	1	0.3	367	100.0
Total	367	100.0		

Frequency Distribution of Persons Killed

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	364	98.1	364	98.1
1	6	1.6	370	99.7
2	1	0.3	371	100.0
Total	371	100.0		

Frequency Distribution of A-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	361	97.3	361	97.3
1	8	2.2	369	99.5
2	2	0.5	371	100.0
Total	371	100.0		

Frequency Distribution of B-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	303	81.7	303	81.7
1	59	15.9	362	97.6
2	7	1.9	369	99.5
3	2	0.5	371	100.0
Total	371	100.0		

Frequency Distribution of C-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	278	74.9	278	74.9
1	76	20.5	354	95.4
2	13	3.5	367	98.9
3	1	0.3	368	99.2
4	1	0.3	369	99.5
5	1	0.3	370	99.7
6	1	0.3	371	100.0
Total	371	100.0		

Frequency Distribution of Crash Type

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ANGLE	26	7.0	26	7.0
ANIMAL	6	1.6	32	8.6
BACKING UP	9	2.4	41	11.0
FIXED OBJECT	56	15.1	98	26.3
HEAD ON	6	1.6	104	28.0
JACKKNIFE	3	0.8	107	28.8
LEFT TURN, DIFFERENT ROADWAYS	24	6.5	131	35.2
LEFT TURN, SAME ROADWAY	21	5.6	152	40.9
MOVABLE OBJECT	10	2.7	162	43.5
OTHER COLLISION WITH VEHICLE	2	0.5	164	44.1
OTHER NON-COLLISION	8	2.2	172	46.2
OVERTURN/ROLLOVER	35	9.4	207	55.6
PARKED MOTOR VEHICLE	9	2.4	216	58.1
RAN OFF ROAD - LEFT	1	0.3	217	58.3
RAN OFF ROAD - RIGHT	28	7.5	245	65.9
REAR END, SLOW OR STOP	54	14.5	299	80.4
REAR END, TURN	12	3.2	311	83.6
RIGHT TURN, DIFFERENT ROADWAY	1	0.3	312	83.9
RIGHT TURN, SAME ROADWAY	7	1.9	319	85.8
SIDESWIPE, SAME DIRECTION	17	4.6	336	90.3
SIDESWIPE,OPPOSITE DIRECTION	36	9.7	372	100.0
Total	372	100.0		

Frequency Distribution of Speed Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	362	97.3	362	97.3
Y	9	2.4	372	100.0
Total	372	100.0		

Frequency Distribution of Work Zone Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	368	98.9	368	98.9
Y	3	0.8	372	100.0
Total	372	100.0		

Frequency Distribution of Roadway Class

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
LCL	64	17.2	64	17.2
NC	150	40.3	214	57.5
RP	94	25.3	309	83.1
US	63	16.9	372	100.0
Total	372	100.0		

Frequency Distribution of Roadway Configuration

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ONE-WAY, NOT DIVIDED	2	0.5	2	0.5
TWO-WAY, DIVIDED, POSITIVE MEDIAN BARRIE	5	1.4	8	2.2
TWO-WAY, DIVIDED, UNPROTECTED MEDIAN	27	7.4	35	9.6
TWO-WAY, NOT DIVIDED	328	90.1	363	99.7
UNKNOWN	1	0.3	364	100.0
Total	364	100.0		

Frequency Distribution of Access Control

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ACCESS_CNT	1	0.3	1	0.3
FULL ACCESS CONTROL	30	8.3	31	8.5
NO ACCESS CONTROL	310	85.4	341	93.9
PARTIAL ACCESS CONTROL	22	6.1	363	100.0
Total	363	100.0		

Frequency Distribution of Traffic Control

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
DOUBLE YELLOW LINE, NO PASSING ZONE	142	42.9	142	42.9
FLASHING SIGNAL WITH STOP SIGN	2	0.6	144	43.5
FLASHING SIGNAL WITHOUT STOP SIGN	1	0.3	145	43.8
FLASHING STOP AND GO SIGNAL	1	0.3	146	44.1
HUMAN CONTROL	6	1.8	152	45.9
NO CONTROL PRESENT	98	29.6	250	75.5
OTHER	2	0.6	252	76.1
RR FLASHER	1	0.3	253	76.4
RR GATE AND FLASHER	1	0.3	254	76.7
STOP AND GO SIGNAL	28	8.5	282	85.2
STOP SIGN	40	12.1	322	97.3
WARNING SIGN	8	2.4	331	100.0
Total	331	100.0		

Frequency Distribution of Alcohol Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
No	359	96.5	360	96.8
Yes	12	3.2	372	100.0
Total	372	100.0		

Frequency Distribution of Interstate vs Intrastate

Intrastate 143
Interstate 228

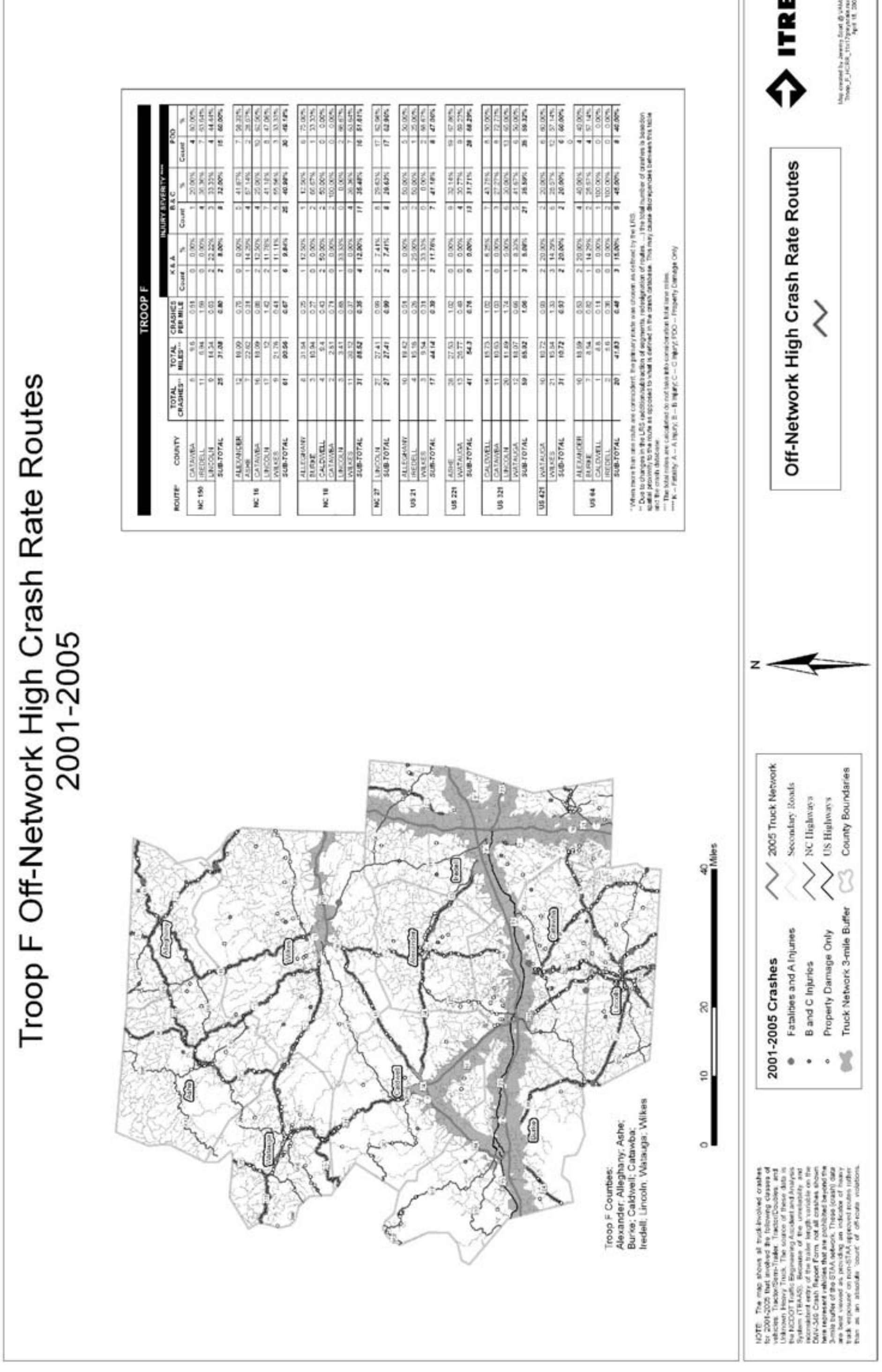


Figure 14: Troop F Off-Network High Crash Rate Routes

Table 11: Attributes of off-network crashes: Troop F

Frequency Distribution of County

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ALEXANDER	41	6.5	41	6.5
ALLEGHANY	25	4.0	66	10.5
ASHE	36	5.7	102	16.2
BURKE	32	5.1	134	21.3
CALDWELL	42	6.7	176	28.0
CATAWBA	100	15.9	276	43.9
CNTY_NM	1	0.2	277	44.0
DAVIE	1	0.2	278	44.2
IREDELL	60	9.5	338	53.7
LINCOLN	131	20.8	469	74.6
MECKLENBURG	1	0.2	470	74.7
SURRY	1	0.2	471	74.9
WATAUGA	83	13.2	554	88.1
WILKES	75	11.9	629	100.0
Total	629	100.0		

Frequency Distribution of Rural vs Urban

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
R	526	83.6	526	83.6
U	102	16.2	629	100.0
Total	629	100.0		

Frequency Distribution of Accident Type

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
D	382	60.7	383	60.9
F	22	3.5	405	64.4
I	224	35.6	629	100.0
Total	629	100.0		

Frequency Distribution of Month of the Year

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
APR	53	8.4	53	8.4
AUG	50	7.9	103	16.4
DEC	54	8.6	157	25.0
FEB	41	6.5	198	31.5
JAN	48	7.6	246	39.1
JUL	44	7.0	290	46.1
JUN	48	7.6	338	53.7
MAR	64	10.2	402	63.9
MAY	42	6.7	444	70.6
NOV	63	10.0	508	80.8
OCT	66	10.5	574	91.3
SEP	55	8.7	629	100.0
Total	629	100.0		

Frequency Distribution of Day of the Week

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
FRI	106	16.9	106	16.9
MON	105	16.7	211	33.5
SAT	31	4.9	242	38.5
SUN	20	3.2	262	41.7
THU	120	19.1	382	60.7
TUE	131	20.8	513	81.6
WED	115	18.3	628	99.8
Total	629	100.0		

Frequency Distribution of Year

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
2001	118	18.8	118	18.8
2002	117	18.6	235	37.4
2003	123	19.6	358	57.0
2004	136	21.7	494	78.7
2005	134	21.3	628	100.0
Total	628	100.0		

Frequency Distribution of Injury Severity

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
A	23	3.7	23	3.7
B	86	13.7	109	17.4
C	115	18.3	224	35.7
K	22	3.5	246	39.2
O	381	60.7	627	99.8
Total	628	100.0		

Frequency Distribution of Number Killed

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	606	96.5	606	96.5
1	18	2.9	624	99.4
2	3	0.5	627	99.8
4	1	0.2	628	100.0
Total	628	100.0		

Frequency Distribution of A-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	603	96.0	603	96.0
1	21	3.3	624	99.4
2	4	0.6	628	100.0
Total	628	100.0		

Frequency Distribution of B-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	527	83.9	527	83.9
1	87	13.9	614	97.8
2	11	1.8	625	99.5
3	3	0.5	628	100.0

Total	628	100.0

Frequency Distribution of C-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	495	78.8	495	78.8
1	114	18.2	609	97.0
2	13	2.1	622	99.0
3	6	1.0	628	100.0
Total	628	100.0		

Frequency Distribution of Crash Type

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ANGLE	39	6.2	39	6.2
ANIMAL	18	2.9	57	9.1
BACKING UP	22	3.5	79	12.6
FIXED OBJECT	88	14.0	168	26.7
HEAD ON	17	2.7	185	29.4
JACKKNIFE	12	1.9	197	31.3
LEFT TURN, DIFFERENT ROADWAYS	36	5.7	233	37.0
LEFT TURN, SAME ROADWAY	36	5.7	269	42.8
MOVABLE OBJECT	16	2.5	285	45.3
OTHER COLLISION WITH VEHICLE	17	2.7	302	48.0
OTHER NON-COLLISION	8	1.3	310	49.3
OVERTURN/ROLLOVER	60	9.5	370	58.8
PARKED MOTOR VEHICLE	16	2.5	386	61.4
RAN OFF ROAD - LEFT	5	0.8	391	62.2
RAN OFF ROAD - RIGHT	21	3.3	412	65.5
REAR END, SLOW OR STOP	79	12.6	491	78.1
REAR END, TURN	7	1.1	498	79.2
RIGHT TURN, DIFFERENT ROADWAYS	6	1.0	504	80.1
RIGHT TURN, SAME ROADWAY	15	2.4	519	82.5
SIDESWIPE, SAME DIRECTION	43	6.8	562	89.3
SIDESWIPE,OPPOSITE DIRECTION	67	10.7	629	100.0
Total	629	100.0		

Frequency Distribution of Speed Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	611	97.1	611	97.1
Y	17	2.7	629	100.0
Total	629	100.0		

Frequency Distribution of Work Zone Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	617	98.1	617	98.1
Y	11	1.7	629	100.0
Total	629	100.0		

Frequency Distribution of Roadway Class

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
LCL	90	14.3	90	14.3
NC	227	36.1	317	50.4
RP	137	21.8	455	72.3
RU	6	1.0	461	73.3
US	168	26.7	629	100.0
Total	629	100.0		

Frequency Distribution of Roadway Configuration

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ONE-WAY, NOT DIVIDED	13	2.1	13	2.1
TWO-WAY, DIVIDED, POSITIVE MEDIAN BA	19	3.1	33	5.4
TWO-WAY, DIVIDED, UNPROTECTED MEDIAN	29	4.7	62	10.1
TWO-WAY, NOT DIVIDED	554	89.9	616	100.0
Total	616	100.0		

Frequency Distribution of Access Control

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
FULL ACCESS CONTROL	59	9.6	60	9.8
NO ACCESS CONTROL	525	85.5	585	95.3
PARTIAL ACCESS CONTROL	29	4.7	614	100.0
Total	614	100.0		

Frequency Distribution of Traffic Control

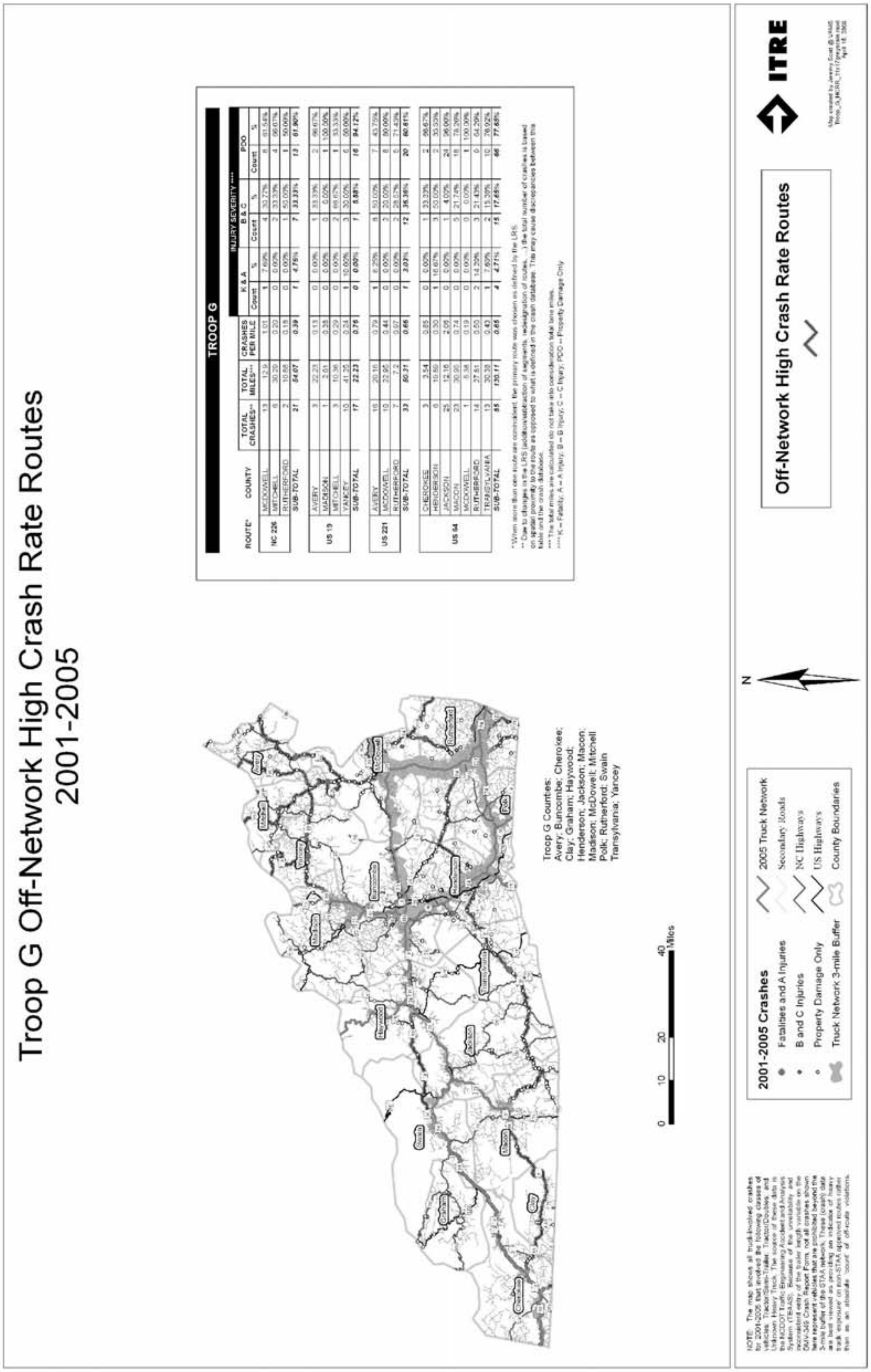
Value	Freq	Percent	Cumulative Freq	Cumulative Percent
DOUBLE YELLOW LINE, NO PASSING ZONE	301	51.7	301	51.7
FLASHING SIGNAL WITH STOP SIGN	4	0.7	305	52.4
FLASHING SIGNAL WITHOUT STOP SIGN	2	0.3	307	52.7
FLASHING STOP AND GO SIGNAL	1	0.2	308	52.9
HUMAN CONTROL	1	0.2	309	53.1
NO CONTROL PRESENT	145	24.9	454	78.0
OTHER	5	0.9	459	78.9
RR GATE AND FLASHER	1	0.2	460	79.0
STOP AND GO SIGNAL	56	9.6	516	88.7
STOP SIGN	57	9.8	573	98.5
WARNING SIGN	6	1.0	580	99.7
YIELD SIGN	2	0.3	582	100.0
Total	582	100.0		

Frequency Distribution of Alcohol Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
No	616	97.9	617	98.1
Yes	12	1.9	629	100.0
Total	629	100.0		

Frequency Distribution of Interstate vs Intrastate

Interstate 406
Intrastate 222



TROOP G										
					INJURY SEVERITY ****					
ROUTE*	COUNTY	TOTAL CRASHES**	TOTAL MILES***	CRASHES PER MILE	K & A Count	K & A %	B & C Count	B & C %	PDO Count	PDO %
NC 226	MCDOWELL	13	12.9	1.01	1	7.69%	4	30.77%	8	61.54%
	MITCHELL	6	30.29	0.20	0	0.00%	2	33.33%	4	66.67%
	RUTHERFORD	2	10.88	0.18	0	0.00%	1	50.00%	1	50.00%
	SUB-TOTAL	21	54.07	0.39	1	4.76%	7	33.33%	13	61.90%
US 19	AVERY	3	22.23	0.13	0	0.00%	1	33.33%	2	66.67%
	MADISON	1	2.61	0.38	0	0.00%	0	0.00%	1	100.00%
	MITCHELL	3	10.36	0.29	0	0.00%	2	66.67%	1	33.33%
	YANCEY	10	41.26	0.24	1	10.00%	3	30.00%	6	60.00%
	SUB-TOTAL	17	22.23	0.76	0	0.00%	1	5.88%	16	94.12%
US 221	AVERY	16	20.16	0.79	1	6.25%	8	50.00%	7	43.75%
	MCDOWELL	10	22.95	0.44	0	0.00%	2	20.00%	8	80.00%
	RUTHERFORD	7	7.2	0.97	0	0.00%	2	28.57%	5	71.43%
	SUB-TOTAL	33	50.31	0.66	1	3.03%	12	36.36%	20	60.61%
US 64	CHEROKEE	3	3.54	0.85	0	0.00%	1	33.33%	2	66.67%
	HENDERSON	6	19.89	0.30	1	16.67%	3	50.00%	2	33.33%
	JACKSON	25	12.16	2.06	0	0.00%	1	4.00%	24	96.00%
	MACON	23	30.96	0.74	0	0.00%	5	21.74%	18	78.26%
	MCDOWELL	1	5.38	0.19	0	0.00%	0	0.00%	1	100.00%
	RUTHERFORD	14	27.81	0.50	2	14.29%	3	21.43%	9	64.29%
	TRANSYLVANIA	13	30.38	0.43	1	7.69%	2	15.38%	10	76.92%
	SUB-TOTAL	85	130.11	0.65	4	4.71%	15	17.65%	66	77.65%

Figure 15: Troop G Off-Network High Crash Rate Routes

Table 12: Attributes of off-network crashes: Troop G

Frequency Distribution of County

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
AVERY	27	6.9	27	6.9
BUNCOMBE	30	7.6	57	14.5
CHEROKEE	7	1.8	64	16.2
CLAY	4	1.0	68	17.3
CNTY_NM	1	0.3	69	17.5
GRAHAM	8	2.0	77	19.5
HAYWOOD	18	4.6	95	24.1
HENDERSON	37	9.4	132	33.5
JACKSON	36	9.1	168	42.6
MACON	35	8.9	203	51.5
MADISON	26	6.6	229	58.1
MCDOWELL	52	13.2	281	71.3
MITCHELL	13	3.3	294	74.6
POLK	8	2.0	302	76.6
RUTHERFORD	48	12.2	350	88.8
SWAIN	4	1.0	354	89.8
TRANSYLVANIA	28	7.1	382	97.0
YANCEY	12	3.0	394	100.0
Total	394	100.0		

Frequency Distribution of Rural vs Urban

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
R	360	91.4	360	91.4
U	33	8.4	394	100.0
Total	394	100.0		

Frequency Distribution of Accident Type

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
D	278	70.6	279	70.8
F	7	1.8	286	72.6
I	108	27.4	394	100.0
Total	394	100.0		

Frequency Distribution of Month of the Year

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
APR	34	8.6	34	8.6
AUG	42	10.7	76	19.3
DEC	29	7.4	105	26.6
FEB	23	5.8	128	32.5
JAN	20	5.1	148	37.6
JUL	28	7.1	176	44.7
JUN	42	10.7	218	55.3
MAR	28	7.1	246	62.4
MAY	30	7.6	276	70.1
NOV	35	8.9	312	79.2
OCT	42	10.7	354	89.8
SEP	40	10.2	394	100.0
Total	394	100.0		

Frequency Distribution of Day of the Week

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
FRI	60	15.2	60	15.2
MON	70	17.8	130	33.0
SAT	25	6.3	155	39.3
SUN	13	3.3	168	42.6
THU	90	22.8	258	65.5
TUE	73	18.5	331	84.0
WED	62	15.7	393	99.7
Total	394	100.0		

Frequency Distribution of Year

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
2001	83	21.1	83	21.1
2002	75	19.1	158	40.2
2003	79	20.1	237	60.3
2004	75	19.1	312	79.4
2005	81	20.6	393	100.0
Total	393	100.0		

Frequency Distribution of Injury Severity

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
A	8	2.0	8	2.0
B	38	9.7	46	11.7
C	62	15.8	108	27.5
K	7	1.8	115	29.3
O	277	70.5	392	99.7
Total	393	100.0		

Frequency Distribution of Number Killed

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	386	98.2	386	98.2
1	6	1.5	392	99.7
2	1	0.3	393	100.0
Total	393	100.0		

Frequency Distribution of A-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	385	98.0	385	98.0
1	6	1.5	391	99.5
2	2	0.5	393	100.0
Total	393	100.0		

Frequency Distribution of B-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	353	89.8	353	89.8
1	30	7.6	383	97.5
2	9	2.3	392	99.7
3	1	0.3	393	100.0
Total	393	100.0		

Frequency Distribution of C-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	322	81.9	322	81.9
1	52	13.2	374	95.2
2	17	4.3	391	99.5
3	2	0.5	393	100.0
Total	393	100.0		

Frequency Distribution of Crash Type

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ANGLE	24	6.1	24	6.1
ANIMAL	6	1.5	30	7.6
BACKING UP	10	2.5	40	10.2
FIXED OBJECT	75	19.0	116	29.4
HEAD ON	5	1.3	121	30.7
JACKKNIFE	5	1.3	126	32.0
LEFT TURN, DIFFERENT ROADWAYS	16	4.1	142	36.0
LEFT TURN, SAME ROADWAY	8	2.0	150	38.1
MOVABLE OBJECT	12	3.0	162	41.1
OTHER COLLISION WITH VEHICLE	3	0.8	165	41.9
OTHER NON-COLLISION	4	1.0	169	42.9
OVERTURN/ROLLOVER	29	7.4	198	50.3
PARKED MOTOR VEHICLE	6	1.5	204	51.8
PEDESTRIAN	2	0.5	206	52.3
RAN OFF ROAD - LEFT	1	0.3	207	52.5
RAN OFF ROAD - RIGHT	7	1.8	214	54.3
REAR END, SLOW OR STOP	38	9.6	252	64.0
REAR END, TURN	3	0.8	255	64.7
RIGHT TURN, DIFFERENT ROADWAY	3	0.8	258	65.5
RIGHT TURN, SAME ROADWAY	10	2.5	268	68.0
SIDESWIPE, SAME DIRECTION	23	5.8	291	73.9
SIDESWIPE,OPPOSITE DIRECTION	103	26.1	394	100.0
Total	394	100.0		

Frequency Distribution of Speed Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	386	98.0	386	98.0
Y	7	1.8	394	100.0
Total	394	100.0		

Frequency Distribution of Work Zone Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	385	97.7	385	97.7
Y	8	2.0	394	100.0
Total	394	100.0		

Frequency Distribution of Class of Road

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
I	1	0.3	1	0.3
LCL	42	10.7	43	10.9
NC	85	21.6	128	32.5
RP	81	20.6	210	53.3
RU	3	0.8	213	54.1
US	181	45.9	394	100.0
Total	394	100.0		

Frequency Distribution of Road Configuration

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ONE-WAY, NOT DIVIDED	2	0.5	2	0.5
TWO-WAY, DIVIDED, POSITIVE MEDIAN BA	3	0.8	6	1.6
TWO-WAY, DIVIDED, UNPROTECTED MEDIAN	25	6.5	31	8.0
TWO-WAY, NOT DIVIDED	356	92.0	387	100.0
Total	387	100.0		

Frequency Distribution of Access Control

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
FULL ACCESS CONTROL	29	7.5	30	7.8
NO ACCESS CONTROL	331	85.5	361	93.3
PARTIAL ACCESS CONTROL	26	6.7	387	100.0
Total	387	100.0		

Frequency Distribution of Traffic Control

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
DOUBLE YELLOW LINE, NO PASSING ZONE	238	63.5	238	63.5
FLASHING SIGNAL WITH STOP SIGN	2	0.5	240	64.0
HUMAN CONTROL	9	2.4	249	66.4
NO CONTROL PRESENT	72	19.2	321	85.6
OTHER	2	0.5	323	86.1
RR CROSSBUCKS ONLY	1	0.3	324	86.4
RR GATE AND FLASHER	1	0.3	325	86.7
SCHOOL ZONE SIGNS	1	0.3	326	86.9
STOP AND GO SIGNAL	26	6.9	352	93.9
STOP SIGN	20	5.3	372	99.2
WARNING SIGN	1	0.3	374	99.7
YIELD SIGN	1	0.3	375	100.0
Total	375	100.0		

Frequency Distribution of Alcohol Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
No	389	98.7	390	99.0
Yes	4	1.0	394	100.0
Total	394	100.0		

Frequency Distribution of Interstate vs Intrastate

Interstate 286
Intrastate 107

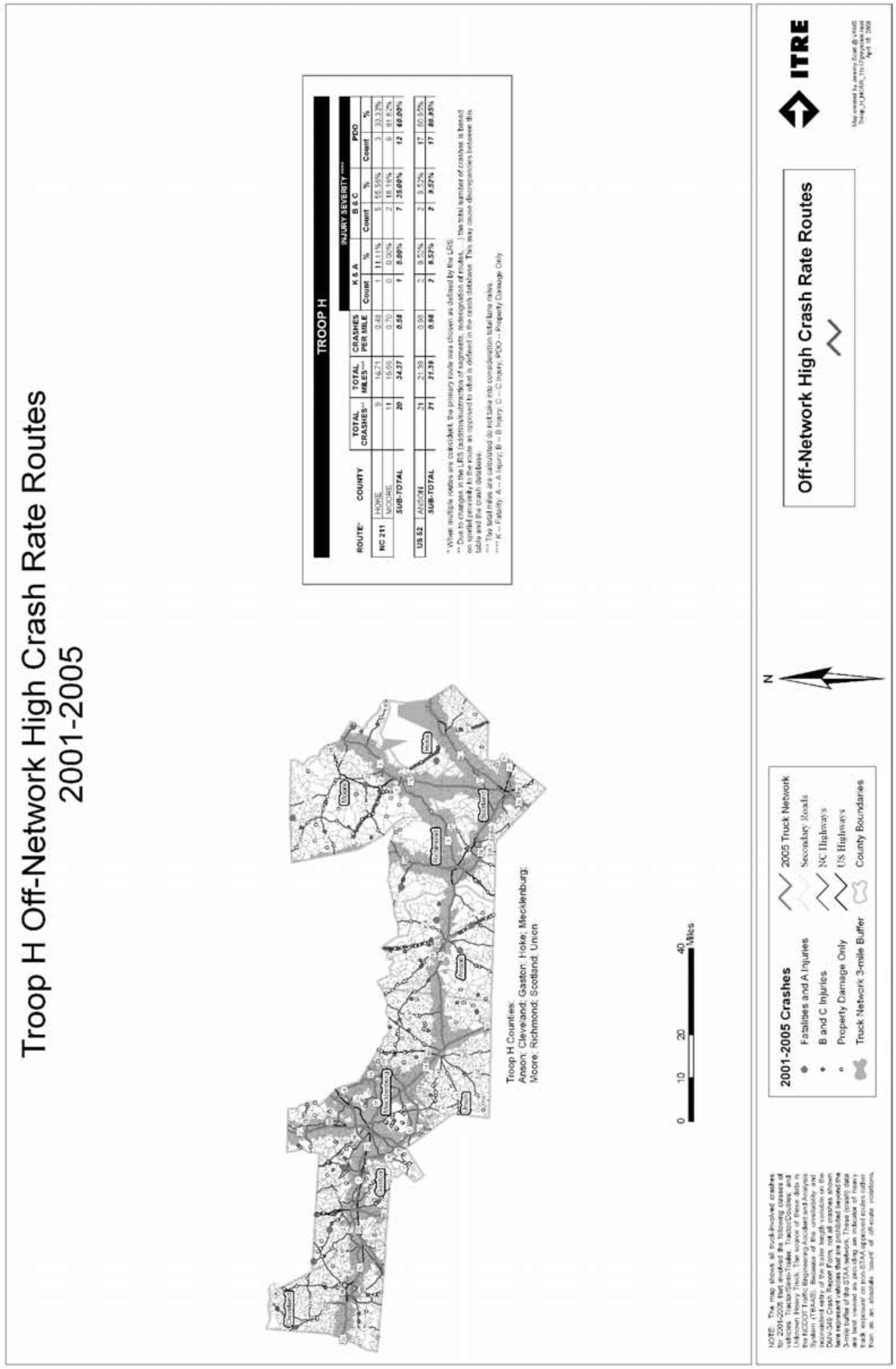


Figure 16: Troop H Off-Network High Crash Rate Routes

Table 13: Attributes of off-network crashes: Troop H

Frequency Distribution of County

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ANSON	60	14.1	60	14.1
CABARRUS	4	0.9	64	15.1
CLEVELAND	31	7.3	95	22.4
GASTON	65	15.3	161	37.9
HARNETT	1	0.2	162	38.1
HOKE	15	3.5	177	41.6
MECKLENBURG	71	16.7	248	58.4
MOORE	73	17.2	321	75.5
RICHMOND	23	5.4	344	80.9
SCOTLAND	3	0.7	347	81.6
UNION	78	18.4	425	100.0
Total	425	100.0		

Frequency Distribution of Rural vs Urban

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
R	323	76.0	323	76.0
U	101	23.8	425	100.0
Total	425	100.0		

Frequency Distribution of Accident Type

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
D	255	60.0	256	60.2
F	13	3.1	269	63.3
I	156	36.7	425	100.0
Total	425	100.0		

Frequency Distribution of Month

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
APR	45	10.6	45	10.6
AUG	32	7.5	77	18.1
DEC	35	8.2	112	26.4
FEB	28	6.6	140	32.9
JAN	40	9.4	180	42.4
JUL	41	9.6	221	52.0
JUN	50	11.8	271	63.8
MAR	31	7.3	302	71.1
MAY	28	6.6	330	77.6
NOV	36	8.5	367	86.4
OCT	28	6.6	395	92.9
SEP	30	7.1	425	100.0
Total	425	100.0		

Frequency Distribution of Day of the Week

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
FRI	83	19.5	83	19.5
MON	86	20.2	169	39.8
SAT	20	4.7	189	44.5
SUN	13	3.1	202	47.5
THU	71	16.7	273	64.2
TUE	82	19.3	355	83.5
WED	69	16.2	424	99.8
KDAY	1	0.2	425	100.0
Total	425	100.0		

Frequency Distribution of Year

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
2001	88	20.8	88	20.8
2002	92	21.7	180	42.5
2003	75	17.7	255	60.1
2004	86	20.3	341	80.4
2005	83	19.6	424	100.0
Total	424	100.0		

Frequency Distribution of Injury Severity

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
A	16	3.8	16	3.8
B	66	15.6	82	19.4
C	74	17.5	156	36.9
K	13	3.1	169	40.0
O	253	59.8	422	99.8
Total	423	100.0		

Frequency Distribution of Number Killed

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	411	96.9	411	96.9
1	12	2.8	423	99.8
2	1	0.2	424	100.0
Total	424	100.0		

Frequency Distribution of A-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	406	95.8	406	95.8
1	17	4.0	423	99.8
2	1	0.2	424	100.0
Total	424	100.0		

Frequency Distribution of B-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	354	83.5	354	83.5
1	61	14.4	415	97.9
2	8	1.9	423	99.8
3	1	0.2	424	100.0
Total	424	100.0		

Frequency Distribution of C-Injuries

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
0	330	77.8	330	77.8
1	72	17.0	402	94.8
2	18	4.2	420	99.1
3	3	0.7	423	99.8
5	1	0.2	424	100.0
Total	424	100.0		

Frequency Distribution of Crash Type

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ANGLE	52	12.2	52	12.2
ANIMAL	11	2.6	63	14.8
BACKING UP	14	3.3	77	18.1
FIXED OBJECT	58	13.6	136	32.0
HEAD ON	4	0.9	140	32.9
JACKKNIFE	4	0.9	144	33.9
LEFT TURN, DIFFERENT ROADWAYS	29	6.8	173	40.7
LEFT TURN, SAME ROADWAY	26	6.1	199	46.8
MOVABLE OBJECT	7	1.6	206	48.5
OTHER COLLISION WITH VEHICLE	6	1.4	212	49.9
OTHER NON-COLLISION	11	2.6	223	52.5
OVERTURN/ROLLOVER	41	9.6	264	62.1
PARKED MOTOR VEHICLE	5	1.2	269	63.3
PEDALCYCLIST	2	0.5	271	63.8
RAN OFF ROAD - LEFT	3	0.7	274	64.5
RAN OFF ROAD - RIGHT	18	4.2	292	68.7
RAN OFF ROAD - STRAIGHT	1	0.2	293	68.9
REAR END, SLOW OR STOP	60	14.1	353	83.1
REAR END, TURN	5	1.2	358	84.2
RIGHT TURN, DIFFERENT ROADWAYS	8	1.9	366	86.1
RIGHT TURN, SAME ROADWAY	9	2.1	375	88.2
RR TRAIN, ENGINE	2	0.5	377	88.7
SIDESWIPE, SAME DIRECTION	26	6.1	403	94.8
SIDESWIPE,OPPOSITE DIRECTION	22	5.2	425	100.0
Total	425	100.0		

Frequency Distribution of Speed Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	409	96.2	409	96.2
Y	15	3.5	425	100.0
Total	425	100.0		

Frequency Distribution of Work Zone Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
N	416	97.9	416	97.9
Y	8	1.9	425	100.0
Total	425	100.0		

Frequency Distribution of Road Way Class

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
LCL	83	19.5	83	19.5
NC	180	42.4	263	61.9
RP	99	23.3	363	85.4
RU	1	0.2	364	85.6
SR	1	0.2	365	85.9
US	60	14.1	425	100.0
Total	425	100.0		

Frequency Distribution of Roadway Configuration

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
ONE-WAY, NOT DIVIDED	5	1.2	5	1.2
TWO-WAY, DIVIDED, POSITIVE MEDIAN BARRIE	16	3.9	22	5.3
TWO-WAY, DIVIDED, UNPROTECTED MEDIAN	39	9.4	61	14.8
TWO-WAY, NOT DIVIDED	351	85.0	412	99.8
UNKNOWN	1	0.2	413	100.0
Total	413	100.0		

Frequency Distribution of Access Control

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
FULL ACCESS CONTROL	36	8.7	37	9.0
NO ACCESS CONTROL	337	81.8	374	90.8
PARTIAL ACCESS CONTROL	38	9.2	412	100.0
Total	412	100.0		

Frequency Distribution of Traffic Control

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
DOUBLE YELLOW LINE, NO PASSING ZONE	146	37.6	146	37.6
FLASHING SIGNAL WITH STOP SIGN	4	1.0	150	38.7
FLASHING SIGNAL WITHOUT STOP SIGN	1	0.3	151	38.9
HUMAN CONTROL	3	0.8	154	39.7
NO CONTROL PRESENT	117	30.2	271	69.8
RR CROSSBUCKS ONLY	4	1.0	275	70.9
RR GATE AND FLASHER	1	0.3	276	71.1
STOP AND GO SIGNAL	37	9.5	313	80.7
STOP SIGN	70	18.0	383	98.7
YIELD SIGN	4	1.0	388	100.0
Total	388	100.0		

Frequency Distribution of Alcohol Involved

Value	Freq	Percent	Cumulative Freq	Cumulative Percent
No	417	98.1	418	98.4
Yes	7	1.6	425	100.0
Total	425	100.0		

Frequency Distribution of Interstate vs Intrastate

Interstate 277
Intrastate 147

Chapter 4: Discussion

In the absence of reliable statewide truck counts it is not possible to precisely gauge the presence of STAA 'dimensioned (i.e., over-length) vehicles' on roadways that are not part of the STAA Truck Network. Although 'trailer length' is a data element on the NCDMV-349 crash report form, it is an element that is frequently not entered or is entered incorrectly.

The present study sought to estimate the off-network presence of STAA dimensioned vehicle from crash data. However, because of the unreliability of the trailer length data field on the crash report form, it was necessary to do the analysis on combination vehicles 48ft or greater in length, double trailers (twins), and other (unknown) heavy vehicles. While the data are confounded in this sense, it is important to point out that the 48ft trailer is gradually becoming obsolete as the industry standard is quickly becoming the 53ft trailer.

Despite this confounding, the present findings are significant in that they provide an estimate of the crash involvement of heavy trucks on roadways not currently included on the STAA network. For this enlarged class of vehicle types, the data provide an indication of the relative risk of heavy trucks on/off the current network. We know that the likelihood of fatal CMV-involved crashes varies by class of roadway, with the risk of a fatality being highest for NC and US-numbered routes, local, and secondary roads. The present data suggest that the risk of a fatality can be twice as high for heavy truck involved collisions off the network as those that take place on the network.

Presently, according to the NCDOT Linear Referencing System (LRS) there are, on average about 10,000 miles of state highway in each troop. On average, only about 800 of these miles (about 8 percent) are designated for use by STAA dimensioned vehicles. As we attempted to show conceptually in an earlier figure, as the 'network' becomes better able to capture the crashes in which heavy trucks are involved, the likelihood of fatal crashes occurring off the network goes down. Put more simply, expanding the present network infrastructure would be good for large truck safety (how ingenious!).

4.1 Toward a Method for Prioritizing the Need for Improvement

Based upon the data, we have suggested two comparable methods for developing relative 'measures of merit' to be used in prioritizing the need for improvement at the troop level. Both are 'logical' in their reliance on off-route crash frequency, the percent of troop crashes that are taking place off the existing network, and the level of injury severity associated with these crashes. Both these methods point to Troop A as being the troop with the most immediate need for improvement. The troop with the lowest calculated need was Troop H.

We also explored alternative methods for ranking the need for improvement within troops based upon the attributes of crashes within ‘clusters’ that have been defined algorithmically. However, a satisfactory method for including the linear distance component between and among crash points into a cluster and/or hot spot analysis tool is still needed and will continue to be investigated. In particular, the hierarchical clustering method is preferred as it takes into account various scale levels when generating the clusters.

ITRE is currently working on a road “vulnerability index” which can serve as an additional information source for decision support. The current purpose of this index is to help identify high priority areas for off network enforcement of overweight trucks. The index will make use of NCDOT bridge data, traffic count data, and pavement condition data. However, it is hoped that this vulnerability index can also be used to prioritize high risk areas. By combining the (medium scale) off network clusters and the (fine scale) truck crash density results we hope to increase confidence measures for identifying high priority enforcement areas.

Additionally, we are in the process of experimenting with an analysis that will look at the ‘temporal’ patterns of off-network crashes (over time) with an eye to seeing if the geo-specific nature of these areas over time can be correlated with other data sources (e.g., population change).

4.2 The Enforcement Alternative

The alternative to a ‘design’ and ‘roadway improvement’ approach would be to increase the funding for motor vehicle enforcement personnel to increase enforcement efforts, and to combine such increased enforcement effort with significantly higher fines and penalties. One could only expect uproar from an industry striving to meet the increasing demands for freight movement, an overburdened and increasingly inadequate infrastructure, increasing congestion, driver shortages, increased labor rates, the availability of compliant equipment, etc.

Ignoring the problem would lead to an increase in the rate of infrastructure damage, increased repair costs, and a decrease in the safety of motorists forced to operate within an increasing congested ‘mixed’ vehicle environment.

The most logical alternative, not necessarily the one favored by most state Departments of Transportation, is to develop realistic plans for strategically improving the existing and future infrastructure to accommodate the growing needs of the industry for longer, wider, and heavier vehicles. Also, serious consideration should be given to reviving inter-modal alternatives for the movement of freight (i.e., revival of rail, construction of truck-only facilities, etc.).

4.3 Responsibility of the Vehicle Manufacturing Community

It would seem plausible also to expect the vehicle manufacturers to give serious design attention to lighter, more maneuverable designs, capable of carrying more weight while exerting less impact on the infrastructure. To the extent we know that axle weight is critically related to pavement damage, one might logically ask, 'why not simply add more axles?'

Consideration also needs to be given to increased design attention to steerable axles, improved braking and control capabilities of long combination vehicles (LCVs), and to the development of more automated (less manpower intensive) methods for cargo loading/unloading.

We have to find ways to move more (both in terms of the number of deliveries as well as its weight) using less manpower intensive methods (drivers, cargo handling personnel, etc.) that more effectively use inter-modal concepts than those currently in place. The answer is to find ways to support industry needs . . . not to find increased ways to constrain its operation.

Chapter 5: Prioritized Recommendations by Agency

NC Department of Transportation (focus on infrastructure design, deployment, operations, and maintenance)

- The NCDOT needs to develop a strategic, long term plan for the systematic expansion of the existing STAA truck network. The plan should be based upon data-driven priorities that will ensure a phased improvement in the availability and continuity of STAA routes in the state.

- In the interim, every effort needs to be made to add miles and connectivity to the current STAA system that do not require significant new investment (e.g., lane widening, addition of paved shoulders, horizontal alignment improvements, etc.).

- The NCDOT should review currently used 'design vehicle' standards in light of industry needs for longer, wider, and heavier commercial vehicles in the future.

- The NCDOT should increase pavement and materiel research focusing on more cost effective, stronger, and more long lasting pavement designs than those currently in use.

- The NCDOT should re-examine current capabilities for obtaining reliable truck count, classification and speed data on all state maintained roads.

- The NCDOT needs to establish a reliable means for obtaining commercial motor vehicle origin-destination and commodity data as part of a more strategic plan for commercial motor vehicle freight operations.

- NCDOT should continue its efforts to obtain and integrate roadway files from agencies outside the NCDOT that are necessary to provide a 'One Map' coverage of the state; i.e., not to be limited to its own Linear Referencing System (LRS) data.

- Encourage AASHTO support for strategic studies focused on the development of innovative strategies and approaches for the surface movement of goods and cargo.

- Encourage state-level expansion and development of inter-modal means (i.e., truck and rail) for more efficient, cost effective surface movement of freight.

NCSHP Motor Carrier Enforcement

- The NCSHP's Motor Carrier Size and Weight enforcement program should carefully review the current estimates of off-network operations from the standpoint of determining the vulnerability of bridges to these over length vehicles, especially those that are overloaded.

- Take under consideration the need to increase the fines and penalties associated with the off-network operation of STAA dimensioned vehicles.

- NCSHP Motor Carrier Enforcement personnel should increase efforts to 'partner' with local enforcement agencies to target STAA non-compliance, recognizing that non-compliance in many urban areas may represent a greater congestion problem than a safety problem.

- In the interim, increase education and public/industry awareness efforts aimed at improving industry compliance with existing STAA use.

- NCSHP should take the lead in developing and implementing a hand held or vehicle-based means to utilize Global Positioning System (GPS) capabilities to determine whether ones current roadway location is contained on or within the 3-mile buffer of the approved STAA truck network. Incorporate within the same GPS device an internal database that is able to output a text/alphanumeric description of the location (to include 'on' road, 'from' road, and 'toward' road). The application should be able to interface with the officer's PC so as to automatically, or upon command, upload both forms of location information into the computer application being used to enter the record of the enforcement action (e.g., e-crash, e-citation, FuelTaCS). Where the officer does not have an electronic data entry capability, the device shall provide a visual display of both GPS and text-based location data.

Joint NCDOT and NCSHP Motor Carrier Enforcement (focus on exerting pressure on the vehicle/trailer manufacturing community)

- Work through all means possible to encourage the vehicle (i.e., trailer) manufacturer industry to investigate new trailer design concepts focused on the development of capabilities that would permit increased maneuverability, increased vehicle ability to carry increased (heavier) loads while exerting less measurable impact on the environment, etc.

North Carolina Division of Motor Vehicles (DMV) Crash Reporting (focus on more accurate means of monitoring the crash involvement of large commercial vehicles)

- NCDMV should take the lead in efforts directed to the collection of all commercial motor vehicle data elements on the NCDMV-349 crash report form (in particular, trailer length, trailer width, and vehicle class)

Joint NCDOT, NCSHP, and State Legislature (focus on the legislative basis for fines and penalties and the means by which those funds are used to support transportation system-specific needs)

- The NCDOT in conjunction with the NC State Legislature and its appropriate committees needs to re-visit the fine and penalty structure for off-route violations. The current $100-plus fine for off-route operations is not a sufficient deterrent. Consideration should be given to basing the amount of the fine on the pavement and bridge conditions encountered off-route, the distance traveled off-route, and whether the travel represents a deliberate effort to bypass a weigh station or other enforcement check points.

- Based on the rapidly deteriorating conditions of North Carolina's highest tier of roads, it is difficult to understand why penalties for overweight trucks and penalties from traffic violations are not directed back to maintaining, improving, and enforcing the laws on these thoroughfares (i.e. Weight/Size and Traffic Penalties should be directed to ROADS and not to SCHOOLS).

Technology Transfer and Implementation Plan

- The results of the present study should be communicated to NCSHP Motor Carrier Enforcement personnel at the individual troop level (both size and weight as well as MCSAP) with particular emphasis on those non-STAA routes identified in this report having the highest crash rates.

- The results of the present study should also be communicated to local and municipal law enforcement personnel, especially in those areas where motor carrier operations are not presently well served by STAA routes (Wayne County being a case in point).

- Statewide, but especially in those areas not well served as STAA routes, the NCDOT, NCSHP, and the NC Trucking Association should establish STAA awareness training for carriers and shippers. The training should be accompanied by the availability of 'tools' that can be used by carriers and shippers to readily identify legal routes to market.

- To the extent that violators are not restricted only to intrastate carriers, situation awareness training methods should also target interstate carriers who routinely transport goods and materials through North Carolina.

- STAA awareness in densely populated areas of the state (e.g., Charlotte-Mecklenburg, the Triad, and the Triangle) should be on the negative role of STAA dimensioned vehicles on congestion rather than safety, per se, in that such crashes, while usually not fatal, can result in significant travel delay to motorists and significant damage to infrastructure within the right-of-way.

- Special enforcement attention should be placed on heavily traveled non-STAA routes with bridges that are presently identified as 'structurally deficient' or 'functionally obsolete.'

- A dialogue should be established between the State and the Commercial Vehicle Safety Alliance (CVSA) on the permissibility of establishing the off-network and overweight operation of a carrier who voluntarily travels over clearly posted low weight bridges as an out-of-service (OOS) violation.

- The NCDOT should supplement current MCE size and weight enforcement efforts to develop a 'vulnerability index' with specific emphasis on the factors of traffic volume, pavement condition, and bridge status on non-STAA routes.

- The current STAA graphic 'aids' prepared by NCDOT should be augmented to show the three mile buffer and those non-STAA routes identified as high non-STAA crash routes.

- The present study should be made available on the ITRE commercial vehicle safety and security website.

- A joint task force should be established with membership from the NCDOT, the NCSHP, the NC Trucking Association, as well as voluntary public/industry participation to identify the requirements for an expanded STAA network in North Carolina.

- STAA planning efforts undertaken by NCDOT should make use of available data resources at the federal level (e.g., FHWA Freight Management and Operations work done within the context of the Freight Analysis Framework (FAF)) as well as NCDOT sponsored research addressing the development of a regional truck 'model' for the state of North Carolina.

- The NCDOT should accelerate efforts to establish reliable statewide methods for obtaining truck counts, by vehicle class, and where possible by commodity type. These data are essential to the development and long-term maintenance of a 'model' of commercial vehicle operations in North Carolina.

- The NCDOT should review its current policies and procedures for expedited approval of new STAA routes.

- The North Carolina legislature should conduct a careful review of overweight fines, penalties, and exemptions toward the objective of establishing monetary fines and penalties capable of exerting control over the behaviors they are intended to affect (i.e., the voluntary transport of overweight loads, the voluntary use of STAA-dimensioned vehicles off the network).

- The NCSHP Motor Carrier Enforcement administration should initiate a dialog with other state size and weight enforcement agencies, FMCSA, CVSA, and FHWA on the merit and feasibility of establishing fines for joint off-route and overweight operations whose dollar value is a function of the extent/duration (miles) of non-STAA and overweight activity as well as the vulnerability of the infrastructure encountered by that activity.

- Non-STAA routes routinely used by operators of STAA dimensioned vehicles to bypass official weigh stations should receive additional, targeted enforcement emphasis.

- The present results should be integrated into the findings and recommendations of the NCDOT Weigh Station Feasibility Study and the current NCSHP-funded study on the establishment and operation of virtual weigh stations.

- The NC Division of Motor Vehicles and its Crash Records Office should increase training efforts to increase the reliability and accuracy of trailer length data entered on the DMV-349 crash report form. The trailer length data element should be identified as a ‘required’ element for coding and ‘edits’ created that would not allow a crash report to be entered into the system without an entry into this data field.

- Inasmuch as the 53ft trailer is rapidly becoming the ‘industry standard,’ the NCDOT should work with other state DOTs (e.g., through AASHTO working committees) to establish realistic and meaningful infrastructure design guidelines to more effectively permit the operation of 53ft trailers.

- Electronic job performance aids (e.g., pocket PCs, PDAs, in-vehicle mobile data terminals/computers used by enforcement) with GPS and digital map capabilities should be developed as a means for enforcement personnel to readily determine if a STAA-dimensioned vehicles is, in fact, off route. When found to be so, the device should prompt the officer as to the appropriate general statute to cite and should provide accurate information on the citation as to the location of the event.

Appendix A

N.C. BOARD OF TRANSPORTATION
RULES FOR ACCESS ROUTES FOR STAA DIMENSIONED VEHICLES

The North Carolina Administrative Code, 19A:02E.0426, is amended to read:

19A NCAC Subchapter 2E, Section .0426 ACCESS ROUTES FOR STAA DIMENSIONED VEHICLES

The following definitions and procedures apply to this Rule:

(1) <u>DEFINITIONS:</u>

(a) STAA (Surface Transportation Assistance Act) Dimensioned Vehicles are described as follows:

(i) A "twin-trailer truck" is a vehicle combination consisting of a truck-tractor and two trailing units, 102 inches wide, as authorized by G.S. 20-115.1.

(ii) A "48-foot Semi-trailer truck" is a vehicle combination consisting of a truck-tractor and one trailer 48 feet in length, 102 inches wide, as authorized by G.S. 20-115.1.

(iii) A "53-foot Semi-Trailer truck" is a vehicle combination consisting of a truck-tractor and one trailer 53 feet in length, 102 inches wide, and a "kingpin" axle distance of 41 feet, as authorized by G.S. 20-115.1 and G.S. 20-116.

(b) The National Truck Network is a network of highway routes within the State consisting of the Interstate and certain Federal-aid Primary highways designated for STAA dimensioned vehicle use by the U.S. Secretary of Transportation, and other highway routes that have been designated for this type vehicle use by the North Carolina Department of Transportation under the authority of G.S. 20-115.1(g).

(c) "Terminal" means any location where:

(i) Freight either originates, terminates, or is handled in the transportation process, or

(ii) Commercial motor carriers maintain operating facilities.

(d) "Reasonable Access" – The term "reasonable access" means provision for STAA dimensioned vehicles access to terminals and services from the National Truck Network, as follows:

(i) Terminals Located Within Three Road Miles from the National Truck Network:

(A) Reasonable access shall be deemed to be the use of the most reasonable, practical route(s) available for access to terminals, and services for gas, food, lodging and repairs.

(B) An access route(s) may only be denied by the Department of Transportation based on specific safety reasons on individual routes.

(ii) Terminals Located Beyond Three Road Miles of the National Truck Network:

(A) Reasonable access shall be deemed to be the use of only those routes specifically authorized by the Department of Transportation, or provided for in this Rule, for access to terminals.

(B) Authorization by the Department of Transportation shall consist of an application review and approval process for these access routes, as provided in this Rule.

(e) “Vehicle Template” is drawing of a twin trailer which tracks the radius of turns to determine design necessary to accommodate vehicle.

(f) “STAA” means Surface Transportation Assistance Act of 1982 and is the enabling federal legislation which allows twin trailers to travel on interstate highways and other approved routes.

(2) <u>REASONABLE ACCESS PROCEDURES:</u>

(a) STAA dimensioned vehicles are allowed “reasonable access” between terminals and the National Truck Network only in accordance with this Section.

(b) For access to terminals and service facilities located within three road miles of the National Network no filing or authorization by the Department of Transportation is required.

(c) For access to terminals located beyond three road miles from the National Truck Network the following procedures apply:

(i) Access routes approved prior to June 1, 1991 for any one particular type of STAA dimensioned vehicle are approved for all STAA dimensioned vehicles for access purposes only.

(ii) Terminal officials and truck operators shall submit an application for a proposed new access route(s) to the State Traffic Engineer of the Department of Transportation for approval. The application shall be on a form provided by the State Traffic Engineer. The submittal shall also include a map, or photocopy of a portion of a map, showing the proposed access route(s) or changes to an existing approved access route(s) and the terminal location.

(iii) The State Traffic Engineer may seek advice from the State Highway Patrol, the Division of Motor Vehicles, or other law enforcement officials concerning the application.

(iv) Public notice of all applications for “reasonable access” pursuant to this Paragraph (2)(c) shall be published by the Department of Transportation in a newspaper regularly circulated in the affected area of the State. The notice shall be published at least once a week on the same day of the week for two consecutive weeks. In addition, governing bodies of incorporated municipalities will be notified by the Department of Transportation of all applications within their jurisdictions.

(v) Access Route Review and Evaluation:

(A) The review and evaluation process of access routes will utilize the application of vehicle templates where suitable roadway plans or photographs are available for the requested route(s). Where such plans or photographs are not available and the use of vehicle templates is not practical, the State Traffic Engineer shall require the terminal official or truck operator requesting the access route(s) to furnish an appropriate STAA dimensioned test vehicle and driver for the purpose of observing the test vehicle traverse the requested access route(s).

(B) Since traffic safety is the overriding concern, the following safety factors shall also be taken into consideration in reviewing and evaluating a requested access route(s):

(I) traffic congestion,
(II) traffic volumes,
(III) route length,
(IV) vehicle mix,
(V) geometric design of the highway,
(VI) intersection geometrics,
(VII) width of the shoulders,
(VIII) width of the pavement,
(IX) superelevation of the pavement,
(X) pavement condition,
(XI) at-grade railroad crossings,
(XII) stopping sight distance,
(XIII) percentage passing sight distance,
(XIV) speed limits,
(XV) vertical and horizontal alignment,
(XVI) ability of other vehicles to pass trucks,
(XVII) widths of bridges,
(XVIII) previous accident experience, and
(XIX) location of schools.

This does not preclude consideration of other relevant safety factors, not included in paragraph (2)(v)(B)(I) through (XIX).

(vi) A route(s) used for the purpose of connecting two National Truck Network routes is considered a "short-cut" route(s) and is not authorized by this Rule. Such a route(s) may be considered for designation as an addition to the National Truck Network by the Department of Transportation under G.S. 20-115.1(g).

(vii) The State Traffic Engineer shall have a period of 90 days from receipt of any fully completed application pursuant to Sub-item (2)(c)(ii) of this Rule to approve or reject the applied for route(s) based on safety considerations and the review and evaluation process outlined in Sub-item (2)(c)(v) of this Rule. Terminal official and truck operators requesting an access route(s) and appropriate law enforcement officials shall be notified of any approval or rejection and the reasons. Automatic approval of a requested access route(s) is provided if such notification is not received within the 90 day period.

(d) The Department of Transportation shall notify appropriate State and local law enforcement officers of an approved "reasonable access" route(s) that serves each terminal within the jurisdiction of the enforcement agency. The State Traffic Engineer shall also make available to terminal officials and commercial motor vehicle operators information regarding reasonable access to and from the National Truck Network.

(e) The Department of Transportation may, at any time subsequent to approval, revoke any routes as a “reasonable access” route(s) based upon safety considerations. Terminal officials, truck operators, and appropriate law enforcement officials shall be notified in writing 30 days prior to any revocation.

(f) Any STAA dimensioned vehicle traveling an access route(s) shall have on board an appropriate cargo manifest.

(g) Approval of an access route(s) for one particular type STAA dimensioned vehicle shall constitute approval for all STAA dimensioned vehicles for access purposes only.

(h) Appeal – A terminal official, truck operator, or an appropriate law enforcement official may appeal the rulings concerning an access route(s) made by the State Traffic Engineer to the Secretary of Transportation. In giving notice of appeal, the documentation to support reasons for believing that the determination of that State Traffic Engineer was erroneous shall be provided. The decision of the Secretary of Transportation shall be the final agency decision.

History Note: Authority G.S. 20-115.1; 136-18, 143B-350;
Board of Transportation Minutes for November 18, 1988;
Eff. November 1, 1991;
Amended Eff. November 1993.

http://www.ncdot.org/doh/preconstruct/traffic/safety/reports/TSI/STAA_Rules.pdf

Appendix B

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

MICHAEL F. EASLEY
GOVERNOR

1501 MAIL SERVICE CENTER, RALEIGH, N.C. 27699-1501

LYNDO TIPPETT
SECRETARY

February 7, 2008

The Honorable Roy Cooper
Attorney General
North Carolina Department of Justice
P. O. Box 629
Raleigh, North Carolina 27602

Dear Mr. Cooper:

Pursuant to G.S. 20-116, 53 foot semitrailers may not be operated on North Carolina streets and highways, "except as provided by G.S. 20-115.1."

General Statute 20-115.1 (b) provides, in pertinent part, that motor vehicle combinations consisting of a truck tractor and 53 foot semitrailer may operate on the interstate highways <u>and the federal-aid primary system highways designated by the U.S. Secretary of Transportation.</u> Subsection (f) provides further, that motor vehicle combinations operating pursuant to G.S. 20-115.1 shall have reasonable access between highways on the interstate system and other qualifying federal-aid-highways, as designated by the United States Secretary of Transportation, and terminals, facilities for food, fuel, repairs, etc.

Although the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) abolished the classification of federal-aid primary system, 23 CFR 658.5 defines Federal-aid Primary System as the Federal-aid Highway System of rural arterials and their extensions into or through urban areas in existence on June 1, 1991. Additionally, 23 CFR 658.5 defines the term "National Network" as: "The composite of the individual network of highways from each State on which vehicles authorized by the provisions of the STAA are allowed to operate. The network in each State includes the Interstate System, exclusive of those portions excepted under Sec. 658.11(f) or deleted under Sec. 658.11(d), and those portions of the Federal-aid Primary System in existence on June 1, 1991, set out by the FHWA in appendix A to this part." Appendix A sets out a detailed list of individual routes that comprised the Federal-aid Primary System as it existed on June 1, 1991.

PHONE 919-733-2520 FAX 919-733-9150

The North Carolina Department of Transportation prints and distributes maps, entitled "North Carolina National Truck Network for STAA Vehicles." These maps designate, by use of red lines, those routes upon which 53 foot semitrailers are authorized. The authorized "red line" routes on the maps correspond directly with those routes as are set out in Appendix A to 23 CFR 658.23.

Pursuant to G.S. 20-115.1(h) and (i), owners and drivers of vehicles with a semitrailer 50 feet or more who violated subsection (b) are subject to a $200.00 fine. The Highway Patrol has been issuing citations for these violations and vehicle owners and drivers have asserted that the red line maps published and distributed by the Department of Transportation and enforced by the Highway Patrol misconstrue the language of G.S. 20-115.1(b). In effect, they argue that although so-called twin trailers may only be authorized on the "red line" routes, 53 foot trailers may lawfully be operated on any of the routes annotated on the map.

In light of the ongoing disagreement related to interpretation of state law and the potential for economic impact, the Departments of Transportation and Crime Control and Public Safety are requesting an opinion of the Attorney General as to the correct interpretation of G.S. 20-115.1(b) generally and, specifically, whether 53 foot semitrailers should be restricted to those routes as are set out in Appendix A to 23 CFR 658.23 unless otherwise exempt pursuant to G.S. 20-115.1(g).

Sincerely,

Lyndo Tippett

Sincerely,

B. E. Beatty

Bryan Beatty

LT/BB/jr

cc: W. Fletcher Clay, Colonel State Highway Patrol

STATE OF NORTH CAROLINA
DEPARTMENT OF JUSTICE

ROY COOPER
ATTORNEY GENERAL

REPLY TO:
Ebony J. Pittman
Transportation Section

February 25, 2008

Honorable Lyndo Tippett, Secretary
North Carolina Department of Transportation
1501 Mail Service Center
Raleigh, NC 27699-1501

Honorable Brian E. Beatty, Secretary
North Carolina Department of Crime Control and Public Safety
4701 Mail Service Center
Raleigh, NC 27699-4701

Re: **Advisory Letter: Interpretation of N.C. Gen. Stat. § 20-115.1(b)**

Dear Secretary Tippett and Secretary Beatty:

In a letter dated February 7, 2008, you requested an advisory letter from the Attorney General's Office regarding N.C. Gen. Stat. § 20-115.1(b), specifically whether a semitrailer of not more than 53 feet should be restricted to those routes as are set out in Appendix A to 23 CFR 658 unless otherwise exempt pursuant to N.C. Gen. Stat. § 20-115.1(g). Please note that this letter has not been approved in accordance with the procedures for an advisory opinion of the Department of Justice.

By way of background, N.C. Gen. Stat. § 20-115.1, "Limitations on tandem trailers and semitrailers on certain North Carolina highways," has separate restrictions for what are commonly known as "twin trailers" from those vehicles known as "53 foot semitrailers."

N.C. Gen. Stat. § 20-115.1 provides, in pertinent part, as follows:

> (a) Motor vehicle combinations consisting of a truck tractor and two trailing units may be operated in North Carolina only on highways of the interstate system (except those exempted by the United States Secretary of Transportation pursuant to 49 USC 2311(i)) and on those **sections of the federal-aid primary system designated by the United States Secretary of Transportation**. No trailer or semitrailer operated in this combination shall exceed 28 feet in length; Provided, however, a 1982 or older year model trailer or semitrailer of up to 28 1/2 feet in length may operate in a combination permitted by this section for trailers or semitrailers which are 28 feet in length.

MAILING ADDRESS:
DEPARTMENT OF TRANSPORTATION
ATTORNEY GENERAL'S OFFICE
1505 MAIL SERVICE CENTER
RALEIGH, NC 27699-1505

TELEPHONE: 919-733-3316
FACSIMILE: 919-733-9329

LOCATION:
TRANSPORTATION BUILDING
1 SOUTH WILMINGTON STREET
RALEIGH, NC 27601

> (b) Motor vehicle combinations consisting of a semitrailer of not more than 53 feet in length and a truck tractor may be operated on the interstate highways (except those exempted by the United States Secretary of Transportation pursuant to 49 U.S.C. 2311(i)) and **federal-aid primary system highways designated by the United States Secretary of Transportation**. . . .

(Emphasis added)

With certain exceptions set forth in this statute, N.C. Gen. Stat. § 20-115.1 limits "twin trailers" to specially designated sections of the federal-aid primary system of highways. However, "53 foot semitrailers" are allowed on the entire federal-aid primary system of highways.

It appears that maps provided by the North Carolina Department of Transportation to law enforcement have generated questions concerning the proper application of subsections (a) and (b) of N.C. Gen. Stat. § 20-115.1. N.C. Gen. Stat. § 20-115.1 (a) sets forth the routes for "twin trailers" to include the National Network. The "North Carolina National Truck Network for STAA Vehicles" map currently used by the North Carolina Department of Transportation shows only those specially designated sections of the federal-aid primary system designated by the U.S. Secretary of Transportation as the National Network. Appendix A to 23 CFR 658 sets out a detailed list of individual routes that comprise the National Network. The Department has correctly used this map to show the more restrictive truck routes regulating "twin trailers" in North Carolina.

N.C. Gen. Stat. § 20-115.1 (b) allows motor vehicle combinations consisting of a truck tractor and 53 foot semitrailer to operate on the interstate highways and the federal-aid primary system highways designated by the U.S. Secretary of Transportation, provided certain measurements relating to axles or rear underride guards are met.

The Code of Federal Regulations defines "federal-aid primary system" as the Federal-aid Highway System of rural arterials and their extensions into or through urban areas in existence on June 1, 1991. 23 CFR 658.5. The 1991 Intermodal Surface Transportation Efficiency Act (ISTEA), abolished the federal-aid primary system. However, for the purpose of truck length, width and weight regulations, 23 CFR 658.5 continues to define the federal-aid primary system as that system which was in existence on June 1, 1991.

Based on a literal reading of N.C. Gen. Stat. § 20-115.1 (b) and 23 CFR 658.5, "53 foot semitrailers" are, therefore, allowed on Interstates and on the federal-aid primary system, as it existed on June 1, 1991. This interpretation expands the number of routes available to "53 foot semitrailers."

I am informed that the Department of Transportation has available a map showing the federal-aid primary system as it existed on June 1, 1991, and can provide it to law enforcement for the regulation of "53 foot semitrailers."

I trust this correspondence is responsive to your inquiry.

Very truly yours,

Ebony J. Pittman

Ebony J. Pittman
Assistant Attorney General

EJP/sp

[135956]