HIGHWAY FACTORS GROUP
CHAIRMAN'S FACTUAL REPORT

CHESTERFIELD TOWNSHIP
BURLINGTON COUNTY, NEW JERSEY

HWY-12-MH-007
(44 Pages)

NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF HIGHWAY SAFETY
WASHINGTON, D.C. 20594

HIGHWAY GROUP CHAIRMAN'S FACTUAL REPORT

A: ACCIDENT

Type:	School Bus, Roll-Off Truck Intersection Related Accident
Date and Time:	February 16, 2012 8:15 AM. EDT
Location:	Bordentown-Chesterfield Rd (Burlington County Route 528) and Old York, Rd (Burlington County Route 660) Chesterfield Township, Burlington County, New Jersey
Vehicle #1:	2012 International 54-Passenger School Bus
Motor Carrier #1:	Garden State Transport Inc
Vehicle #2:	2004 Mack Granite Roll Off Truck
Motor Carrier #2:	Herman's Trucking, Inc
Fatalities:	01
Injuries:	18
NTSB #:	**HWY-12-MH-007**

B: HIGHWAY FACTORS GROUP

David S. Rayburn
NTSB – Group Chairman

Michael J. Nei
Principal Engineer, Traffic
Office of the County Engineer
Mount Holly, NJ. 08060-6000

Martin C. Livingston
Traffic Engineer
Office of the County Engineer

Sergeant Richard Brunett#5127
New Jersey State Police
West Trenton, NJ. 08628

Kyle Wilson
Chief of Police
Chesterfield Township
Chesterfield, New Jersey 08620

Michael Davison
Sergeant
Chesterfield Township Police Department

C: ACCIDENT SUMMARY

See docket item #1 for accident narrative. See Collision Diagram below

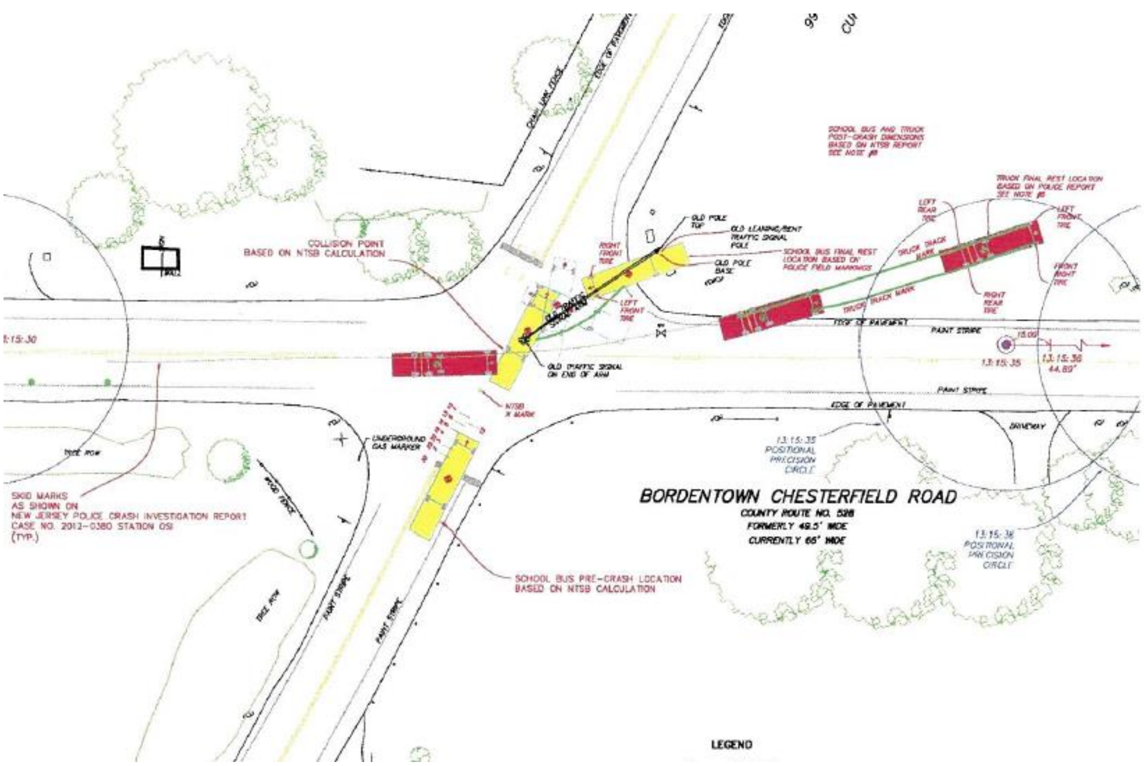


Figure 1

A pdf version of the scene diagram, collision diagram and land sight line surveys are in the docket as items 4,5, and 6, which can be expanded in viewing size to show greater detail.

508 Description – This diagram depicts the Mack/Rolloff truck as a red rectangle traveling from the viewer's left to right. The school bus displayed as a yellow rectangle is traveling from the bottom of the drawing toward the top. They collide in the intersection with the front of the truck coming into contact with the left rear side of the bus.

D: DETAILS OF THE INVESTIGATION

Prefatory data was obtained that included construction history, average daily traffic, speed surveys, vehicle classification data, traffic accidents, and fatal accidents.

Highway data was obtained that included the functional classification, highway design, posted speed limit, and 85th percentile speed[1]. Other highway data obtained included highway markings, design speed, horizontal and vertical geometry of the county roads and at the intersection. Documented stop line placement. Detailed information will be provided about the sight distance available at the intersection, and Manual for Uniform Traffic Control Devices (MUTCD) warrants on traffic signal installation. Additionally, information about the visibility study conducted will be presented along with skid testing data, acceleration data, and accident reconstruction information.

Next, descriptions of the scene information will be provided. Finally information about connected vehicle technology and data about accidents nationwide at stop and yield controlled intersections will be presented as an attachment data report from the NTSB Research and Engineering Division.

E: Prefatory Data

Burlington County Route 660 was originally part of the King's Highway system dating back to the 1730's. The modern day construction of the intersection was in the 1930's. Records indicated that Rt. 528 existed prior to 1849; it was initially surveyed in 1806. Rt. 528 was resurfaced last in September 2005 and Rt. 660 was resurfaced last in August 2010. Both roadways are functionally classified as collectors.[2] The intersection is the boundary between urban and rural designations.

During resurfacing additional drainage was provided and both roadways were striped to provide 11-foot-wide travel lanes and 3-foot-wide shoulders. In July 2008 construction and installation was completed on the flashing intersection control beacon (flashing yellow and red lights). The yellow flashing beacon controls traffic on the major

[1]The 85th percentile speed is the speed at which 85% of the vehicle traffic is traveling either at or below that speed or, 15% of the vehicle traffic is traveling above that speed.

[2] Collectors are functionally classified as a design type of roadway. Collectors serve a dual function in accommodating the shorter trips and feeding traffic to arterials or more major roadway networks. Thus an intermediate design speed and level of service are appropriate. Section 1.3.5, "A policy on Geometric Design of Streets and Highways 2011 Edition, PP1-12

road Rt. 528 and the flashing red light controls traffic on the minor road Rt. 660 Each roadway has a single lane in each direction. The northbound and southbound approaches to the intersection on Rt. 660, and the eastbound approach to the intersection on Rt. 528 are marked with double yellow pavement stripes designating them as no passing zones. The westbound approach on Rt.528 has a single solid yellow pavement mark prohibiting passing in the westbound direction and a spaced yellow pavement stripe allowing passing in the eastbound direction after the intersection. The collision occurred on Rt. 528 at milepost 2.93 or Station number 121+50.[3] All of the travel lanes were delineated from the shoulders by solid white pavement stripes. The intersection is classified as a plain four legged intersection without dedicated turning lanes.

F: TRAFFIC METRICS

The Average Daily Traffic (ADT) on Rt. 528 at milepost 4 was approximately 6000 vehicles per day in 2004, and on the minor road Rt. 660, it was approximately 1,200 vehicles per day. The commercial vehicle ADT was 27 percent at that time but is viewed as inaccurate because a nearby construction project was underway when the study was performed. County Traffic engineers estimate that the truck and bus ADT is about 5 percent of the total on both routes. The most recent speed study was performed on Rt. 528 2/1/2006. At that time the posted speed limit was 50 mph. The speed study was conducted about 550 feet from the intersection near residences #95-97. The 85th percentile speed for cars was 55 mph and 54 mph for trucks. The average speed for cars was 48 mph and for trucks it was 49 mph. There was not a speed survey available for the minor road or Rt. 660. The posted speed limit on Rt. 528 was lowered to 45 mph by Burlington County in October 2006 in order to meet expected land use changes caused by a nearby development of 1200 proposed homes and a 60,000 square-foot retail facility near the accident location. The speed limit on Rt. 660 was 45 mph. At the time of the accident, 700 homes have been constructed in the development but construction of the planned retail facility had not yet begun. Traffic was estimated in 2006 to increase approximately 2% per year.

The Burlington County Engineer's office estimated that at the completion of the development, plans for a roundabout or a signalized intersection with left turn lanes for all quadrants would be developed. However, at this time any improvements of safety at the intersection would not include a traffic signal because the intersection does not meet any of the warrants in the MUTCD for the installation of a traffic signal. A current ADT count and speed study was performed two weeks after the accident. The current ADT on County Route 528 was 4,558 vehicles per day, and the 85th percentile speed was 48 mph. The traffic count and survey on Rt. 660 showed that the ADT was 1,521 vehicles per day and the 85th percentile speed was 53 mph. The traffic flow was compared to the current charts in the MUTCD to determine if it satisfied the warrant for a traffic signal. The traffic flow alone or in combination with the accident history did not satisfy the warrants for a traffic signal as prescribed in the MUTCD.

[3] Station numbers are official measurements found on highway design plans.

G: ACCIDENT HISTORY

In the five-year-period from 1/1/2007 through 12/31/2011, 15 accidents occurred at the intersection of Rt. 528 at Rt. 660. An additional car deer accident occurred east of the intersection for a total of 16 accidents. There were no other fatal accidents during this five years and only one serious injury accident that occurred in 2007. The remainder of the accidents involved only complaints of pain or property damage only. See chart below

2011 – No accidents occurred
2010 – 4 accidents occurred
2009 – 7 accidents occurred
2008 – 4 accidents occurred
2007 – 1 accident occurred

During this period, three right angle accidents occurred that involved vehicles which were traveling east and north, similar to the school bus and roll off truck. One of these accidents involved a snow-covered roadway where a vehicle slid past the stop sign control into the intersection.

Five right angle accidents occurred on the other side of the intersection and involved south and westbound vehicles. There were six other right-angle impacts at other quadrants of the intersection. In all there was one opposite direction accident, one deer accident and14 right-angle intersection accidents.

H: HIGHWAY GEOMETRY

The approaches to the accident intersection are essentially level. The minor road (Rt.660) intersects Rt. 528 at an acute angle of approximately 63 degrees, which can have an effect on sight distance[4]. Essentially acute angle intersections such as this one require a longer path to travel across the minor road and require a correspondingly greater sight distance. The driver's view to the left for northbound traffic on Rt. 660 at Rt. 528 is limited by the trunks and canopies of white pine trees, and there are two wooden utility poles that can restrict a driver's view.[5] This foliage limits the line of sight at the stop line to approximately 195 feet if a driver is stopped such that his front bumper is touching the painted stop line and the viewing distance is eight feet farther back. The trees are located to the right of Rt. 528 East, approximately 23 feet from the travel lane. The 4-8-inch diameter pines are spaced at 10-11-foot intervals. The canopies extend outward approximately 13 feet from the trunks. The trunks are estimated to be 1-2 feet from the

[4] Figure 9-22 and Section 9.5.4 in the 2011 AASHTO Policy on Geometric Designs of Highways and Streets provides a calculation procedure to modify the calculation procedure and sight distance table 9-5 and Figure 9-17.
[5] Title 16 New Jersey Department of Transportation Chapter 25 Utility Accomodation, section 16:25-5.4 states that utility poles shall be located as close to the right-of-way line as practical, preferably five feet from the right-of-way line.

public right-of-way and the canopies encroach over the right-of-way. Nearby residents indicated that the previous owner of the property planted the trees approximately 10 years ago.

(See Design Sight Distance Section for more details)

I. MUTCD GUIDANCE/ EXCERPTS& RELATED STATUTES

The 2009 Manual for Uniform Traffic Control Devices which is the current version, was evaluated to show the prescribed standards and guidance applicable to flashing intersection control beacons and placement of stop signs and stop lines. Also definitions in the MUTCD were cited below: Note: Standards appear in bold text while guidance and options appear in non-bold text. Also conditions found with respect to standards and guidance appears in italic text

Standard – "A statement of required, mandatory, or specifically prohibitive practice regarding a traffic control device. All standard statements are labeled, and the text appears in bold type. The verb "shall" is typically used. The verbs "should" and "may" are not used in standard statements. Standard statements are sometimes modified by Options. Standard statements shall not be modified or compromised based on engineering judgment or an engineering study".

Guidance – "A statement of recommended, but not mandatory, practice in typical situations, with deviations allowed if engineering judgment or an engineering study indicates the deviation to be appropriate. All guidance statements are labeled, and the text appears in unbold type. The verb "should" is typically used. The verbs "shall" and "may" are not used in Guidance statements. Guidance statements are sometimes modified by Options."

Option – "A statement of practice that is a permissive condition and carries no requirement or recommendation. Option statements sometimes contain allowable modifications to a Standard or Guidance statement. All option statements are labeled, and the text appears in unbold type. The verb "may" is typically used. The verbs "shall" and "should" are not used in Option statements".

Support – "An informational statement that does not convey any degree of mandate, recommendation, authorization, prohibition, or enforceable condition. Support statements are labeled, and text appears in unbold type. The verbs "shall" "should" and "may" are not used in support statements.

Beacon – "A highway traffic signal with one or more signal sections that operates in a flashing mode.

Intersection Control Beacon – "A beacon used only at an intersection to control two or more directions of travel.

Traffic Control Signal – "Any highway traffic signal by which traffic is alternately directed to stop and permitted to proceed."

Warrant: "A warrant describes a threshold condition based upon average or normal conditions that, if found to be satisfied as part of an engineering study, shall result in analysis of other traffic conditions or factors to determine whether a traffic control device or other improvement is justified. Warrants are not a substitute for engineering judgment. The fact that a warrant for a particular traffic control device is met is not conclusive justification for the installation of the device."

Stop Line – "A solid white pavement marking extending across approach lanes to indicate the point at which a stop is intended or required to be made."

Section 4D.04 Meaning of Vehicular Signal Indications

"**Standard" – The following meanings shall be given to highway traffic signal indications for vehicles and pedestrians":**

Flashing yellow signal indications shall have the following meanings:

1. **Vehicular traffic, on an approach to an intersection, facing a flashing CIRCULAR YELLOW signal indication is permitted to cautiously enter the intersection to proceed straight through or turn right or left or to make a U-turn except as such movement is modified by lane-use signs, turn prohibition signs, lane markings, roadway design, separate turn signal indications, or other traffic control devices.**

   Such vehicular traffic, including vehicles turning right or left or making a U-turn, shall yield the right-of-way to:

   (a) Pedestrians lawfully within an associated crosswalk, and
   (b) Other vehicles lawfully within the intersection

   "In addition, vehicular traffic turning left or making a u-turn to the left shall yield the right-of-way to other vehicles approaching from the opposite direction so closely as to constitute an immediate hazard during the time such turning vehicle is moving across or within the intersection."

Flashing red signal indications have the following meanings:

Vehicular traffic, on an approach to an intersection, facing a flashing CIRCULAR RED signal indication shall stop at a clearly marked stop line; but if there is no stop line, before entering the crosswalk on the near side of the intersection; or if there is no crosswalk, at the point nearest the intersecting roadway where the driver has a view of approaching traffic on the intersecting roadway before entering the intersection. The right to proceed shall be subject to the rules applicable after making a stop at a stop sign.

Section 3B.16 <u>Stop and Yield Lines</u>

Guidance

08 – Stop lines should be 12-24 inches wide

10 – If used, stop and yield lines should be placed a minimum of 4 feet in advance of the nearest crosswalk line at controlled intersections, except yield lines at roundabouts as provided in section 3C.04 and at midblock crosswalks. In the absence of a marked crosswalk , the stop line or yield line should be placed at the desired stopping or yielding point, but should not be placed more than 30 feet or less than 4 feet from the nearest edge of the intersecting traveled way."

Note: On Burlington County Rt. 660 north the stop line was placed 29.75 feet from the fog-line edge of RT 528 East and 21 feet from the prolongation of the curb or pavement lines. It was 24 inches wide.

Section 2C.59 <u>CROSS TRAFFIC DOES NOT STOP PLAQUE (W4-4P)</u>

Option:

01 - "The CROSS TRAFFIC DOES NOT STOP (W4-P4) plaque may be used in combination with a STOP sign when engineering judgment indicates that conditions are present that are causing or could cause drivers to misinterpret the intersection as an all stop way."

04 – **Standard – "If a W4-P4 or plaque with an alternative message is used, it shall be mounted below the STOP sign.**

Note: The stop sign on Burlington County Route 660 North did not have a CROSS TRAFFIC DOES NOT STOP Plaque. Although not typically used in New Jersey, as part of intersection improvements, the plaque was added after the accident, and a larger stop sign was added.

Section 4C.01 <u>Studies and Factors for Justifying Traffic Control Signals</u>

Standard: 01 **"An engineering study of traffic conditions, pedestrian characteristics, and physical characteristics of the location shall be performed to determine whether installation of a traffic control signal is justified at a particular location."**

02 "**The investigation of the need for a traffic control signal shall include an analysis of factors related to the existing operation and safety at the study location and the potential to improve these conditions, and the applicable factors contained in the following traffic signal warrants:"**

Warrant 1, Eight-Hour Vehicular Volume
Warrant 2, Four-Hour Vehicular Volume
Warrant 3, Peak Hour
Warrant 4, Pedestrian Volume
Warrant 5, School Crossing
Warrant 6, Coordinated Signal System
Warrant 7, Crash Experience
Warrant 8, Roadway Network
Warrant 9, Intersection Near a Grade Crossing

03 **The satisfaction of a traffic signal warrant or warrants shall not in itself require the installation of a traffic control signal.**
05– "A traffic signal should not be installed unless one or more of the factors in this chapter are met."
06– "A traffic signal should not be installed unless an engineering study indicates that installing a traffic signal will improve the overall safety and/or operation of the intersection."

Note: The only warrants that could be applied to this intersection were warrants 1, 2, and 7. (See MUTCD Excerpts Below)

"Section 4C.02 <u>Warrant 1, Eight Hour Vehicular Volume"</u>

"Support:

01 - The Minimum Vehicular Volume, Condition A. is intended for application at locations where a large volume of intersecting traffic is the principal reason to consider installing a traffic control signal.

02 - The Interruption of Continuous Traffic, Condition B, is intended for application at locations where Condition A is not satisfied and where the traffic volume on a major street is so heavy that traffic on a minor intersecting street suffers excessive delay or conflict in entering or crossing the major street.

03 - It is intended that Warrant 1 be treated as a single warrant. If Condition A is satisfied, then Warrant 1 is satisfied and analyses of Condition B and the combination of Condition A and B are not needed. Similarly, if Condition B is satisfied, then Warrant 1 is satisfied and an analysis of the combination of Conditions A and B is not needed."

"Standard:

04 **The need for a traffic control signal shall be considered if an engineering study finds that one of the following conditions exist for each of any 8 hours of an average day:**

A. The vehicles per hour given in both of the 100 percent columns of Condition A in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection; or

B.

The vehicles per hour given in both of the 100 percent columns of Condition B in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection.

In applying each condition the major-street and minor-street volumes shall be for the same 8 hours. On the minor street, the higher volume shall not be on the same approach during each of these 8 hours."

"Option:

05 - If the posted or statutory speed limit or the 85th percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of not less than 10,000, the traffic volumes in the 70 percent columns in Table 4C-1 may be used in place of the 100 percent columns.

Guidance:

06 - The combinations of Conditions A and B is intended for application at locations where Condition A is not satisfied and Condition B is not satisfied and should be applied only after an adequate trial of other alternatives that could cause less delay and inconvenience to traffic has failed to solve the traffic problems."

"Standard:

07 - The need for a traffic control signal shall be considered if a traffic engineering study finds that both of the following conditions exist for each of any 8 hours of an average day:

A. The vehicles per hour given in both of the 80 percent columns of Condition A in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection; and

B. The vehicle per hour given in both of the 80 percent columns of Condition B in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively to the intersection.

These major-street and minor-street volumes shall be for the same 8 hours for each condition; however, the 8 hours satisfied in Condition A shall not be required to be the same 8 hours satisfied in condition B. On the minor street, the higher volume shall not be required to be on the same approach during each of the 8 hours."

Table 4C-1. Warrant 1, Eight-Hour Vehicular Volume

Condition A—Minimum Vehicular Volume

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	500	400	350	280	150	120	105	84
2 or more	1	600	480	420	336	150	120	105	84
2 or more	2 or more	600	480	420	336	200	160	140	112
1	2 or more	500	400	350	280	200	160	140	112

Condition B—Interruption of Continuous Traffic

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	750	600	525	420	75	60	53	42
2 or more	1	900	720	630	504	75	60	53	42
2 or more	2 or more	900	720	630	504	100	80	70	56
1	2 or more	750	600	525	420	100	80	70	56

[a] Basic minimum hourly volume
[b] Used for combination of Conditions A and B after adequate trial of other remedial measures
[c] May be used when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000
[d] May be used for combination of Conditions A and B after adequate trial of other remedial measures when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000

Figure 2

508 Compliance Description: Figure 2 shows the amount of traffic needed to satisfy the warrant for a traffic signal; with one lane on each approach for the major and minor road it shows that for each hour for 8 hours the traffic has to be 500 vehicles per hour on the major road and 150 vehicles per hour on the minor road. Or in condition B with 750 vehicles per hour on the major road and 75 vehicles per hour on the minor road.

Conditions Found – The volume of traffic on the major and minor road did not satify the amounts depicted in the charts for each of the 8 hours reqiured during a 12 hour-long survey.

Option:

08 - If the posted or statutory speed limit or the 85^{th} percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of not less than 10,000, the traffic volumes in the 56 percent columns in Table 4C-1 may be used in place of the 80 percent columns.

Section 4C.03 Warrant 2, Four-Hour Vehicular Volume

Support:

01 - The Four-Hour Vehicular Volume signal warrant conditions are intended to be applied where the volume of intersecting traffic is the principal reason to consider installing a traffic control signal.

Standard:

02 - The need for a traffic control signal shall be considered if an engineering study finds that, for each of any 4 hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) all fall above the applicable curve in Figure 4C-1 for the existing combination of approach lanes. On the minor street, the higher volume shall not be required to be on the same approach during each of these 4 hours.

Option:

03 - If the posted or statutory speed limit or the 85^{th} percentile speed 0n the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of not less than 10,000, Figure 4C-2 may be used in place of Figure 4C-1.

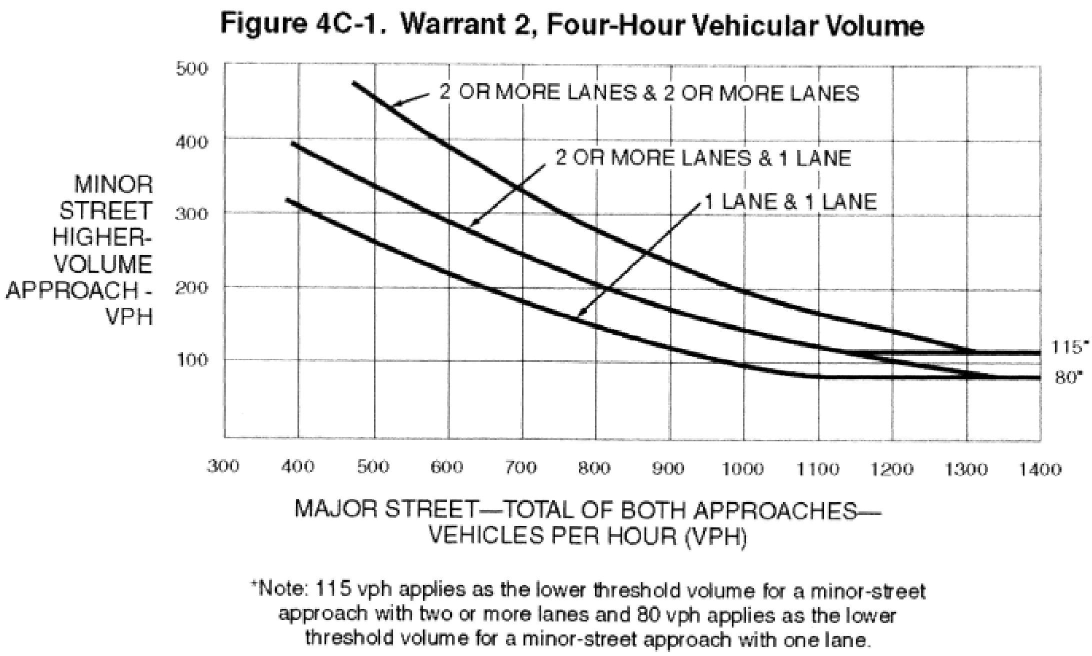


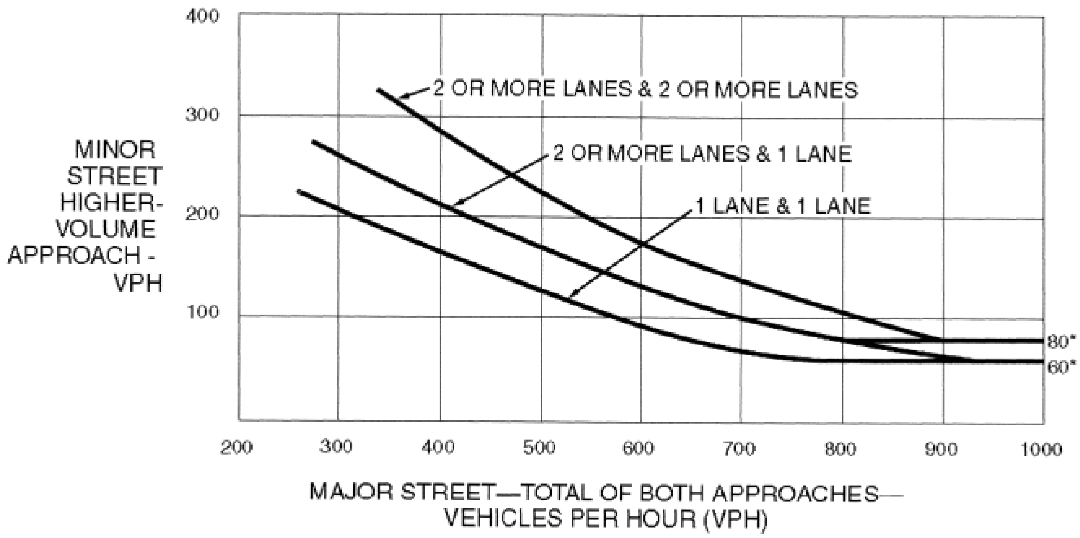
Figure 3

508 Compliance Description: Figure 3 shows a plotted curve for warrant 2 depicting the minimum number of vehicle required in each lane per hour on the minor and major roads for each of 4 hours. In this warrant over 300 vehicles per hour on the minor road and 400 vehicles per hour on the major road are needed to satisfy the warrant in the upper left plot of the curve. Moving down to the lower plot of the curve if 1400 vehicle per hour are on the major road then 80 vehicles per hour are needed on the minor road approach to satisfy the warrant.

Conditions Found – The number of vehicles in both the major and minor road approaches did not exceed the volume specified in the chart.

Figure 4C-2. Warrant 2, Four-Hour Vehicular Volume (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)



*Note: 80 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 60 vph applies as the lower threshold volume for a minor-street approach with one lane.

Figure 4
508 Compliance Description: Figure 4 shows a similar curve plot but the vehicles perhour are reduced to a 70% factor

<u>Conditions Found – </u>The volume did not exceed the curve plotted in the chart.

Section 4C.08 <u>Warrant 7, Crash Experience</u>

Support:

01 - The Crash Experience signal warrant conditions are intended for application where the severity and frequency of crashes are the principal reason to consider installing a traffic control signal.

Standard:

02 - The need for a traffic control signal shall be considered if an engineering study finds that all of the following criteria are met:

A. Adequate trial of alternatives with satisfactory observance and enforcement has failed to reduce the crash frequency; and

B. Five or more reported crashes, of type susceptible to correction by a traffic signal, have occurred within a 12-month period, each crash involving personal injury or property damage apparently exceeding the applicable requirements for a reportable crash; and

C. For each of any 8 hours of an average day, the vehicles per hour (vph) given in both of the 80 percent columns of Condition A in Table 4C-1, or the vph in both of the 80 percent columns of Condition B in Table 4C-1exists on the major-street and the higher-volume minor-street approach, respectively, to the intersection, or the volume of pedestrian traffic is not less than 80 percent of the requirements specified in the Pedestrian Volume warrant. The major-street and minor-street volumes shall be for the same 8 hours. On the minor street, the higher volume shall not be required to be on the same approach during each of the 8 hours.

Option:

03 - If the posted or statutory speed limit or the 85th percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of not less than 10,000, the traffic volumes in the 56 percent columns in Table 4C-1 may be used in place of the 80 percent columns.

Conditions Found – The number of crashes had not exceeded the threshold and the volume of traffic had not exceeded the curved plot in the chart.

New Jersey Traffic Regulation 39:4-144, Stopping or Yielding Right-of-Way

No driver of a vehicle or street car shall enter upon or cross an intersecting street marked with a “stop” sign unless he has first brought his vehicle or street car to a complete stop at a point within 5 feet of the nearest crosswalk or stop line marked upon the pavement at the near side of the intersecting street and shall proceed only after yielding the right of way to all traffic on the intersecting street which is so close as to constitute an immediate hazard.

Uniform Vehicle Code Section 11-403 Stop and Yield Signs

“The Uniform Vehicle Code (UVC) is a specimen set of motor vehicle laws, designed and advanced as a comprehensive guide or standard for state motor vehicle or traffic laws. It is not based on theory; it is based on actual experience under various state laws throughout the nation. It reflects the need for uniformity in traffic regulation throughout the United States, and to this end, serves as a reliable contemporary guide for use by state legislatures. The UVC was published in 1926 and is updated as needed by the custodian, the National Committee on Uniform Traffic Laws and Ordinances."

"Certain portions of the code set forth the rules of the road-the things that people shall and shall not do as they drive or walk. If the public is to understand, remember and observe these rules in moving from state to state, they should be exactly the same, word for word, in every state. Such uniformity also makes easier the task of police officers, judges, traffic engineers, motor vehicle administrators, and educators. The language of the code has been tested by long experience and there is no need for deviation."

11-403 – Stop signs and Yield signs

(a) Preferential right of way may be indicated by stop signs or yield signs as authorized in section 15-10 of the UVC.

(b) Except when directed to proceed by a police officer, every driver of a vehicle approaching a stop sign shall stop at a clearly marked stop line, but if none, before entering the crosswalk on the near side of the intersection, or if none, then at the point nearest the intersecting roadway where the driver has a view of approaching traffic on the intersecting roadway before entering it. After having stopped, the driver shall yield the right of way to any vehicle in the intersection or approaching on another roadway so closely as to constitute an immediate hazard during the time such driver is moving across or within the intersection or junction of roadways. Such driver shall yield the right of way to pedestrians within an adjacent crosswalk.

J: POST ACCIDENT TRAFFIC STUDIES

The Burlington County Engineer's office completed a signal warrant evaluation within one month after the accident and the traffic analysis and accident history analysis showed that the intersection characteristics did not satisfy any of the warrants for the installation of a traffic signal. Additionally, the installation of a signal would cause concerns about an increased number of rear-end collisions on Rt. 528, and would create congestion and inefficient movement of traffic on Rt. 528. (See attachment 3 for details on signal warrant study)

K: AT GRADE INTERSECTION SIGHT DISTANCE AND MAINTENANCE

The Federal Highway Administration (FHWA) has designated the following 13 specific design elements as controlling or required criteria for roadway design:[6]

1. Design speed
2. Lane width
3. Shoulder width

[6] http://www.fhwa.dot.gov/design/0625sup.cfm

4. Bridge width
5. Structural capacity
6. Horizontal alignment
7. Vertical alignment
8. Grade
9. Stopping Sight distance
10. Cross slope
11. Superelevation
12. Vertical Clearance
13. Horizontal Clearance

Intersection sight distance is not a controlling criteria for design but is a recommended guideline.

Federally funded highway construction and reconstruction projects must either meet established design criteria for these elements or a formal design exception must be prepared and approved. The New Jersey Highway Design Manual lists these same Controlling Design Elements (CDE's) for state highways in New Jersey, but some of the values are different. The geometric design of streets and highways not on the State Highway System should conform to the standards in the current AASHTO – A Policy on the Geometric Design of Highways and Streets.

Design values and criteria published by the American Association of State Highway and Transportation Officials (AASHTO) will be utilized to evaluate some of the design geometry and circumstances of this accident. However, it must be recognized that the design of this intersection predates the existence of the first, "Policy on Intersections at Grade", published in 1940 by AASHTO's predecessor, AASHO, The American Association of State Highway Officials. This AASHO policy would have been one of the reference documents applicable to geometric roadway design slightly after this intersection was surveyed with its presently skewed alignment in 1938. The 2011 AASHTO publication, "A Policy on the Geometric Design of Streets and Highways", known as the "Green Book", is adopted by reference in the Federal Register by the FHWA and is an authoritative policy manual on geometric design features. The fact that existing streets and highways do not satisfy current AASHTO design values does not mandate the initiation of improvement projects nor does it imply that these roads are unsafe. The intent of AASHTO policy is to provide guidance to the designer of new projects.

Chapter 9 of (AASHTO's), 2011 "A Policy on Geometric Design of Highways and Streets" publication, was examined for excerpts on the recommended design sight distance to provide at this intersection. The sight distance required by the truck driver on the major road was controlled only by stopping sight distance since he was provided preferential right-of-way by the flashing intersection control beacon. The recommended stopping sight distance was to be 360 feet.[7] Referring to the NTSB Sight Distance Evaluation (Measurement A), at sight triangles 1, 2, and 3, the truck had a clear view of

[7] See AASHTO, 2011 Policy on Geometric Design of Highways and Streets Table 3-1 page 3-4.

the bus at 287 feet, 345 feet, and 489 feet from the intersection respectively. If the school bus was stopped between sight triangles 2 and 3, it would be stopped within five feet of the stop (NJSA 39:4-144) giving the approaching truck adequate stopping sight distance.

Although stopping sight distance was the required design control at the intersection there are also recommended design values for departure sight distance. The New Jersey DOT Roadway Design Manual was examined: and like FHWA New Jersey does not require departure sight distance as a design control feature on local roads. However, NJDOT does recommend values for departure sight distance which reflect the AASHTO values. See NTSB Figure 5 which is figure 6A in the NJDOT Design Manual

SIGHT DISTANCE AT INTERSECTIONS FOR LEFT, OR RIGHT TURNING & CROSSING VEHICLES WITH STOP CONTROL	FIGURE: 6–A BDC07MR–05

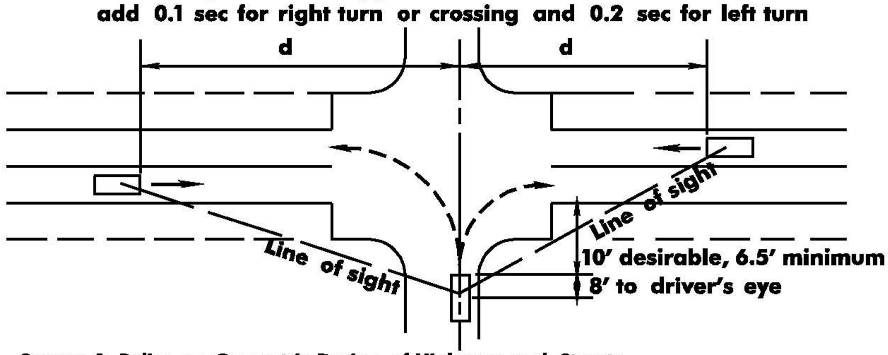
Intersection Sight Distance(d) Stop Control on Minor Road
Two Lane Highway

Design Speed	Left–Turn			Right–Turn or Cross		
	P	SU	WB	P	SU	WB
25	280	350	425	240	315	385
30	335	420	510	290	375	465
35	390	490	595	335	440	540
40	445	560	680	385	500	620
45	500	630	760	430	565	695
50	555	700	845	480	625	775
55	610	770	930	530	690	850
60	665	840	1015	575	750	930
65	720	910	1100	625	815	1005
70	775	980	1185	670	875	1085

For highways with more than 2 lanes or when approach grade on minor road exceeds 3%, the distance (d) must be calculated using the formula: $d = 1.47Vt_g$

Design Vehicle	Time Gap, t_g Left–Turn	Time Gap, t_g Right–Turn & Cross
P	7.5 (See Notes)	6.5 (See Notes)
SU	9.5 (See Notes)	8.5 (See Notes)
WB	11.5 (See Notes)	10.5 (See Notes)

Notes:
1. For left turn or crossing add 0.5 sec. for P and 0.7 sec. for SU & WB for each additional lane crossed.
2. For each percent the upgrade on minor road exceeds 3%, add 0.1 sec for right turn or crossing and 0.2 sec for left turn



Source: A Policy on Geometric Design of Highways and Streets.

Figure 5

508 Compliance Description: Figure 5 lists three design vehicles P= passenger vehicle, SU= single unit ruck,

and WB= truck and trailer. For each design vehicle the figure has a corresponding recommended time gap and departure sight distance for each speed limit. For instance, it shows that if a vehicle is stopped at an intersection such that the driver's viewing position is 18 feet back from the intersecting street then he should be able to see traffic approaching from 630 feet away if the speed limit is 45 mph.

<u>Chart Explanation</u>

According to the chart a single unit truck (similar to the school bus in design dimensions) should be provided 565 feet of departure sight distance when the speed limit is 45 mph and the truck is a performing a crossing maneuver. For a left turn the design departure sight distance is 630 feet. This design chart presumes the vehicle is stopped on the minor road 10 feet back from the major road. Generally, if a designer chooses to provide the recommended sight distance for a left turn maneuver then there is adequate departure sight distance for a crossing maneuver. This is true unless the roadway has six or more lanes or if the departure path crossing maneuver is on an uphill grade.

Departure sight distance provides sufficient sight distance for a stopped driver on a minor road approach to depart from the intersection and enter or cross the major road. In this case departure sight distance will be estimated for the school bus which was on the minor road attempting to cross Burlington County Route 528 East.

The text indicates that a time gap of 9.5 seconds should be used for a single unit truck, which is the design vehicle applied to the school bus in this case. Using that time gap and the 45 mph speed limit it can be seen in NJDOT figure 6A that approximately 630 feet of sight distance is needed for a left turn maneuver. The actual stop line where a required stop would initially have to be made was 29.75 feet from the edge line of Rt. 528 and 21 feet from the pavement edge. At that position the recommended design sight distance was not available. (See visibility testing for more details) However, at the 18-foot decision point in the New Jersey Design manual the recommended departure sight distance was available.

When the effect of skew angle is calculated, the increased path distance must exceed 12 feet before the time gap formula is increased from 9.5 seconds to 10.2 seconds. The calculation showed that modification of the gap time was not necessary. Skew angle refers to the degree which an intersection varies from 90 degrees which is the alignment recommended by AASHTO.

The Burlington County Engineer's office indicated the rationale for placing the stop line further back from the intersection was to provide the needed turning radius for larger vehicles. See figures 6 and 7 below which depict the turning radius needed by larger design vehicles which used the area. If the painted stop line was placed closer to the intersection stopped traffic could be clipped by turning trucks which frequented the area, such as, horse trailers from a horse farm approximately one mile away.

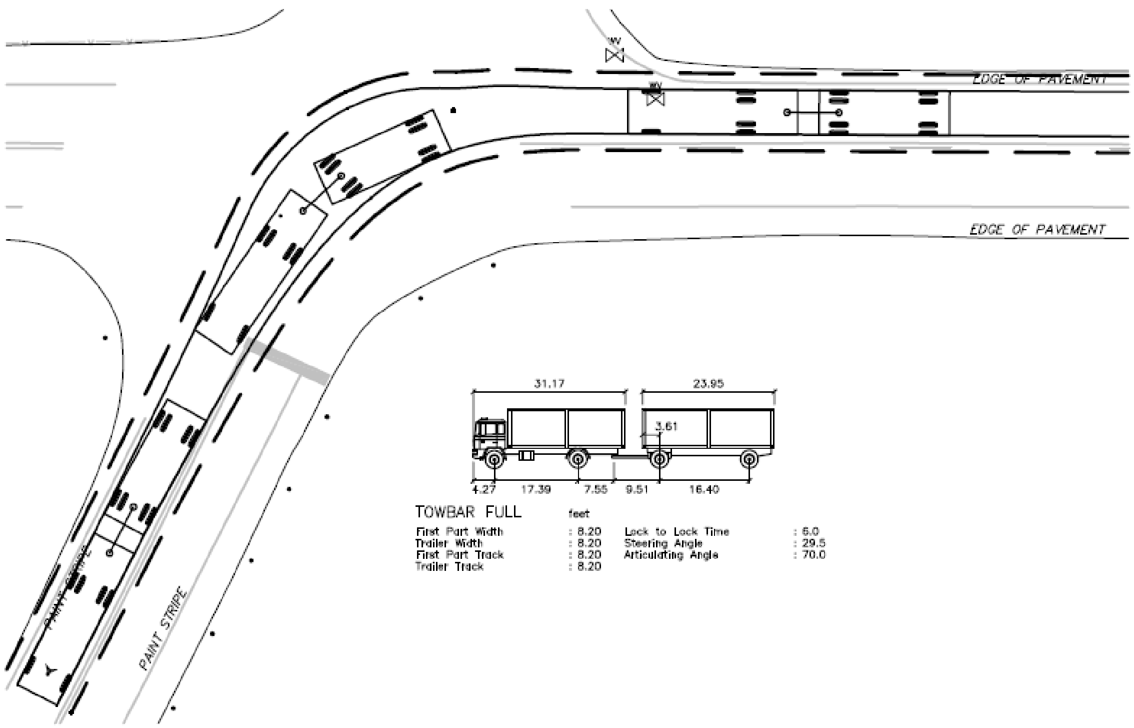


Figure 6

508 Description

This figure shows a truck and trailer turning left from westbound CR 528onto southbound CR 660 with the stop line placed in its present location where turning trucks would not clip stopped traffic.

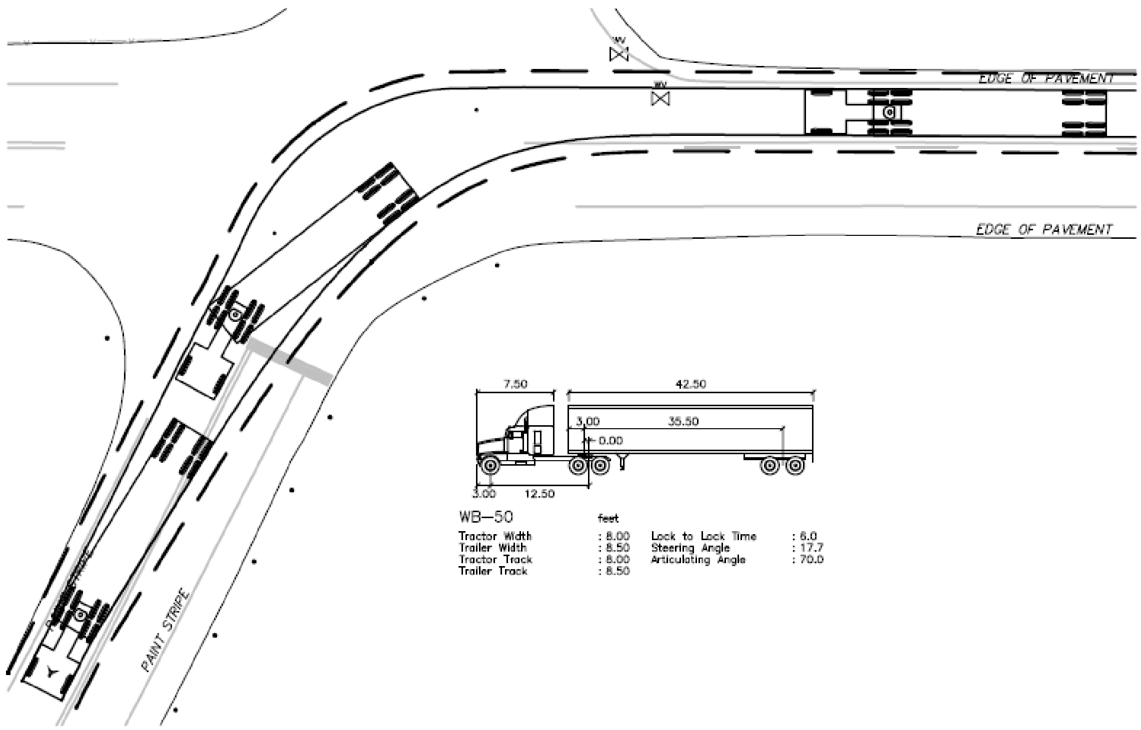


Figure 7

508 Description – *This figure shows a turning tractor semi-trailer and the radius needed to make the turn without clipping traffic at the stop line which is positioned on the schematic as it was painted at the scene.*

L: <u>General Powers of Municipalities in New Jersey</u>

"Code 40:48-2.26 Brush and hedges near roadways and intersections, cutting of", provides the following, "The governing body of every municipality shall have power to make, enforce, amend and repeal ordinances requiring the owner or tenant of lands lying within the limits of such municipality to keep all brush, hedges, and other plant life, growing within ten feet of any roadway and within 25 feet of the intersection of two roadways, cut to a height of not more than two and a half feet where it shall be necessary and expedient for the preservation of public safety , within ten days after notice to cut the same, and to provide for the cutting of the same by or under the direction of some officer of the municipality, to be designated in said ordinance, in cases where the owner or tenant shall have refused or neglected to cut the same in the manner and in the time provided above and to provide for the imposition of penalties for the violation of any such ordinance." L.1949,c.152,p.535 1, eff. May 19, 1949.

In keeping with this enabling act, Chesterfield Township had a municipal code that imposed duties and responsibilities on property owners to prevent the growth of hedges and shrubs onto the public right of way.[8] In section 152.6 (B) of the code it prescribed some duties with respect to tree growth but was less specific.[9]

In 2011, New Jersey passed a State Statute[10] requiring municipalities to obtain a sight triangle easement for all proposed intersections in residential developments.[11] The easement must establish sight triangle easements in accordance with AASHTO intersection sight distance guidelines. Additionally, the statutes limit skewed intersection design to 75 degrees instead of the 60- degree limit design guideline by AASHTO.

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[8] Code of Township of Chesterfield New Jersey, V12 updated 01-01-11/Part II General Legislation/Chapter 152 Property Maintenance/152.6 Duties and Responsibilities of Owner or Operator

D – Landscaping. Lawns hedges, and bushes shall be kept trimmed and maintained so as to keep from becoming overgrown. Specifically, lawns shall be trimmed and maintained at a height no greater than 6 inches. Hedges and bushes shall be trimmed and maintained such that they do not extend over public sidewalks, streets, or other rights-of-way.

[9] (2) Natural Growth. Dead and dying trees and limbs or other natural growth, including but not limited to brush, wood, weeds, ragweed, stunps, roots and all plant growth which are noxious, dangerous, or detrimental to human health and safety or which impede Township fire and other rescue vehicles from accessing private property for emergencies, which by reason of rotting or deteriorating conditions or storm damage, constitute a haxard to persons in the vicinity therof. Trees shall be kept pruned trimmed, and maintained in an orderly state to prevent such conditions, including all situations in which such conditions would constitute blighting and/or having negative asthetic or other impact upon adjoining or nearby property and/or impede access to private property by Township public safety and fire rescue vehicles. Open areas shall be graded evenly to eliminate holes, depressions gullies, mounds, accumulations or debris or other unsightly or unsafe conditions.

[10] N.J.A.C. 5:21 (2011)

[11] Section 5:21-4.19 Street grade, intersection, pavement and lighting construction standards (b) the [11] N.J.A.C. 5:21 (2011)
following shall apply to intersections:

1. Street intersections shall be as nearly at right angles as possible and in no case shall be less than 75 degrees.

6. Sight triangles shall be in accordance with AASHTO's "A Policy on Geometric Design of Highways and Streets" standards and based on the speed limit established by government agency having jurisdiction. Sight triangle easement shall be required and shall include the area on each street corner that is bounded bythe line which connects the sight or connecting points located on each of the right-of-way lines of the intersecting street. The planting of trees or other plantings, or the location of structures exceeding 30 inches in height that would obstruct the clear sight across the area of easements, shall be prohibited, and public right-of-entry shall be reserved for the purpose of removing any object, material or otherwise, that obstructs clear sight.

M: ROADSIDE DESIGN GUIDELINES AND POLICY

The AASHTO Roadside Design Guide (RDG) recommends a clear zone distance of 20-22 feet on relatively flat foreslopes where the speed limit is 45-50 mph and the ADT exceeds 6000 vehicles per day. The clear zone is 16-18 feet for ADT 1500-6000 (see AASHTO Chart below) The ADT on CR 528 was 1500-6000 vehicles.

DESIGN SPEED	DESIGN ADT	FORESLOPES			BACKSLOPES*		
		6:1 or Flatter	5:1 to 4:1	3:1	3:1	5:1 to 4:1	6:1 or Flatter
40 mph or less	Under 750	7-10	7-10	**	7-10	7-10	7-10
	750-1500	10-12	12-14	**	10-12	10-12	10-12
	1500-6000	12-14	14-16	**	12-14	12-14	12-14
	Over 6000	14-16	16-18	**	14-16	14-16	14-16
45-50 mph	Under 750	10-12	12-14	**	8-10	8-10	10-12
	750-1500	14-16	16-20	**	10-12	12-14	14-16
	1500-6000	16-18	20-26	**	12-14	14-16	16-18
	Over 6000	20-22	24-28	**	14-16	18-20	20-22
55 mph	Under 750	12-14	14-18	**	8-10	10-12	10-12
	750-1500	16-18	20-24	**	10-12	14-16	16-18
	1500-6000	20-22	24-30	**	14-16	16-18	20-22
	Over 6000	22-24	26-32*	**	16-18	20-22	22-24
60 mph	Under 750	16-18	20-24	**	10-12	12-14	14-16
	750-1500	20-24	26-32*	**	12-14	16-18	20-22
	1500-6000	26-30	32-40*	**	14-18	18-22	24-26
	Over 6000	30-32*	36-44*	**	20-22	24-26	26-28
65-70 mph	Under 750	18-20	20-26	**	10-12	14-16	14-16
	750-1500	24-26	28-36*	**	12-16	18-20	20-22
	1500-6000	28-32*	34-42*	**	16-20	22-24	26-28
	Over 6000	30-34*	38-46*	**	22-24	26-30	28-30

Source: AASHTO Roadside Design Guide, Chapter 3.

TABLE A-2-1

NTSB Figure 8

508 Compliance Description: Figure six Lists design speeds ranging from 40-70 mph along with corresponding amounts of traffic listed as Average Daily Traffic or (ADT) The next columns are roadside slopes of foreslopes and backslopes. For instance, the clear zone for County Road 528 is determined by following down in the chart to 45-50 mph, then over to 1500-6000 ADT. Looking down the slope heading to 6:1 or flatter shows the clear zone to be 16-18 feet.

Chapter 4 of the 2006 RDG has specific clear zone recommendations for traffic signal poles. Essentially, traffic signal poles are not recommended for consideration of shielding by a barrier if they are located in the clear zone unless the speed limit is 50 mph or greater. The pole at this location is located at 22 feet from the travel lane of Rt. 528 West, and is not located in the clear zone. New Jersey has another detail requirement sheet specifying the pole should be placed at least five feet from the center radius point on the road edge. This pole was located at 10 feet from the pavement radius edge.

N: SCENE DOCUMENTATION

The following weights, dimensions and angles were measured at the accident scene and follow-up investigation:

Truck Weight with driver: 85,114 pounds
Truck center of gravity pre-crash travel distance along tire friction marks: 100 feet
Truck center of gravity travel distance post crash along tire marks: 189.2 feet
Truck center of gravity travel distance post crash on pavement: 111.66 feet
Truck center of gravity travel distance post crash off pavement: 77.54 feet
Truck approach angle to impact: 0 degrees
Truck departure angle from impact 1-1.5 degrees

School bus weight with driver and passengers: 20,358 pounds
School bus estimated pre-crash travel distance from stop: 54 feet
Estimated travel time from acceleration tests: 4.9 seconds
Approach angle to impact 60.98 degrees measured counterclockwise from 0 degrees
School bus center of gravity travel distance post crash: 43.99 feet
School bus center of gravity departure angle 17.64 degrees

Friction data: Sliding friction on pavement .747 – Source NJDOT Dry skid test 40 mph
Sliding friction on field – estimated from impact simulation and Army research (See RE Report)
Peak friction on Pavement .957 g's @ 58 mph with antilock brakes in Ford Police car. (See Attachment 6 for raw acceleration data)

The truck was approximately 2.5 feet to the left of the centerline of the highway when it collided with the bus. The driver said he swerved to the left and braked hard enough to lock the tires prior to impact. See Chesterfield PD photos for details of scene tire mark evidence.

O: TESTING AND RESEARCH (VISIBILITY TESTING)

About 9 am on Tuesday February 21, 2012, the NTSB along with Chesterfield TWP and Florence TWP Police, New Jersey State Police, and the Burlington County Traffic Engineer's office conducted visibility testing at the accident intersection. A 2012 International 54-passenger school bus and a 2011 Mack 4-axle dump truck were used to establish sight lines at various distances. Sight Triangles were measured for the northbound approach of Old York Road (CR 660) at various increments from the edge line of the eastbound travel lane in accordance with AASHTO and MUTCD standards for a single unit truck which is the design vehicle length most closely related to a school bus.[12] (See Below for exemplar Vehicle and driver details)

Exemplar School bus – 2012 IHC VIN# 4DRBUAAP0CB395235
Driver: Owner GST
Exemplar Truck – 2011 Mack VIN# 1M2AX07C0BM0097
Employee of Hermann Trucking

For the purposes of this discussion a driver's sight line is the distance he can see from his seated position across the terrain to the other vehicle positioned on the roadway. The departure sight distance is the measurement on the roadway that the truck was from the intersection when the bus driver viewed it from various sight lines in the sight triangles that were established.

Sight triangles were measured for eastbound approach of Bordentown-Chesterfield Road (CR 528) for the Mack truck with roll off in accordance with AASHTO standards.

The eastbound CR 528 (Bordentown-Chesterfield Road) is classified as an Urban Collector while westbound is a Rural Collector. CR 660 (Old York Road) is also classified as a Collector Road. The centerline of CR 660 (Old York Road) is the boundary between Urban and Rural.

The evaluation was to establish a sight triangle of 630 feet for a single unit truck in accordance with Figure 6A in the New Jersey Highway Design Manual and equation 9-1 of the AASHTO Manual shown below:

(9-1) $\mathbf{ISD = 1.47V_{major}\, t_g = 628.43}$ **rounded to 630 feet**

ISD = Intersection Sight Distance
V_{major} = Design speed of the major road (mph)

[12] See Table 2-1a Design Vehicle Dimensions. Page 2-3, 2011 Edition AASHTO's "Policy on Geometric Design of Highways and Streets." Departure Sight Distance Charts in Chapter 9 only list passenger vehicles, single unit trucks, and truck tractor semi-trailers.

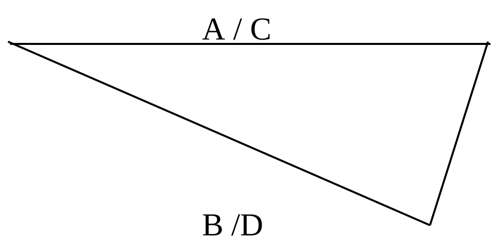
= 45mph posted speed limit

t_g = **Time gap for minor road vehicle to enter the major roadway**
=9.5 seconds for a Single Unit truck Table 9-5 on page 9-37

The starting point (location 1) for the first sight triangle was the existing stop line, measured 30 feet from the edge of the travel way. Location 2- 25 feet from the edge of the travel way meets the criteria established in Title 39:4-144 that states a vehicle shall stop within 5 feet of a stop line. Locations 3-6 were established at increments of 3 ft. The final exercise (location 7) was conducted at a point 10 feet from the edge of the travel way to establish the minimum AASHTO Sight Triangle. It should be noted that the exercise conducted at location 7 also meets the minimum requirements of the **2009 MUTCD (Section 3B.16)** for the placement of a stop line in relationship to the extended curb line or edge of pavement.

The drivers could see the distances at the triangles described below:

NJDOT Figure 6A Departure Sight Triangle



location 7 @ 10ft
location 6.5 @ 12 ft
location 6 @ 13 ft
location 5 @ 16 ft
location 4 @ 19 ft
location 3 @ 22 ft
location 2 @ 25 ft
location 1 @ 30 ft

Figure 9

A- Sight Distance from truck driver's view to the intersection of the edge line of the eastbound approach and the extended centerline of the northbound approach.

B- Clear Sight Triangle (Distance from the front bumper of the school bus to the front of the truck

C- Sight Distance from bus driver's point of view to the intersection of the edge line of the eastbound approach and the extended centerline of the northbound approach.

D- Clear Sight Triangle (Distance from the bus driver's eye to the front of the truck)

Test Results:

1 / 30 **2 / 25** **3 / 22** **4 / 19**

A	287.24ft	345.11ft	489.46ft	615.07ft
B	274.69ft	335.28ft	480.22ft	607.38ft
C	206.36ft	242.74ft	290.02ft	332.15ft
D	195.66ft	233.29ft	281.17ft	324.17ft

	5 / 16	**6 / 13***	**6.5 / 12***	**7 / 10***
A	686.34ft	743.66ft	810.00ft	814.76ft
B	680.69ft	738.42ft	805.18ft	811.17ft
C	463.13ft	626.79ft	686.19ft	782.69ft
D	459.78ft	620.86ft	680.27ft	787.27ft

- During exercises 6, 6.5 and 7 the driver had to turn approximately 110 degrees to view the truck.
- At location 7 the driver's eye was above the 18ft AASHTO Decision Point.
- See photographs 11-20 for details of sight lines

As can be seen from the tables above eight sight triangles were measured from points on BCR 660 beginning at the stop line and moving toward BCR 528. Each one of these measurements provides a dimension for angle B/D which is the sight line distance for the drivers across the terrain. Angles A/C represent a dimension on the pavement from the intersection to where the vehicle was located when the respective drivers could see each vehicle. For instance, at sight triangle #1 the school bus was positioned such that its' front bumper was lined up with the inside edge of the 24-inch-wide painted stop line which was located on BCR 660 30 feet from the intersection. At this location the exemplar truck driver could see the school bus when his truck was positioned 287 feet from the intersection and his straight sight line was 274 feet. However, the seated location of the exemplar school bus driver was 8 feet further back from the front bumper, therefore, the bus driver had a clear sight line dimension of 195 feet across the terrain. And the truck was 206 feet from the intersection when this viewing dimension was measured. In other words, at every sight triangle the truck driver can see the bus before the bus driver can see the truck because the bus driver's position is further back from the bumper.

If the school bus driver had stopped at sight triangle #2, it would be stopped within five feet of the white stop line[13] and made what is considered a legal stop. In fact, since the stop line is 24 inches wide he could have stopped 2 feet farther forward which

[13] New jersey Traffic Regulation 39:4-144, stopping or yielding right-of-way states, "No driver of a vehicle or street car shall enter upon or cross an intersecting street marked with a "stop" sign unless he has first brought his vehicle or street car to a complete stop at a point within five feet of the nearest cross walk or stop line marked upon the pavement at the near side of the intersecting street and shall proceed only after yielding the right-of-way to all traffic on the intersecting street which is so close as to constitute an immediate hazard."

would be between sight triangles #2 and #3. At sight triangle #2 the bus driver could see the truck when the truck was positioned 242 feet from the intersection, and his straight line sight distance across the terrain was 233 feet. Conversely, when the truck was 345 feet from the intersection at sight triangle #2, he could see the bus; his straight sight line across the terrain was 335 feet.

At sight triangle #5, which is the location that the exemplar school bus driver said he would stop at, the bus was positioned 14 feet forward of the stop line and 16 feet from the intersection. At this location the school bus had a straight sight line of 459 feet and the truck was 463 feet from the intersection. (See figure 14 for bus driver's view) At this sight triangle the truck driver had a straight sight line of 680 feet and he was positioned 686 feet from the intersection when he could see the bus.

At sight triangle #7 the school bus was 10 feet from the intersection and his eye position was eight feet further back for a total eye position of 18 feet from the intersection. This position is known as the AASHTO decision point and is considered by research[14] to be the most likely and desirable point that traffic will stop at a stop controlled intersection. It is also the position which the New Jersey DOT uses to calculate departure sight distance. (See New Jersey Highway Design Manual figure 6A)

P: TRAFFIC OBSERVATION STUDY

On February 23, 2012, NTSB investigators placed a Cannon EOS Rebel T3i camera at the intersection in an unobtrusive location and recorded traffic travelling north on CR 660 (Old York Road) as it reached the intersection of CR 528. On February 24, 2012, a second set of video was recorded using a Flip UltraHD video camera. Investigators reviewed the video and determined that 43 vehicles came to the stop sign. Of those vehicles, 39 came to a stop past the stop point as defined by the white stop bar painted on the roadway. This represents approximately 91% of the observed traffic. The observed traffic was comprised of all types of light vehicles, trucks, and one school bus.

A video study was performed again on August 31, 2012, to see if the improved sight distance altered driver's stopping behavior. It appeared not to have altered the stopping behavior of traffic. A dozen trucks and cars were observed. 11 of the 12 vehicles stopped nearly one car length past the white stop bar.

Q: Acceleration Testing of International School Bus

[14] National Cooperative Highway program Research Report 383, "Intersection Sight Distance", Transportation Research Board (TRB) Washington, D.C. 1996

On dry pavement at 2:00 PM on February 21, 2012, four (4) acceleration tests were performed using an International Navistar School Bus similar to the one involved in the accident on February 16, 2012.

The test was conducted over a distance of 54 feet from location 5, 16ft from the edge of the eastbound travel way. This was to the point where the rear tire of school bus was impacted by the Mack truck using the bus driver's statement to estimate the stopped location of the school bus. The following are the test results:

Test 1 - 5.51 seconds
Test 2 - 5.32 seconds
Test 3 – 5.01 seconds (late start on stop watch)
Test 4 – 5.32 seconds

The school bus attained a speed of approximately 14.9 mph during the test.
(See Attachment 6 for raw acceleration test data)

R: DECELRATION VALUES AND DISTANCES TRAVELED

Skid tests on Rt. 528 in the direction of the Roll-off truck's travel, performed with a 2011 model Ford Crown Victoria Patrol car at 56.6 mph showed that the test vehicle decelerated at .956 G's. The information was recorded with A VC 3000 accelerometer. Wet pavement skid tests were conducted by the NJDOT with a ASTM ribbed tire. The tests showed that the wet pavement friction on Rt. 528 was .43 g's. Three runs were made at six different locations over .17 miles for a total of 18 tests. They varied from a high average of .459 to a low average of .388 g's. Six dry pavement test skids were also run at the site with the ASTM ribbed test tire showing that the average coefficient of friction was .747 G's. Both wet and dry tests were run at 40 mph.

An acceleration test at the intersection showed that the exemplar school bus was able to achieve a .14 g acceleration level along the 54 foot distance from the stop bar to where the rear side was struck. (See Highway Attachment 6 for raw acceleration data)

S: <u>Improvements At Intersection After the Accident</u>

The Burlington County Engineer's office working with the NTSB reviewed the geometry and operation of the intersection following the accident. The following list summarizes the improvements made and future improvements in the design process:

1. Conducted a signal warrant analysis which concluded that a traffic signal installation was not warranted at that time.
2. Larger (36-inch Square) stop signs, with retroreflectorized posts were added on the Old York Road approaches
3. A "Cross Traffic does Not Stop" Plaques were added to the stop signs on the Old York

Road approaches.

4. 40 mph warning signs were added on Rt.528 East and West to the W2-1 (intersection warning) signs in advance of the intersection

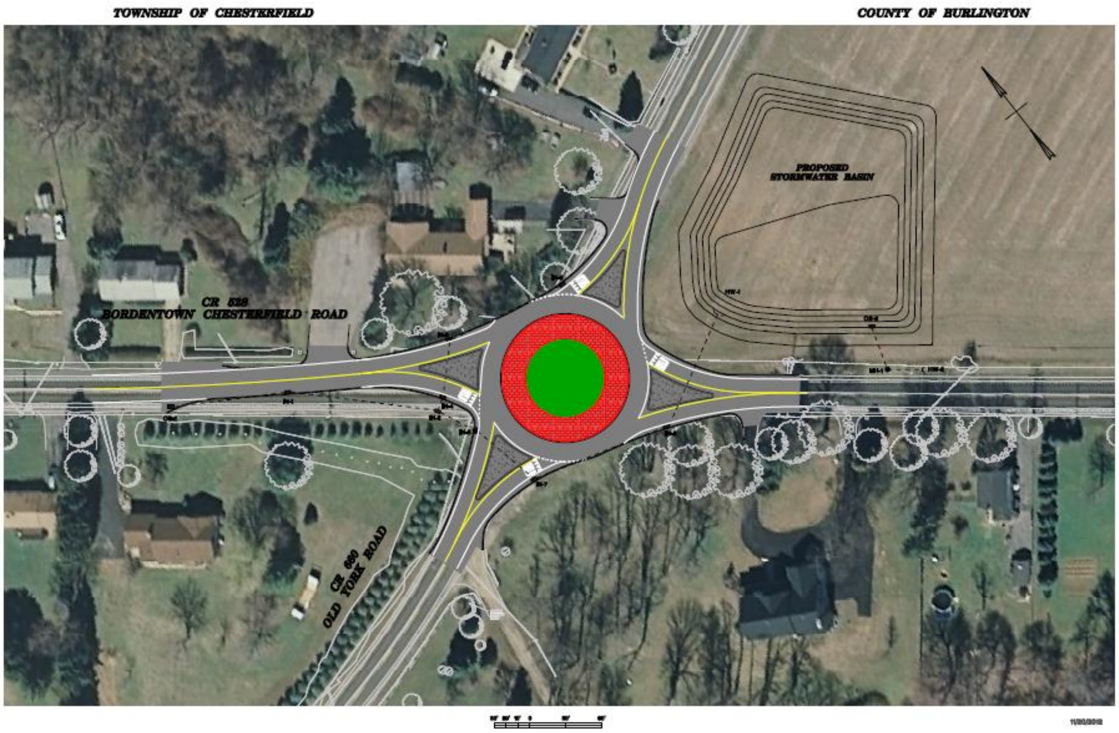
5. Fourteen trees were moved and replanted from the southwest quadrant of the intersection to improve the line of sight. Two trees were removed from the northwest quadrant of the intersection to improve the line of sight.

6. The Burlington County Engineer's Office has been in contact with the FHWA and NJDOT and preliminary studies to establish a Roundabout at the intersection are underway.

The Burlington County Engineer's Office has finalized concept plans to construct a modern roundabout at the intersection of County Route 528 (Bordentown-Chesterfield Rd.) & County Route 660 (Old York Rd.). The proposed roundabout will replace the existing skewed intersection alignment which is STOP controlled on the Old York Rd. approaches. The approach legs to the roundabout will be designed to include splitter islands to reduce the speeds of vehicles entering the intersection. Roadway lighting will be designed and installed at the roundabout to meet current NJDOT standards. Storm water management improvements will be designed and constructed in accordance with NJDEP regulations. A roundabout is a proven design alternative which will reduce vehicle speeds approaching the intersection and reduce conflicts between turning vehicles. A study conducted by the Insurance Institute for Highway Safety showed that roundabouts can reduce the number of crashes by up to 40% and fatal crashes by 90%.

The County has started the process to acquire the additional right-of-way needed to construct the roadway geometric and storm water management improvements. It is anticipated that construction work will be completed in 2014 and that the project will be funded with $1,000,000.00 of FHWA Roadway Safety Funds, $350,000.00 of NJDOT Discretionary Aid and $350,000.00 of County funds.

See Concept Drawing below:



508 – Description - This drawing depicts the reconfiguration of the intersection to a traffic circle.

T: <u>V2V Truck and Car Safety Program</u>

The Intelligent Transportation Systems Joint Program Office (ITS JPO) within the USDOT's Research and Innovative Technology Administration (RITA) in partnership with FHWA, FMCSA, NHTSA, and FTA conducts research to advance transportation safety, mobility, and environmental sustainability through electronic and information technology applications. Connected vehicle research is at the core of the USDOT's program. In 2014 NHTSA will use the research[15] results to make an agency decision on whether the technology is mature enough and provides adequate safety benefits to mandate in all heavy trucks, to encourage voluntary deployments, or to require additional research. A decision for light vehicles will be made in 2013.

Research performed in 2011-12[16] indicated a number of issues unique to commercial vehicles would have to be prioritized and solved so that all of the connected

[15] http://www.its.dot.gov/safety_pilot/index.htm Accessed on April 30, 2013
[16] Leblanc, David and Belowzowski, Bruce, "Interoperability Issues For Commercial Vehicle Safety Applications", University of Michigan Transportation Research Institute, DOT 811674, September 2012

vehicle safety applications could be implemented in heavy trucks. The executive summary of the research noted that very dew efforts regarding connected vehicle technology had focused on heavy trucks. First the group researched the literature and existing research related to the interoperability and performance of safety applications to commercial vehicles and proposed a list of 10 candidate issues which were thought to be significant and unique to commercial vehicles. Next, 16 respondents composed of subject matter experts in DSRC and commercial trucking were interviewed. Analysis of the responses indicated that at least 60 percent of the respondents thought six of the candidate issues to be potentially significant, and subsequent analysis resulted in 19 issues to be addressed along with a group of 16 recommendations for action that could help the connected vehicle program move forward in heavy trucks. The table of issues and recommendations is produced below:

<table>
<tr><th>Issue Category</th><th>Issue Priority Level</th><th>Issue</th><th>Potential Impact</th><th>Recomm. Priority Level</th><th colspan="2">Recommendation</th></tr>
<tr><td rowspan="2">SAE J2735 basic safety message</td><td>2</td><td>Articulated vehicles are not yet incorporated into the SAE J2735 basic safety message standard.</td><td>The occupied space and path for articulated vehicles cannot be accurately broadcast when turning.</td><td rowspan="2">2</td><td rowspan="2" colspan="2">Revise the SAE J2735 basic safety message to accommodate articulated and heavy vehicles.</td></tr>
<tr><td>3</td><td>The SAE J2735 scaling for vehicle weight does not allow for broadcasting the actual weight of medium and heavy commercial vehicles.</td><td>With an incorrect weight estimate, other vehicles may make inappropriate choices.</td></tr>
<tr><td rowspan="2">Trailer parameters</td><td>1</td><td>Trailer size parameters are not known by most power units, e.g., tractors in a semi-trailer configuration. While trailers are not unique to commercial vehicles, this is a critical issue for commercial vehicles.</td><td>Vehicles pulling trailers do not currently know length or weight. Safety application performance can be affected on both the host and remote vehicles.</td><td rowspan="2">1 (left),

1 (right)</td><td rowspan="2">Determine requirements for trailer parameter signals in the basic safety message. (Is weight really needed? How accurate must trailer length be?)</td><td rowspan="2">Investigate ways for a power unit to know trailer parameters, e.g., trailer electronics, power unit-based estimates, use of remote vehicle data, etc.</td></tr>
<tr><td>1</td><td>To broadcast trailer size parameters, there are choices about whether to equip trailers with hardware or to estimate trailer parameters using a tractor-only solution. Determining whether there is a best solution would likely enable faster resolution of this issue.</td><td>Ability of remote vehicles to know trailer length. Equipping trailers will meet resistance from the carrier industry, and estimating trailer parameters on the tractor would be difficult to do reliably. Thus an issue is to find a feasible way to obtain and broadcast the trailer length.</td></tr>
</table>

Issue Category	Issue Priority Level	Issue	Potential Impact	Recomm. Priority Level	Recommendation
DSRC blockage	1	Blockage of DSRC may occur when the line of sight between two DSRC antennas. is obstructed. Large vehicles can affect their own communications as well as that of neighboring vehicle pairs.	Safety application performance may degrade due to the latency of lost messages..	1 1	Estimate the impact on safety applications of the latencies that result from common blockage scenarios due to large vehicles. Facilitate tests to understand blockage conditions, multipath issues, ground null locations, and their influence on packet receipt. Involve radio suppliers with diverse antenna/receiver setups.
DSRC multipath	2	DSRC multipath effects occur due to the large surfaces of commercial vehicles reflecting the DSRC.	Safety application performance may degrade due to latency or nulls and/or may lead to more complicated receivers.		
DSRC ground nulls	2	Antenna height changes the location of ground reflection nulls.	Dead spot at a fixed range that depends on two antenna heights. Is this at a "critical" range?	1	Determine the location and the potential negative impact of ground nulls for high-mounted DSRC antennas.
DSRC dual-antenna	3	Secondary issue: If two or more antennas are on the same vehicle,. there may be implementation issues.	Two antennas broadcasting the same information simultaneously may create self-blocking nulls and unnecessarily flood the area with redundant DSRC waveforms.	n/a	No recommendations are provided for secondary contingency issues.
Scalability	3	Will large vehicles complicate the issues of scalability, i.e., operation in an active DSRC area?	Obstruction & multipath could worsen the problem of communication in DSRC-congested areas.	2	Include large vehicles as part of scalability testing.

Issue Category	Issue Priority Level	Issue	Potential Impact	Recomm. Priority Level	Recommendation
Relative positioning	2	Errors in relative position estimates between two vehicles can occur due to differences in GPS satellite sets being used by a tall vehicle and a smaller vehicle traveling adjacent to the tall vehicle.	Safety application performance degradation.	2	Test to measure the absolute and relative positioning errors for a small vehicle that is adjacent to a tall vehicle. (Is this distinct from the urban canyon problem?)
Aftermarket	3	Do enough vehicles have the SAE J1939 bus populated with basic safety message variables?	Would slow penetration of aftermarket devices.	>3	Industry might consider standardizing a data bus gateway or other means to provide aftermarket systems access to the minimum BSM set.
Aftermarket	2	The public standard SAE J1939 makes it easier for nefarious broadcasts onto the bus. The OBE would pass along this false information.	Could compromise system safety by allowing hackers to create undesirable behavior on the road.	1	Determine whether rogue message broadcasts onto J1939 pose a risk to other vehicles. (Unconfirmed issue.)
Certification	1	Need a functional test to describe what communication performance should be.	Will allow radio vendors to focus development. May help define the remote vehicles for use in application-level track tests.	2	Consider developing a functional specification and test procedure set that defines expectations for performance around commercial vehicles. If viable for suppliers to replicate, it could accelerate industry readiness.
Certification	2	Since DSRC performance may depend on the physical configuration of vehicles, aftermarket device certification begs the question of how (and who) certifies these devices.	It is possible that OEMs may not want responsibility for certifying aftermarkets, and aftermarket manufacturers may not have the resources to certify with all makes and models.	2	Consider the certification process for aftermarket safety devices, using insights from testing (which may answer how many vehicle configurations need to be tested to have confidence in proper DSRC performance)..

Issue Category	Issue Priority Level	Issue	Potential Impact	Recomm. Priority Level	Recommendation
Certification	3	Secondary issue: If transmission power is increased around large vehicles, then this attribute needs to be tested.	Certification and application-level testing may be necessary to explore modulating of transmission power.	n/a	No recommendations are provided for secondary contingency issues.
Application testing	2	Large vehicle effects on DSRC communication are not well documented. Will this uncertainty confound testing of safety application performance?	Real-world performance may be worse than the Application testing performance on a track.	3	Consider establishing standard large-vehicle antenna configurations for remote vehicles used in application-level testing.
Industry involvement	2	Not enough technical experts from the commercial vehicle industry are on standards committees.	Will miss opportunity for efficiency in research, or improved performance, if industry contributors are absent..	2	Consider ways in which to increase the number of commercial vehicle experts in the standards committees.
Industry involvement	1	Enthusiasm, understanding, and engagement of commercial vehicle industry in connected vehicles is not yet high.	Commercial vehicle issues may remain hidden, adding risk to deployment benefits and timing.	2	Continue outreach, particularly with fleets, possibly focusing on return-on-investment aspects of DSRC equipment.
Volunteered issues	2	Overpowered CB radios are common in class 8 freight vehicles. Can this affect DSRC communication?	Unknown potential for affecting the DSRC reception onboard these vehicles.	2	Test DSRC performance with nearby overpowered CB radio antennas.

Many of the priority problem areas involved how to integrate information about semi-trailers of various sizes and weights. Researchers are trying to determine if the data could be uploaded into the tractor or whether a separate sensor is needed for semi-trailers. Other priority issues involved certification procedures of after-market devices, and how to position DSRC antennae on truck tractors so they are not masked by trailing units.

This section of the report will describe connected vehicle technology, safety applications under development, technical descriptions of systems under development, the ongoing research to implement those systems, the role of the USDOT in initiating rulemaking to require these systems, and finally the scope of the intersection accident problem that would lend itself to improvement by the requirement of these systems through rulemaking.

Connected vehicle technology has the potential to improve safety by allowing cars, trucks and buses to talk to each other using a wireless network. Drivers will be unaware of the systems only when they emit a safety warning indicating a potentially dangerous situation, such as, a sudden lane change by a passing vehicle, a stopped vehicle ahead, or as in this case improper movement into an intersection when another vehicle is approaching within a hazardous proximity.

The USDOT initiated the Integrated Truck Safety Program and the Commercial Vehicle Retrofit Safety Device Program to incorporate wireless dedicated short-range communications (DSRC) technology into commercial vehicle platforms to refine crash avoidance applications. The following applications are now under development:

1. Forward collision warning
2. Blind spot warning/lane change

3. Intersection movement assist
4. Electronic emergency brake light
5. Do Not Pass Warning
6. Left Turn Assist

The program called for driver clinics in 2011 and model deployment or Safety Pilot Study beginning in August 2012 and ending in August 2013. The truck driver clinics assessed driver acceptance of the new wireless safety applications and help with the development of driver-vehicle interface designs. There were two clinics with 100 drivers experiencing this technology under controlled circumstances.

The preliminary results of the six passenger car driver clinics showed positive results for all safety applications. Over 90 percent of the respondents indicated they would like to have V2V safety features in their vehicles, with the intersection movement assist application rated the highest in desirability (93.9%), usefulness (95.5%), and intuitiveness (92.8%).[17] Intersection Movement Assist (IMA) and Left Turn Assist (LTA) are designed to provide countermeasures to assist the driver in avoiding accidents involving crossing path accidents at junctions and Left Turn Across Path from the opposite direction accidents (LTAP/OD). Heads-up displays, audible and haptic signals will warn drivers when it is unsafe to cross an intersection or turn left in front of an approaching vehicle.

The Safety Pilot Model deployment is using a test site in Ann Arbor, Michigan where approximately 2,800 cars trucks and buses equipped with V2V devices are being tested under real world conditions.

The fact sheet on the model deployment test[18] shows that the DOT and auto manufacturers have invested 25 million dollars in this phase of connected vehicle technology. The deployment test is run over 73 lane miles of highway in Ann Arbor, Michigan and involves testing fully integrated safety systems (ISS), Aftermarket Safety Devices (ASD), Retrofit Safety Devices (RSD), and Vehicle Awareness Devices (VADs). Also infrastructure V2I Road Safety Equipment (RSE) will be tested at 29 sites during the Deployment.

The Dedicated Short Range Communication provides for wireless short range (200-300 meters) capabilities that permit secure very fast data transmission critical in communication based active safety applications. The Federal Communications Commission (FCC) allocated 75 MHz of spectrum in the 5.9 GHz band for use by Intelligent Transportation Systems vehicle safety and mobility applications. DSRC was developed with the goal of enabling technology that support safety applications and communication between vehicle-based devices and the infrastructure to reduce collisions. These systems are capable of sending Basic Safety Messages (BSMs) 10 times per second, such as vehicle location and speed. The following types of systems are implemented during the safety pilot:

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[17] http://.its.dot.gov/safety_pilot/index.htm
[18] http://its.dot.gov/safety_pilot/index.htm

Fully Integrated systems
Aftermarket Safety Devices
Retrofit Safety Devices
Vehicle Awareness Devices

Fully Integrated Systems

Fully integrated vehicles have electronic devices or Integrated Safety Systems (ISS) installed during vehicle production. Integrated safety systems are connected to proprietary data buses and provide highly accurate information using in-vehicle sensors. The ISS both broadcasts and receives BSMs and can process the content through visual, sound and/or haptic warning of received messages to alert the vehicle driver. These are being developed for light vehicles and trucks. Approximately 64 cars and 3 trucks have fully integrated systems for the model deployment of the safety pilot.

After Market Safety Devices

After Market Safety Devices (ASDs) are installed after the initial vehicle is manufactured and can send and receive BSM's from other vehicles over a DSRC wireless communications link. An ASD has a driver interface, runs V2V and V2I safety applications, and issues audible and/or visual warnings to the driver of the vehicle through the ASD. The safety pilot is using about 300 ASD in cars during the model deployment.

Retrofit Safety Devices

A retrofit safety device is an electronic device installed specifically in a truck or bus by an authorized service provider at a service facility after the vehicle has completed the manufacturing process. This type of device is connected to a vehicle data bus and can provide highly accurate information from in-vehicle sensors. The device has a working driver interface, both broadcasts and receives BSMs, and can process content of the received messages to provide warnings to the driver of a vehicle. These are being developed for transit buses and trucks. In the safety pilot there are 16 trucks and 3 transit buses equipped with retrofit devices.

Vehicle Awareness Devices

Vehicle awareness Devices or (VADs) is an after-market electronic device installed in a vehicle without connection to vehicle systems. The VAD is only capable of sending the BSM over a DSRC wireless communication link. A VAD does not generate warnings, but transmits a vehicles speed and location only. They may be used in any type of vehicle. In the safety pilot approximately 2,305 cars, 60 trucks, and 85 transit buses are equipped with VADs. All of these safety devices can transmit 10 messages per second.

Safety Applications During the Safety Pilot

Drivers in the safety pilot will experience the following safety applications:

1. Forward Collision Warning – (FCW) Warns the driver if he/she fails to brake when a vehicle in the drivers path is stopped or traveling slower and there is a potential risk of collision.
2. Lane Change Warning/Blind Spot Warning (LCW/BSW) – Warns the driver when he/she tries to change lanes if there is a car in the blind spot or an overtaking vehicle.
3. Emergency Electric Brake Light Warning (EEBL) – Notifies the driver that there is a vehicle ahead (or several vehicles ahead) that the driver can't see but which is braking hard for some reason.
4. Intersection Movement Assist (IMA) – Warns the driver when it is not safe to enter an intersection – for example, when something is blocking the driver's view of opposing or crossing traffic.

The Scope of the Accident Problem That Can be Addressed by Connected Vehicle Technology

NHTSA concluded in its' research that approximately 76 percent of light vehicle accidents that occur excluding those by impaired drivers could be addressed by safety applications of connected vehicle technology. These accidents account for an approximate 180,000,000,000.00 annual economic loss.[19] See the table below for economic losses of target crashes that can be addressed by connected vehicle technology.

[19] Toma, Samuel and Swanson, Elizabeth and Najm, Wassin G, "Light Vehicle Crash Avoidance Needs and Countermeasure Profiles for Safety Applications Based on Vehicle to Vehicle Communication", USDOT Research Information and Technology Administration, John Volpe National Transportations Systems Center, DOT HS 811733

Societal Harm of Target Pre-Crash Scenario Groups

Target Pre-Crash Scenario Groups		Comprehensive Costs		Functional Years Lost	
		Total	Percentage	Total	Percentage
Rear-End	Rear-end/LVS	$ 29,716,000,000	10.8%	198,000	10.2%
	Rear-end/LVD	$ 12,215,000,000	4.4%	82,000	4.2%
	Rear-end/LVM	$ 10,342,000,000	3.8%	72,000	3.7%
	Rear-end/striking maneuver	$ 2,381,000,000	0.9%	16,000	0.8%
	Rear-end/LVA	$ 667,000,000	0.2%	5,000	0.3%
	Total	$ 55,321,000,000	20.1%	373,000	19.2%
Lane Change	Changing lanes/same direction	$ 8,414,000,000	3.1%	60,000	3.1%
	Turning/same direction	$ 6,176,000,000	2.2%	43,000	2.2%
	Drifting/same direction	$ 3,483,000,000	1.3%	25,000	1.3%
	Total	$ 18,073,000,000	6.6%	128,000	6.6%
Opposite Direction	Opposite direction/no maneuver	$ 29,558,000,000	10.8%	213,000	11.0%
	Opposite direction/maneuver	$ 3,500,000,000	1.3%	25,000	1.3%
	Total	$ 33,058,000,000	12.0%	238,000	12.2%
LTAP/OD	LTAP/OD @ non signal	$ 15,481,000,000	5.6%	111,000	5.7%
	LTAP/OD @ signal	$ 14,777,000,000	5.4%	105,000	5.4%
	Total	$ 30,258,000,000	11.0%	216,000	11.1%
Junction Crossing	SCP @ non signal	$ 41,095,000,000	14.9%	292,000	15.0%
	Turn @ non signal	$ 930,000,000	0.3%	6,000	0.3%
	Turn right @ signal	$ 908,000,000	0.3%	6,000	0.3%
	Total	$ 42,933,000,000	15.6%	304,000	15.6%
TCD Violation	Running red light	$ 18,274,000,000	6.6%	129,000	6.6%
	Running stop sign	$ 3,075,000,000	1.1%	22,000	1.1%
	Total	$ 21,349,000,000	7.8%	151,000	7

SCP ≡ Straight Crossing Paths LVS ≡ Lead Vehicle Stopped LVM ≡ Lead Vehicle Moving
LVD ≡ Lead Vehicle Decelerating LTAP/OD ≡ Left Turn Across Path/Opposite Directions
LVA ≡ Lead Vehicle Accelerating

As can be seen from this table Left Turn Across Path Opposite Direction (LTAP/OD) and junction crossing accidents such as, Chesterfield produce the most societal harm in terms of comprehensive costs.

The NTSB analyzed FARS and the National Automotive Sampling System (NASS) General Estimates System (GES) data for 2002-2011. The focus of the analysis was to illustrate the scope of the accident problem at intersections. The Table below shows the annual fatal intersection crash counts, fatalities, and injured persons. According to the National Highway Traffic Safety (NTHSA) Fatality Analysis Reporting System (FARS), in 2011, there were 6,817 fatal accidents occurring at the intersections[20], resulting in a total of 7,265 fatalities. Although intersection fatal crash counts and fatalities declined gradually during the 10-year period (2002-2011), they represented 22 percent of all fatal crashes and fatalities on U.S. public roads. Over the 10-year period, an estimated total of 12.3 million persons were injured in an intersection crashes in the

[20] A combination of vehicle-level and crash-level variables (Relation to Junction and Intersection Type) in the FARS data base were used to identify intersection fatal accidents.

U.S.[21] These represented 49 percent of all injured persons on U.S. public roads. Of the 80,005 fatal accidents occurring at the intersections, 57,542 accidents occurred at the intersection where at least one traffic control device was present (72 percent).

	Fatal Crashes (FARS)				Injury Crashes (GES)	
Year	No. of Crashes	% of all U.S. crashes	No. of Fatalities	% of all U.S. Fatalities	No. of Injured Persons	% of all U.S. Injured Persons
2002	8,876	23	9,730	23	1,483,558	51
2003	8,808	23	9,669	23	1,395,975	48
2004	8,679	23	9,451	22	1,333,554	48
2005	8,715	22	9,519	22	1,322,963	49
2006	8,340	22	9,105	21	1,238,002	48
2007	8,252	22	8,913	22	1,181,498	47
2008	7,461	22	8,063	22	1,101,610	47
2009	6,982	23	7,561	22	1,080,256	49
2010	7,122	24	7,710	23	1,117,578	50
2011	6,817	23	7,265	22	1,081,655	49
10-years	80,052	22	86,986	22	12,336,650	49

Figure 10 shows Fatal crashes at intersection by traffic control device, FARS, 2002-2011. The figure shows that vast majority of fatal accidents occurred at the intersections with highway traffic signals (46 percent) or stop signs (48 percent).

[21] General Estimates System data come from a nationally representative sample of police reported motor vehicle crashes of all types, from minor to fatal. The system began in 1988, and was created to identify traffic safety problem areas, provide a basis for regulatory and consumer initiatives, and form the basis for cost and benefit analyses of traffic safety initiatives. The information is used to estimate how many crashes of different kinds take place, and what happens when they occur. Additional information can found in http://www.nhtsa.gov/NASS

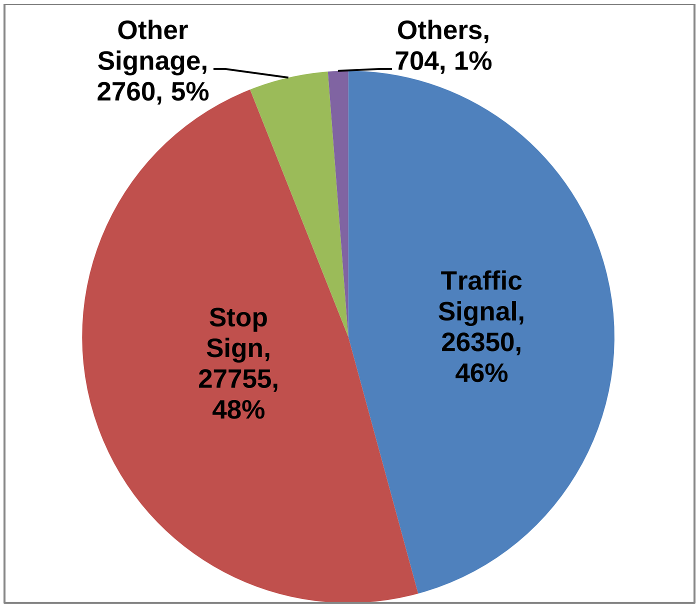

Figure 10

During the 10-year period, 86,986 fatalities occurred at intersections. The table below shows that sixty-six percent were passenger vehicle occupants, 15 percent motorcyclists, and 13 percent pedestrians.

Fatalities by road user types at intersections, FARS, 2002-2011.

Road user type	Fatalities	%
Passenger vehicle occupants	57730	66
Motorcyclists	13083	15
Large truck occupants	632	1
Bus occupants	62	0.07
Pedestrians	11516	13
Bicyclists	2525	3
Others	1438	2
Total	86986	100

NHTSA statistics[22] also showed that in the 20-year-period 1987-2007, there were 40 fatal side impact accidents involving school buses that resulted in 50 fatalities. Also, in another intersection accident[23] where the front of the school bus impacted the side of the truck tractor semi-trailer 21 children were fatally injured when the bus sank in a gravel pit following the initial impact.

These statistics show that there is a definite need to ameliorate the intersection accident problem, there has been extensive research in these areas and the systems have developed to the stage of major field operational trials. The NHTSA has stated that an agency decision will be reached in 2013 to either require the technology through rulemaking or continue research and that that same decision will occur in 2014 concerning the requirement of connected vehicle technology on trucks and buses.

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[22] School Transportation Related Crashes 2008 Accident Fact Sheet http://www-nrd.nhtsa.dot.gov/Pubs/811165.pdf and http://www-nrd.nhtsa.dot.gov/Pubs/97SchoolBuses.pdf

[23] NTSB Accident Report No. HAR-90-02, 9/21/1989 Alton, Texas, Collision of Mission Consolidated Independent school District School bus and Valley Coca Cola Bottling Co., Inc Truck Tractor Semi-trailer at the intersection of Bryan Road and Texas Farm-to-Market Road 676