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FAMU-FSU COLLEGE OF ENGINEERING

**A QUALITATIVE STUDY OF FATAL INTERSECTION
CRASHES IN THE STATE OF FLORIDA**

By

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ABSTRACT

One of the most primary requirements of any efficient transportation system is safety of the users. The national highways should provide the required mobility and accessibility accompanied with safety for its smooth functioning. Efforts are being made to improve the safety of our highways, which are still exposed to a significant number of fatalities due to traffic crashes. An intersection is, at its core, a planned point of conflict in the roadway system. With different crossing and entering movements by both drivers and pedestrians, an intersection is one of the most complex traffic situations that motorists encounter. Add the element of speeding motorists who disregard traffic controls and the dangers are compounded. At-grade intersections are one of the highest frequency accident-prone locations. Studies reveal that almost 40 % of the total crashes occur at the intersections. Left turn collisions and Red Light Running crashes are found to be common types of accidents occurring at intersections. Most of the crashes at unsignalized intersections are right angle collisions. Such high frequency of crashes at a particular kind of location makes it obvious that there are more factors that need to be studied in addition to the traffic volume and traffic characteristics. This research thesis aims at analyzing the Statewide Traffic Crash data for crashes at intersections in the State of Florida and to determine the contributing causes of the crash which are not only driver errors, as are generally accepted. The analysis shall look into the type of the crash, Roadway Geometrics and other Transportation Engineers' concerns, which could have added to the probability of the crash and thereby suggesting relevant countermeasures.

The source data used for analysis was obtained from the Florida Department of Transportation (FDOT) and the scope of the research is restricted to the State of Florida. Failure to yield the right of way due to inattention or misjudging of safe gap is the most frequently observed contributing factor to the crashes at intersections, which may be a result of inadequate sight distance, improper stop signs or higher posted speeds, which are a cause of concern for a Transportation Engineer. In an attempt to make the roads safer for the users, suitable generic and site-specific countermeasures are suggested in this research.

CHAPTER 1

OVERVIEW

1.1. Introduction

An intersection is, at its core, a planned point of conflict in the roadway system. With different crossing and entering movements by both drivers and pedestrians, an intersection is one of the most complex traffic situations that motorists encounter. Add the element of speeding motorists who disregard traffic controls and the dangers are compounded. One of the most primary requirements of any efficient transportation system is safety of the users. The highways of our country should provide the required mobility and accessibility accompanied with safety for its smooth functioning. Efforts are being made to improve the safety of our highways, which are still exposed to a significant number of fatalities due to traffic crashes. In the year 2003, there have been almost 240,000 traffic crashes with around 2,880 fatal crashes causing more than 3,000 fatalities, which is a 1.1% increase in fatalities from the previous year. These numbers clearly indicate the need for deeper research into the fatal crashes so as to indicate the contributing and causal factors in the occurrence of the crashes. Thus, intersections have a significant share in the fatal crashes in Florida. Almost one third of the total fatal crashes in Florida occurs either at or are influenced in some way due to the presence of an intersection. Due to such high precedence of crashes at or influenced by a particular roadway facility, an in-depth review of the fatal crashes at or influenced by intersections is undertaken in this thesis. A judicious decision needs to be made for the safety and priority of all the users and there will always be a certain tradeoff in preference of one for the other. An intersection needs to provide balance between smooth traffic operations for majority vehicles, commute traffic, and safety of all. The data used for the purpose of this research was obtained from Florida Department of Transportation and the fatal intersection crash research is carried out as a part of the larger study on the fatal crashes in the state of Florida during the years 1998 – 2000.

1.2. Research Objectives

This research thesis primarily aims at analyzing the Statewide Traffic Crash data for crashes at intersections in the State of Florida and trying to determine the contributing causes of the crash which are not only driver errors, as are generally accepted. The analysis shall look into the type of the crash, Roadway Geometrics and other Transportation Engineers' concerns, which could have added to the probability of the crash and thereby suggesting relevant countermeasures. At the offset following research goals were identified:

1. Study the Fatal Intersection Crashes available on the database for the years 1998, 1999, and 2000. This included the fatal intersection crashes involving heavy trucks for the years 1998 and 1999 and all the fatal intersection crashes in the year 2000.
2. Identify patterns in the occurrence of crashes. This included the summary statistics for the crash distribution based on pre-identified critical parameters such as functional class of highways, number of lanes, speed limits on roads, traffic control etc.
3. Perform detailed study of the fatal intersection crashes through video log and site visit reports. The fatal intersection crashes for this detailed crash study was identified as crashes that did not involve DUI, and the intersection geometry demanded a site visit.
4. Obtain generic and site specific countermeasures to address the issue of fatal crashes at intersections in the state of Florida.

1.3. Background and Literature Review

One of the most primary requirements of any efficient transportation system is safety of the users. The highways of our country should provide the required mobility and accessibility accompanied with safety for its smooth functioning. Efforts are being made to improve the safety of our highways, which are still exposed to a significant number of fatalities due to traffic crashes.

An intersection is, at its core, a planned point of conflict in the roadway system. With different crossing and entering movements by both drivers and pedestrians, an intersection is one of the most complex traffic situations that motorists encounter. Add the element of speeding motorists who disregard traffic controls and the dangers are compounded. (ITE, 2004)

At-grade intersections are one of the highest frequency accident-prone locations. Literature reveals that almost 50 % of the total crashes nationwide occur at the intersections and almost 25 % of traffic fatalities are caused due to intersection or intersection related crashes (TSF, 2003).

The intersections need to be designed and operated for all users such as:

- Pedestrians
- Bicyclists
- Older drivers and younger drivers
- Pedestrians of all ages and cognitive and physical abilities/disabilities
- Transit/light rail/trolley vehicles
- Trucks including loading/unloading maneuvers
- Emergency vehicles
- Proximate driveways serving commercial properties
- Commuters

A judicious decision needs to be made for the safety and priority of all the users and there will always be a certain tradeoff in preference of one for the other. An intersection needs to provide balance between smooth traffic operations for majority vehicles, commute traffic, and safety of all.

Literature reveals that left turn collisions and red light running crashes are found to be common types of accidents occurring at intersections. Most of the crashes at un-signalized intersections are right angle collisions (Agent et al., 2003). Such high frequency of crashes at a particular kind of location makes it obvious that there are more factors that need to be studied in

addition to the traffic volume and traffic characteristics. This research presents the data collection effort, analyses and results for crashes at intersections in the State of Florida for the years 1998 to 2000 trying to determine the contributing causes of the crash which are not only driver errors, as are generally accepted. The analyses looked into the type of the crash, Roadway Geometrics and other Transportation Engineers' concerns, which could have added to the probability of the crash and thereby suggesting relevant countermeasures.

Based on the review of literature (ITE, 2004) and the cases in this study, failure to yield the right of way at an intersection is the major cause of crashes. The failure to yield the right of way is not always only the drivers' fault. Understanding the way people react to vehicle conflicts is a part of improving intersection safety. Drivers vary widely in their skills and their willingness to take risks at intersections. Also contributing may be sight obstruction issues that need to be addressed at some intersections that do not provide sufficient sight distances with certain obstructions blocking the line of sight of the drivers or with inappropriate design of intersection not offering enough sight distance due to curve in road etc.

There are various factors, which may be driver related, roadway related, environment related or even vehicle related that contribute to the crashes at intersections. The intersection safety briefings issue of 2004 says, "Many signs and signals, even when new, are not large or bright enough-especially at night or in dim lighting-for drivers to act safely on the information these traffic control devices are providing. Many drivers may have good vision but are not able to see well at night because of poor sensitivity to the contrast between light and dark."

Older drivers usually are much less inclined to take risks with narrow margins of error than are younger drivers, especially those in their teens and 20s. However, older drivers often take risks unknowingly because of the diminished motor skills, poor vision and reduced cognitive ability that can come with old age. This can lead them to make poor judgments at intersections that can result in crashes. Drivers 85 years of age and older are more than 10 times as likely as drivers in the 40-to-49 age group to have multi-vehicle intersection crashes while the youngest driver age groups have the highest traffic violation and crash involvement rates. This is often due to poor judgment and inexperience, especially among teenage drivers. This problem is

also due to a willingness of young drivers to take risks that include speeding, dangerous maneuvers and violating red light signals and stop signs. (IIHS, 2001)

Figure 1 below shows the typical conflict points for a vehicle turning left at an intersection. Incidentally, more than 50 % of the crashes at intersections involve a left turn maneuver by one of the vehicles involved in the crash. The intersections involve through and turning movements of traffic in the same direction as well and the slowing vehicles that need to turn are a potential source for back end collisions. Figure 2 below shows the conflict points for a right turning vehicle. The lower image in Figure 2 shows a potential angled collision, which can also be a rear end collision. Figure 3 shows the conflict point for straight crossing vehicles. Figure 3 shows a passenger side impact; a similar situation can also give rise to a driver side impact. (Figure Source: NHTSA Report, 2004.)



Figure 1: Conflict Points for a Left Turning Vehicle at an Intersection



Figure 2: Conflict Points for a Right Turning Vehicle at an Intersection

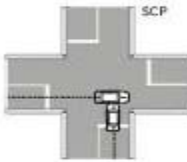


Figure 3: Conflict Point for Straight Crossing vehicles at an Intersection

Reduction of fatal intersection crashes can only be accomplished by careful use of good road design, traffic engineering choices, comprehensive traffic safety laws and regulations, consistent enforcement efforts, sustained education of drivers and pedestrians, and the drivers' and pedestrians' willingness to obey and sustain the traffic safety laws and regulations. The crashes at intersections can be counteracted by introduction of suitable intersection control and providing sufficient sight distances on all the legs of the intersection.

CHAPTER 2

METHODOLOGY

For the purposes of this study, fatal intersection crashes have been defined as the fatal crashes that occurred either at the intersection or the occurrence of the fatal crash was directly influenced by the presence of an intersection. The methodology used to analyze the fatal intersection crashes was based on individual review of each crash followed by the statistical significance and correlation of pertinent crash parameters. The case reviews identified primary and secondary casual factors, and attributed factors by classes (roadway, vehicle, human, or environment) and subclasses. The charts were used to identify the parameters that had high precedence of crashes, so that countermeasures can be targeted towards improving on these parameters. The parameters chosen here were selected based on their contribution towards the crash and an effort was made as to determine the factors that add to the risk of a fatal crash at an intersection.

2.1. Intersection Crash Types and Contributing Factors

The scope of the definitions given here is limited to this individual chapter of the report, dealing with fatal intersection crashes.

- *Sight Distance Issue:* Classically as defined sight distance is the length of the roadway a driver can see ahead at any particular time. (Garber et al., 1997) Decision sight distance is the distance required for a driver to detect unexpected or otherwise difficult-to-perceive information source or hazard in a roadway environment that may be visually cluttered, recognize the hazard of its threat potential, select an appropriate speed and path, and initiate and complete the required safety maneuvers safely and efficiently. (Alexander, G.J et al., 1975) In case of intersections for a driver with secondary right of way that is the driver who is supposed to yield to other vehicles before entering the intersection, the driver needs to have a clear view in both

directions of the intersecting roadway, to safely judge and complete his desired maneuver. These definitions were kept in mind while determining the sight distance issues at a crash site. Factors causing sight distance issues are as follows: Curves in road, trees, shrubs or other fixed objects obstructing the line of sight, other vehicles stopped due to the traffic control at an intersection. Figure 4 shows a typical sight distance issue caused by the trees obstructing the line of sight at an intersection. (Figure source: FHWA, 1992).

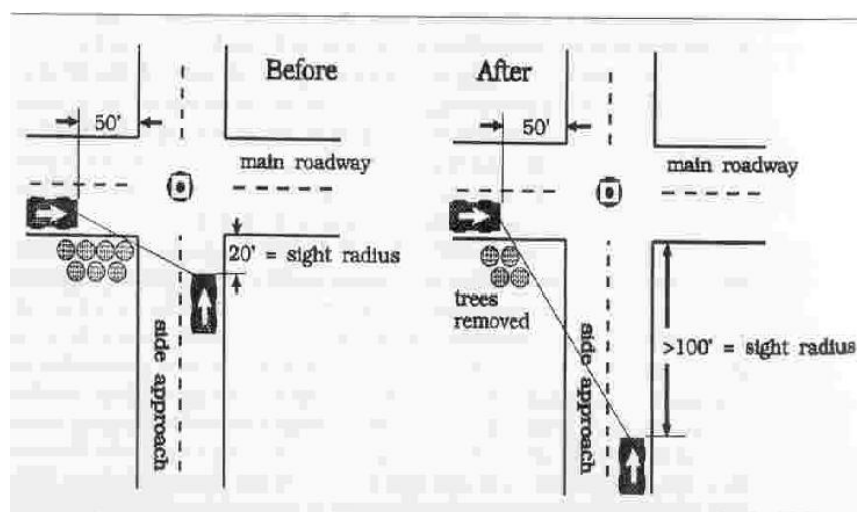


Figure 4: A Typical Intersection with a Sight Distance Issue Due to Trees

- Roadway Geometry Issue:** The geometry of the road, for example presence of curve, which limits the sight distance, skewed intersections causing difficult maneuvers across the intersections, wide intersections leading to judgment and perception errors by drivers were looked into while determining the roadway geometry issues at an intersection where the fatal intersection crash occurred. The Figure 5 below shows the crash diagram for DHSMV crash number 58107041, as seen from the figure, the intersection is un-signalized and has a complex geometry and confusing lane assignment. In addition the intersection is on a curve, which adds the element of limited sight distance for drivers on all four legs of the intersections and as such the

intersection geometry has potentially significant contribution towards the occurrence of the crash.

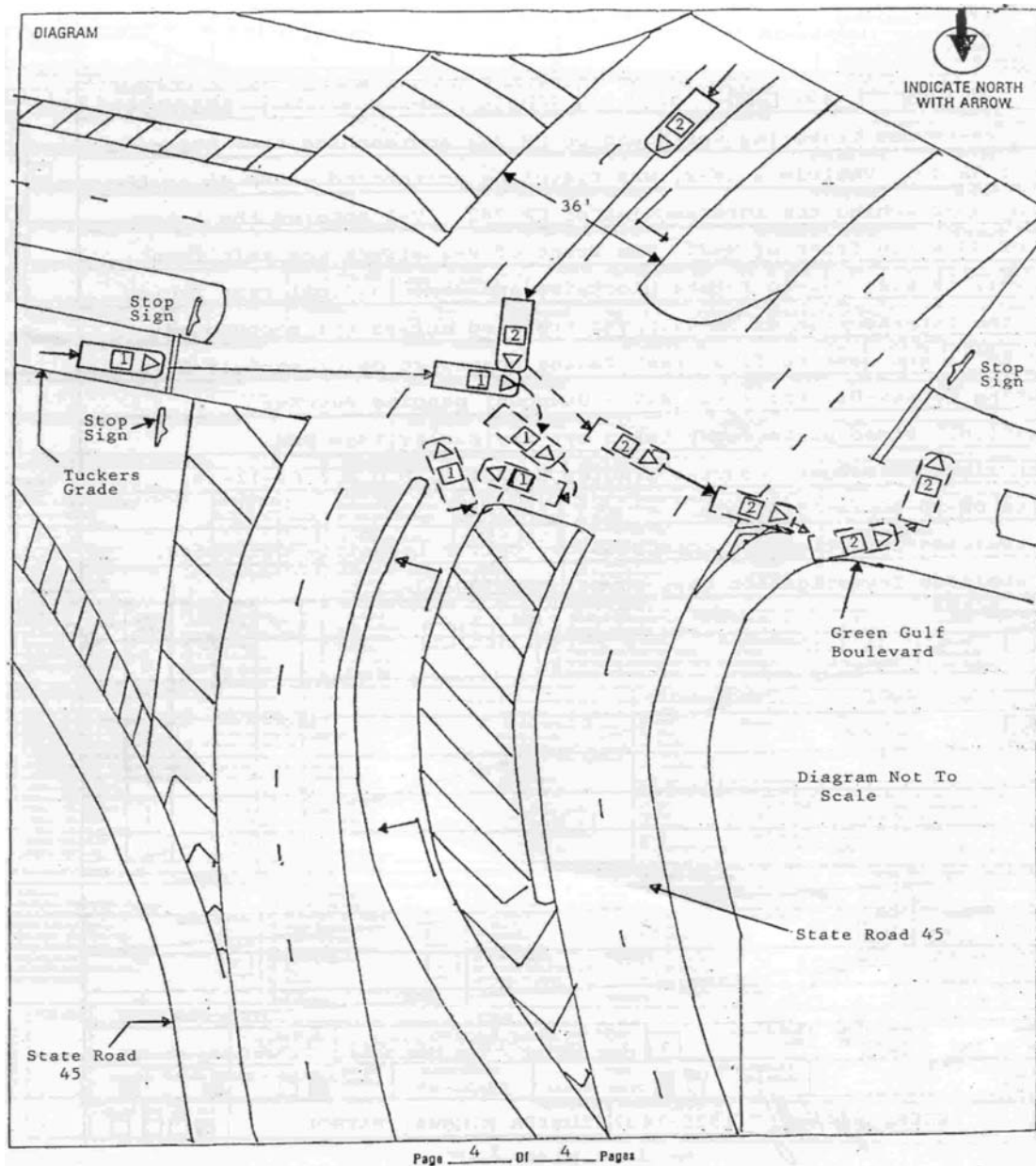


Figure 5: A Typical Intersection with Roadway Geometry Issues

- *Traffic Operation Issue:* The roadway lane assignment and usage, traffic controls, signal phasing etc are the factors looked at while determining the traffic operations issues at an intersection. Unavailability of turning lanes, improper or excessive access to a high-speed road, inadequate or absent traffic control, lane assignment leading to confusing or conflicting vehicular movements were some of the factors identified while looking for traffic operation issues in the fatal intersection crashes.
- *Signalization Issue:* This forms a subset of traffic operations, and while identifying the contribution of signalization in the occurrence of the fatal intersection crashes, facts such as the signal phasing, absence of signal where deemed needful were looked into and the signalization issues were identified. If the signal is not noticeable well in time, it may lead to rear end or even red light running crashes, which was noted as a potential contributing factor in certain fatal intersection crashes.
- *Signage Issue:* Traffic signs, whether regulatory or control, play a vital role in the smooth operation on the roadway. Drivers need to be advised about the kind of intersection they would be approaching. Certain fatal intersection crashes were identified with potential signage issues such as a 55 MPH road terminating in a Stop Sign controlled T-junction without any prior warning signage. In geographical areas that are known to have foggy conditions, signs also need to be highly retro-reflective and may be even supplemented with flashing warning lights etc.
- *Environment Issue:* Inclement weather conditions, fog, heavy rains, wet and slippery roadway due to rain make the driving conditions hazardous and even a careful driver may get into a crash due to such environmental issues.
- *Pedestrian Facility Issue:* As mentioned earlier, one of the major intersection safety concerns is the elimination of vehicle and pedestrian conflict. To achieve this objective, the roadway needs to provide adequate pedestrian facilities such as crosswalks and side walks to and from all pedestrian generators. Issues such as whether the area is properly lighted or not, whether it has proper crosswalk or not, whether it has a pedestrian signal or not were studied while identifying the pedestrian

issues in fatal intersection crashes. Again, the in-depth analysis of pedestrian cases has been undertaken in a separate chapter and not discussed in detail in this chapter.

2.2. Identifying Intersection and Intersection Related Crashes

The identification of the fatal intersection crashes was done based on two primary criteria. Firstly, all the crashes that had the following site location codes were filtered out and identified as potential fatal intersection crashes.

- 2 = At Intersection
- 3 = Influenced by an Intersection
- 4 = Driveway Access

Driveways were included in the set of intersection crashes because many of the attributes (e.g. conflict points) and countermeasures would be very similar. In fact, many of the “driveway” crashes involved commercial business access points that are channelized, stop sign controlled, and indistinguishable from standard intersections between public roads. However, it was noted that there were numerous inconsistencies in definitions and coding used by different officers. Examples include differentiating between driveways and intersections, determining what crashes are *influenced* by an intersection, and distinguishing between an exit/entrance ramp and an intersection, for instance when a crash occurs at a signalized intersection at the end of an exit ramp. For this reason, a second criterion used was based on the proximity of the crash to a known intersection.

To conduct this proximity check, GIS was used to spatially layout the fatal crashes on a Florida State roadway base map. The roadway base map was obtained from the GIS directory available on the <http://www.dot.state.fl.us/planning/statistics/gis/default.htm> website. The crashes from the table were added to this layer as route events using Roadway ID as the identifier and location milepost as the point of event. Using another point layer, all the intersections in the state of Florida were laid out on the base map. The proximity check for the

fatal crashes was done using the selection tool, “Select By Location” provided in ArcView GIS Software. The features in the crash layer (crash points) were selected based on their distance from the features in the intersection layer. A 100 feet radius was used for the proximity check. A separate layer was formed using the selected features from the crash layer. The DHSMV crash numbers and other crash attributes were obtained in a table from the attribute table of this new layer. All the crashes on the list were then reviewed to confirm if the presence of an intersection had any bearing on the occurrence of the crash. It should be noted here that although a few cases were identified as fatal intersection crashes through this process most of the crashes though geographically near (within 100 feet of) an intersection, were not actually related to the intersection. The Figure 6 below shows the different filtering stages of the data to extract the fatal intersection crashes. Initially, from the total of over 2000 fatal crashes, about 950 crashes were identified as potentially intersection-related crashes, but the number was finally refined to around 700 crashes, as shown in Figure 6.

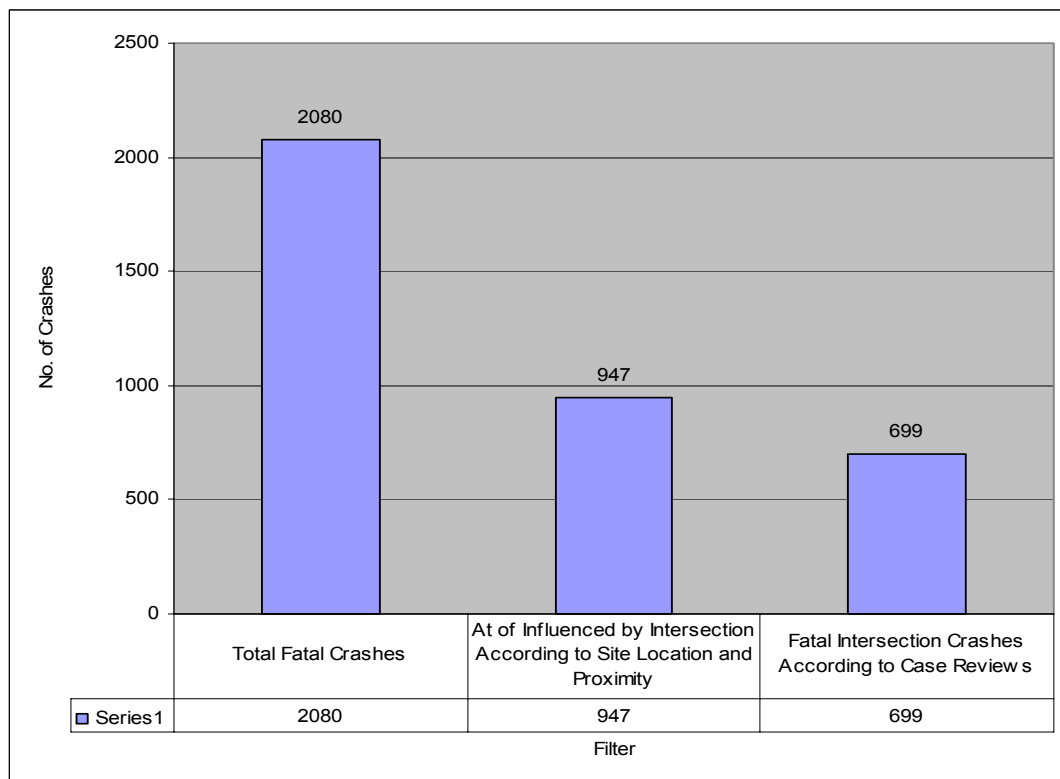


Figure 6: Fatal Intersection Crashes Filtering

2.3. Case Review of Fatal Intersection Crashes

After all the fatal intersection crashes were identified, each crash case was approached systematically and reviewed and the crash reconstruction diagrams studied. Next, the fatal crashes were broken down by whether they occurred at a traffic signal, stop sign, or at no traffic control device. The crashes were then examined to see if the driver violated the traffic signal or stop sign. Additionally, the type of violation was noted, whether the driver failed to obey or failed to yield at the sign/signal. Next, the fatal crashes were broken down by whether they occurred at a traffic signal, stop sign, or at no traffic control device. The crashes were then examined to see if the driver violated the traffic signal or stop sign. Additionally, the type of violation was noted, whether the driver failed to obey or failed to yield at the sign/signal. The vehicle movements and traffic control present were used to identify the crash type. The crash report was studied to identify the driver error. Each case was assigned a primary, secondary and tertiary contributing factor based on judgment after thoroughly reviewing the crash report.

Each case was checked for driver and non-driver issues. Non-driver issues such as “Sight Distance Issue,” “Roadway Geometry Issue,” “Traffic Operation Issue,” “Signalization Issue,” “Signage Issue,” “Environment Issue,” and “Pedestrian Facility Issue” were identified for each case. Further driver issues such as “DUI,” “Speeding,” “Inattention / Careless,” “Improper Turn,” “Ran Red Light,” “Ran Stop Sign,” “Rear End,” “Misjudged Gap” were also coded. It should be noted here that certain fields such as “Misjudged Gap” or “Inattention/ Careless” have been identified based on the best judgment after reviewing the case. It is to a certain extent an estimate since what exactly went on in the mind of the driver cannot be determined after the crash, especially if the driver was a victim in the crash. It may be questionable as to whether the victim saw the vehicle and then proceeded into the intersection or was simply inattentive and just failed to see the vehicle. A review of driver action (e.g. stopping at a stop sign or green ball in the case of a permissive left prior to entering the intersection) and speed, and the speed and position (i.e. near or far lane) of the oncoming/crossing vehicle was used to help determine the likely cause of the crash.

Another aspect that needs attention here is that “gap” here is not the classical definition of the available gap, which is defined as the time space between two consecutive vehicles. For

the purposes of intersection fatal crash driver error, gap may be understood as the time required for a through vehicle to cover the distance to the intersection and enter the intersection at the speed which it is moving on the major road from its current position. This gap is irrespective of the previous vehicle that went through that particular intersection. It should also be understood that misjudging of gap could also be, to a certain extent, due to inattentiveness and as such some crashes may show “Inattention/ Careless” and “Misjudged Gap” both as driver error issues.

2.4. Over Representation Factor

This procedure was based on a technique used in the pilot study of the fatal crash data for the State of Florida (Spainhour et al. 2003), which in turn is based on methodology developed by the Critical Analysis and Reporting Environment (CARE) lab at the university of Alabama (Parrish et al. 2003).

Inferential statistics such as correlation and regression require a significant understanding of statistics. Hence simplified, yet statistically significant approach of frequency distributions, called overrepresentation was used for analyses. Another important point to note is that the data is not continuous, thus the advanced statistical analysis such as regression models and control charts would not help much. This means that every crash is unique with discrete data. Thus a simple method of overrepresentation is used for analysis. To calculate the overrepresentation factor, two data subsets are required, the experimental subset and a comparison or control subset. Overrepresentation factor is not just percent involvement but it is comparison to the complement of the set, to differentiate important factors & differences between sets. Likely, it cannot reduce rate in the set more than the rate in the complement i.e. reduce the overrepresentation factor to one. Data quality and quantity are both important in arriving at correct conclusions. Owing to large sample size narrower confidence interval was chosen.

A normal distribution of binomial is assumed, so both subsets must include a sample size of at least 20 to allow concluding significance. Usually, this indicates well over 99 percent

confidence that the difference is significant. Using a high degree of confidence and disallowing the low sample size significantly improves the chances of finding important differences.

There are two components to an overrepresentation:

- 1) The degree or magnitude of the overrepresentation, and
- 2) Whether or not the overrepresentation is statistically significant.

According to the CARE method, the threshold for statistical significance is always at 99 percent level; the user is allowed to set the threshold for the magnitude of the overrepresentation. This statistical significance is based on a sample size of 20 or more. The default overrepresentation threshold used by the CARE researchers is 1.5 and that for under representation is 0.667, these numbers mean that an attribute can be said to be over or under represented only if there the value is 50 percent more or less than the observed. Attribute values, which are both high in magnitude and statistically significant, are substantially over represented. Under representation data values typically represent values for which there is no problem. Overrepresentations often indicate problems that must be addressed through countermeasures. The concept of overrepresentation can be better understood from the various results obtained using the same. This simple tool is very important in making decisions with little or no statistical training.

The researchers in this project have extended the concept of overrepresentation to fit the data set. Since in some cases the sample sizes are less than 20, the statistical significance is computed at 95 % level. And, confidence interval is constructed for the overrepresentation factors.

The formula for the confidence interval for the overrepresentation factor (OR) is shown below. The relative risk is the ratio of percentage of positive cases from the total population to the non-positive cases from the total population. The overrepresentation factor is calculated in a similar way as relative risk. Hence the confidence interval for calculation of relative risk is used for calculating the confidence interval for overrepresentation factor.

This formula is for 95 percent confidence interval:

$$\text{Upper limit} = \exp^{(\ln OR + 1.96 * SE (\ln OR))}$$

$$\text{Lower limit} = \exp^{(\ln OR - 1.96 * SE (\ln OR))}$$

Where:

$\ln OR$ = Natural Logarithm of Overrepresentation Factor

$SE (\ln OR)$ = Standard Error of the Natural Logarithm of OR

= Variance of Natural Logarithm of OR

$$= \sqrt{\frac{(C / A)}{(A + C)} + \frac{(D / B)}{(B + D)}}$$

The value 1.96 is the appropriate t-value from t-distribution corresponding to 95% confidence and sample size.

CHAPTER 3

CASE STUDIES

This chapter shows four sample case studies, showing the case review of the fatal intersection crashes. It should be understood that the roadway issues mentioned here are potential issues which apparently have a certain degree of contribution towards the occurrence or the severity of the crash. The observations and the issues noted have been derived after a thorough review and study of the crash report, the homicide investigation report and the video log reviews of the crash roadway.

3.1. Case Study 1

- DHSMV # 51808559
- D1 – 37 Years of Age DUI @ 25 MPH on 25 MPH Posted Speed Limit.
- D2 – 32 Years of Age Not DUI @ 35 MPH on 35 MPH Posted Speed Limit.
- Time of Crash – 8:33 PM
- Stop Control for D1.
- No Control for D2.
- Straight Vs. Straight Movements

Figure 7 shows the crash reconstruction diagram for the crash mentioned in the case study 1 above. The crash occurred when vehicle 1 (V1) pulled into the path of vehicle 2 (V2) from the stop sign. Both the vehicles were within the speed limits but driver of vehicle 1 (D1) was driving under the influence of alcohol and as such the primary contributing factor to the crash is DUI. However, looking at the roadway issues, it is seen that certain sight and traffic operation issues do have a secondary contribution to the occurrence of the fatal intersection crash. The path of V1 crosses across the path of V2 prior to the stop bar. Also stopped vehicles in adjacent lane obstruct the line of sight from D1's point of view. Figure 8 shows the view of intersection in the crash under study. The picture shows a sharp curve right after the intersection, which further limits the sight distance from D1's point of view.

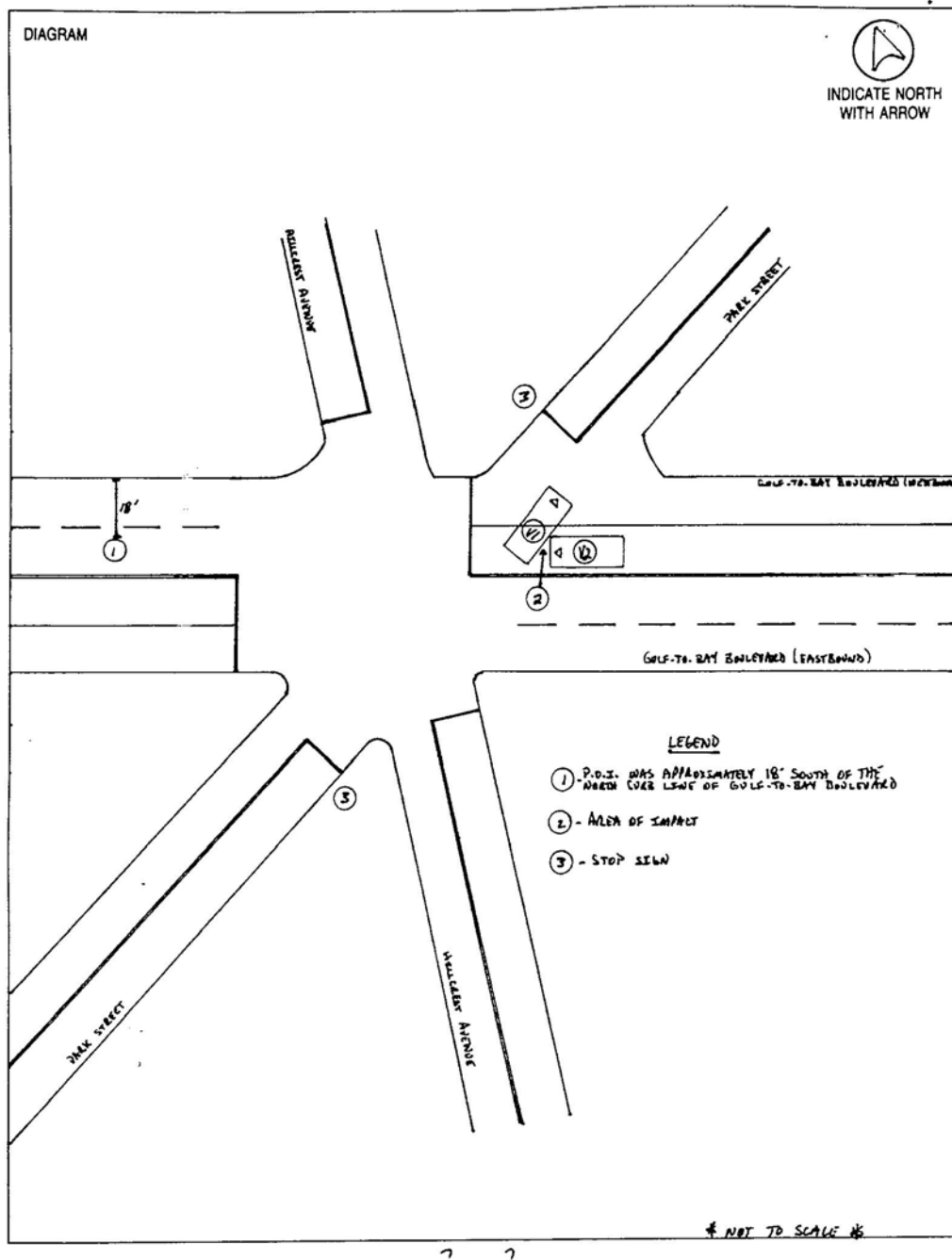


Figure 7: Crash Reconstruction Diagram for DHSMV # 51808559



Figure 8: Intersection in DHSMV Crash # 51808559

Following are certain observations made regarding the roadway issues that have a secondary or tertiary contribution towards the fatal intersection crash.

- Complex confusing intersection movements.
- Line of sight issue.
- Curve just to the west of intersection, sight distance issue.
- Pavement marking issue.
- Traffic operation issue.

3.2. Case Study 2

- DHSMV # 58106133
- D1 – 91 Years of Age Not DUI @ 15 MPH on 45 MPH Posted Speed Limit.
- D2 – 48 Years of Age Not DUI @ 40 MPH on 45 MPH Posted Speed Limit.
- Time of Crash – 12:20 PM
- Signalized Intersection.
- Left Turn Oncoming Movements.

Figure 9 shows the reconstruction diagram for DHSMV crash number 58106133. D1 is 91 years of age trying to make a left turn in front of oncoming traffic. Speeding and DUI are not contributing factors in the crash but driver age leading to misjudging of the gap is the primary contributing factor. As seen from the diagram the intersection is on the curve and offers limited sight distance. Also from Figure 10 and Figure 11 the line of sight for D1 is obstructed due to the trees present in the median and its rather difficult for a left turner in D1's position to have a clear view of vehicles coming up the curve from V2's direction. Following are the observations made regarding the roadway issues contributing into the fatal intersection crash and as mentioned earlier these are the potential issues.

- Wide intersection.
- 3 travel lanes to cross – D1, 91 years of age.
- Signal phasing issue.
- Sharp curve on both approaches to intersection – sight distance issue.
- Trees in median obstruct clear view of oncoming vehicles down the curve.

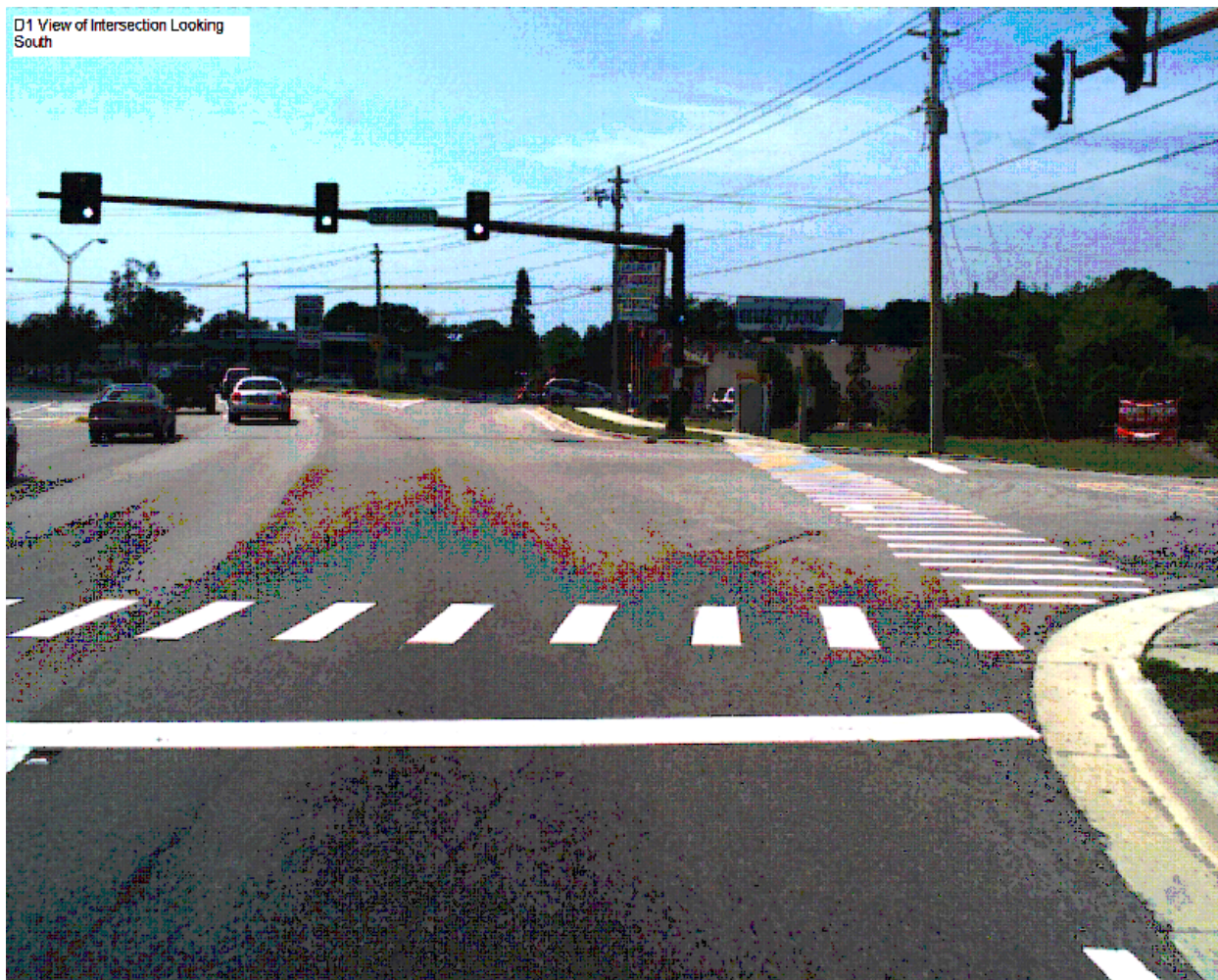


Figure 10: D1's View of Intersection in DHSMV Crash # 58106133

D2 View of Intersection Looking North



Figure 11: D2's View of Intersection for DHSMV Crash # 58106133

3.3. Case Study 3

- DHSMV # 50014426
- D1 – Hit and Run – CMV Making U – Turn.
- D2 – 32 Years of Age Not DUI @ 55 - 65 MPH on 55 MPH Posted Speed Limit.
- Unknown Time – Officer Notified at 8:07 AM.
- Uncontrolled Movements.
- Rear End.

Figure 12 shows the reconstruction diagram for the crash in the case study. The crash is a rear end crash with inattentive D2 rear-ending V1, which left the scene of crash.

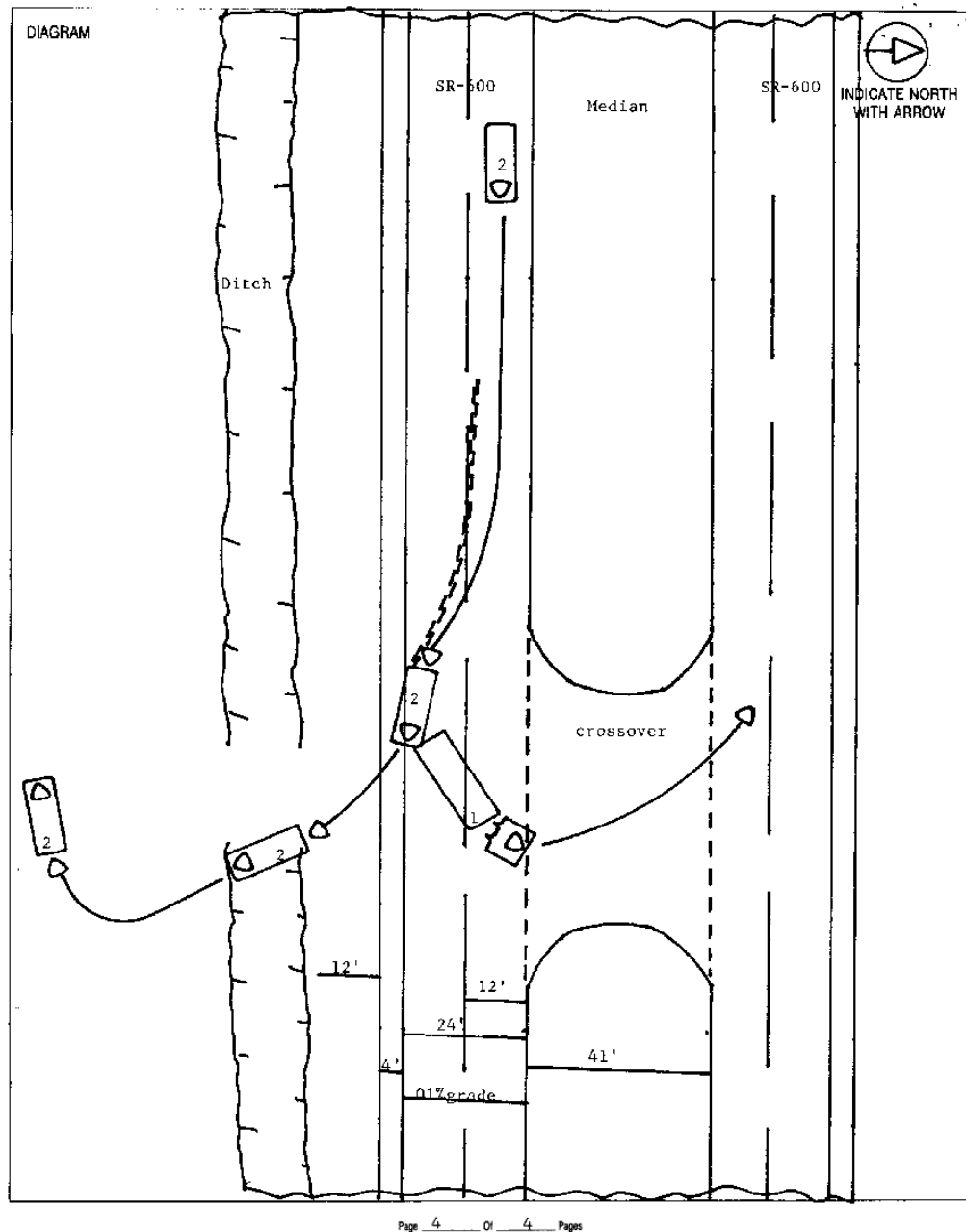


Figure 12: Crash Reconstruction Diagram for DHSMV Crash # 50014426

Figure 13 below shows the driver's view of the roadway just before the crash. The picture is a view from approximately 150 feet to 200 feet prior to the crash location. It can be noticed that D2's view of the roadway is restricted due to the vertical curve in the road. The break in the median where the CMV was trying to make a U-turn is right totally hidden for the drivers moving up the curve at 55 MPH and as such it is a potentially significant sight distance issue contributing to the crash and so also, the absence of a storage turn lane is a potential traffic operation issue contributing to a certain degree in the fatal crash. Another issue mentioned in the report is the possible insufficient lighting on the sides of the CMV reducing its visibility.



Figure 13: D2's View Prior to Crash in DHSMV Crash # 50014426

Following are the observations made regarding the potential contributing factors in the fatal intersection crash.

- Horizontal and vertical curve just prior to crash site.
- Insufficient sight distance for speed limit.
- CMV U-turn – No turn lane – traffic operation issue.
- Possibly insufficient lighting on sides and rear of CMV – vehicle issue.

3.4. Case Study 4

- DHSMV # 57427968
- D1 – 18 Years of Age Not DUI @ 55 - 60 MPH on 45 MPH Posted Speed Limit.
- D2 – 66 Years of Age Not DUI @ 15 MPH on 35 MPH Posted Speed Limit.
- V3 and V4 – Secondary Impact.
- Time of Crash – 11:24 PM
- Signalized Intersection.

Figure 14 shows the reconstruction diagram for DHSMV crash number 57427968. The crash occurred when an inattentive D1 ran the red light and hit V2 in the left side. The primary contributing factor to the crash is the running of red light due to inattentiveness by D1 and also speeding by D1. But it would not be fair to dismiss the fact the visibility of the signal is rather low as it comes up right after a vertical sag in road and the overpass seen in Figure 15 certainly hinders a clear sight to the signal. The study of the video logs for the roadway revealed that it changes character from rather rural or suburban to urban at this intersection and there isn't enough warning signage for the same, which may have a potential contribution in the fatal intersection crash considering that D1 was from elsewhere in state and was probably unfamiliar with the roadway.

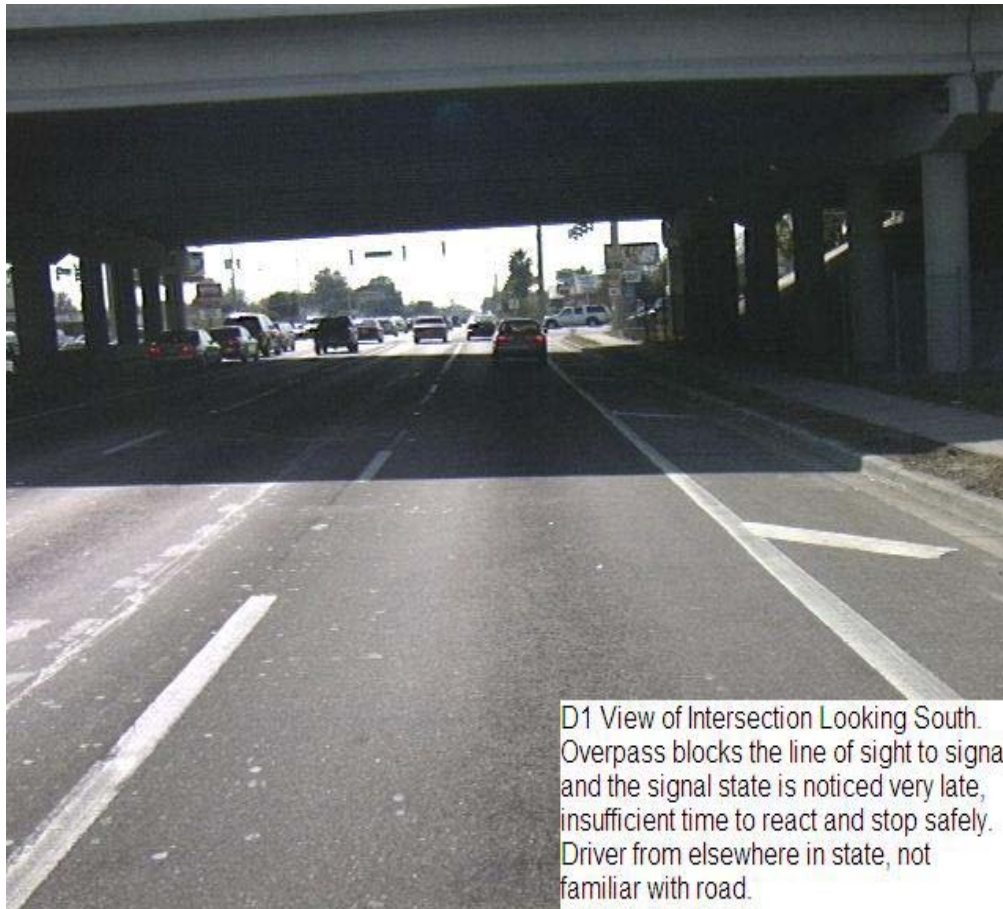


Figure 15: D1's View of Roadway Just Before the Crash in DHSMV # 57427968

Following are certain observations made regarding the potential contributing factors to the crash.

- Speed zone changes north of crash site from 55 MPH to 45 MPH.
- No signal prior to crash site for more than 2.5 miles.
- Signal not easily noticeable on roadway – the overpass bridge blocks view.
- No warning signage for signalized intersection, change in traffic character – rural to urban.
- View from D2's point of view also blocked to allow the drivers to be defensive.
- View from inside left turn lane on NB roadway not clear – potential for left turn oncoming crash.

CHAPTER 4

DATA SET

This chapter deals with the general aspect of the data and shows the distribution of fatal intersection crashes and gives the over representation factors for fatal intersection crashes comparing with non intersection fatal crashes, based on various factors such as year of crash, county of crash, month of the year, day of the week, hour of the day and so on.

Table 1 below shows the distribution of the fatal intersection crashes by year. As can be seen from the table and as mentioned earlier, the available data is limited only to crashes involving heavy trucks for the years 1998 and 1999. It can be seen that the fatal intersection crashes are evenly distributed over the three years and the percentage occurrence is consistent with the national average found in literature. (TSF, 2003) except for the year 1998 when the percentage of fatal intersection crashes involving heavy trucks is over represented.

Table 1: Fatal Intersection Crashes by Year

	1998	1999	2000	Total
	(Heavy Trucks)	(Heavy Trucks)	(All Cases)	
Total	199	198	1683	2080
Intersection Crashes	84	71	544	699
% Intersection Crashes	42.21%	35.86%	32.32%	33.61%

Table 2 below shows the crash distribution for the year 2000. The percentage distribution of the crashes within the year is consistent with the overall data. It can be seen that the involvement of heavy trucks in fatal intersection crashes is not over represented here.

Table 2: Fatal Intersection Crashes for Year 2000

Total	Heavy Trucks	Other	Total
	178	1505	1683
Intersection Crashes	59	485	544
% Intersection Crashes	33.15%	32.23%	32.32%

Table 3 shows the distribution of fatal intersection crashes by the county. The counties with more urban land area have more number of intersections and this is naturally represented by higher number of crashes in these counties. Dade County has highest number of fatal intersection crashes with 73 fatal intersection crashes and Hillsborough and Polk County are ranked second and third with 53 and 50 fatal intersection crashes respectively.

Table 3: Fatal Intersection Crashes by County

COUNTY	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
ALACHUA	10	1.43%	29	2.10%	0.681	0.334	1.390	UNSURE
BAKER	2	0.29%	7	0.51%	0.564	0.118	2.710	UNSURE
BAY	7	1.00%	13	0.94%	1.064	0.426	2.654	UNSURE
BRADFORD	2	0.29%	11	0.80%	0.359	0.080	1.616	UNSURE
BREVARD	19	2.72%	43	3.11%	0.873	0.513	1.486	UNSURE
BROWARD	45	6.44%	130	9.41%	0.684	0.493	0.948	UNDER
CALHOUN	1	0.14%	6	0.43%	0.329	0.040	2.730	UNSURE
CHARLOTTE	18	2.58%	10	0.72%	3.556	1.650	7.663	OVER
CITRUS	8	1.14%	8	0.58%	1.976	0.745	5.242	UNSURE
CLAY	4	0.57%	8	0.58%	0.988	0.298	3.269	UNSURE
COLLIER	9	1.29%	32	2.32%	0.556	0.267	1.158	UNSURE
COLUMBIA	2	0.29%	16	1.16%	0.247	0.057	1.071	UNSURE
DADE	73	10.44%	110	7.97%	1.311	0.989	1.737	UNSURE
DESOTO	3	0.43%	7	0.51%	0.847	0.220	3.264	UNSURE
DIXIE	2	0.29%	2	0.14%	1.976	0.279	13.996	UNSURE
DUVAL	29	4.15%	57	4.13%	1.005	0.649	1.557	UNSURE
ESCAMBIA	16	2.29%	17	1.23%	1.859	0.945	3.658	UNSURE
FLAGLER	1	0.14%	9	0.65%	0.220	0.028	1.729	UNSURE
FRANKLIN	0	0.00%	5	0.36%	0.000			
GADSDEN	1	0.14%	7	0.51%	0.282	0.035	2.289	UNSURE
GILCHRIST	2	0.29%	1	0.07%	3.951	0.359	43.501	UNSURE

Table 3: Continued...

GLADES	4	0.57%	3	0.22%	2.634	0.591	11.737	UNSURE
GULF	0	0.00%	2	0.14%	0.000			
HAMILTON	1	0.14%	3	0.22%	0.659	0.069	6.319	UNSURE
HARDEE	4	0.57%	4	0.29%	1.976	0.496	7.876	UNSURE
HENDRY	1	0.14%	2	0.14%	0.988	0.090	10.875	UNSURE
HERNANDO	7	1.00%	5	0.36%	2.766	0.881	8.683	UNSURE
HIGHLANDS	8	1.14%	15	1.09%	1.054	0.449	2.473	UNSURE
HILLSBOROUGH	53	7.58%	84	6.08%	1.247	0.895	1.737	UNSURE
HOLMES	1	0.14%	5	0.36%	0.395	0.046	3.376	UNSURE
INDIAN RIVER	1	0.14%	18	1.30%	0.110	0.015	0.820	UNDER
JACKSON	5	0.72%	10	0.72%	0.988	0.339	2.879	UNSURE
JEFFERSON	0	0.00%	10	0.72%	0.000			
LAFAYETTE	1	0.14%	1	0.07%	1.976	0.124	31.539	UNSURE
LAKE	11	1.57%	26	1.88%	0.836	0.415	1.682	UNSURE
LEE	23	3.29%	33	2.39%	1.377	0.815	2.327	UNSURE
LEON	6	0.86%	24	1.74%	0.494	0.203	1.203	UNSURE
LEVY	7	1.00%	9	0.65%	1.537	0.575	4.109	UNSURE
MADISON	2	0.29%	7	0.51%	0.564	0.118	2.710	UNSURE
MANATEE	20	2.86%	21	1.52%	1.882	1.027	3.448	OVER
MARION	18	2.58%	16	1.16%	2.223	1.140	4.332	OVER
MARTIN	6	0.86%	24	1.74%	0.494	0.203	1.203	UNSURE
MONROE	7	1.00%	17	1.23%	0.814	0.339	1.952	UNSURE
NASSAU	5	0.72%	11	0.80%	0.898	0.313	2.575	UNSURE
OKALOOSA	5	0.72%	16	1.16%	0.617	0.227	1.678	UNSURE
OKEECHOBEE	2	0.29%	10	0.72%	0.395	0.087	1.798	UNSURE
ORANGE	24	3.43%	63	4.56%	0.753	0.475	1.194	UNSURE
OSCEOLA	12	1.72%	20	1.45%	1.185	0.583	2.411	UNSURE
PALM BEACH	27	3.86%	71	5.14%	0.751	0.487	1.159	UNSURE
PASCO	20	2.86%	35	2.53%	1.129	0.657	1.941	UNSURE
PINELLAS	37	5.29%	41	2.97%	1.783	1.154	2.755	OVER
POLK	49	7.01%	61	4.42%	1.587	1.102	2.286	OVER
PUTNAM	4	0.57%	10	0.72%	0.790	0.249	2.511	UNSURE
SANTA ROSA	4	0.57%	9	0.65%	0.878	0.271	2.841	UNSURE
SARASOTA	12	1.72%	26	1.88%	0.912	0.463	1.796	UNSURE
SEMINOLE	10	1.43%	14	1.01%	1.411	0.630	3.161	UNSURE
ST. JOHNS	7	1.00%	22	1.59%	0.629	0.270	1.464	UNSURE
ST. LUCIE	3	0.43%	15	1.09%	0.395	0.115	1.360	UNSURE
SUMTER	6	0.86%	18	1.30%	0.659	0.263	1.652	UNSURE
SUWANNEE	1	0.14%	7	0.51%	0.282	0.035	2.289	UNSURE
TAYLOR	4	0.57%	7	0.51%	1.129	0.332	3.844	UNSURE
UNION	0	0.00%	2	0.14%	0.000			
VOLUSIA	20	2.86%	37	2.68%	1.068	0.625	1.826	UNSURE
WAKULLA	3	0.43%	5	0.36%	1.185	0.284	4.946	UNSURE
WALTON	3	0.43%	10	0.72%	0.593	0.164	2.147	UNSURE
WASHINGTON	1	0.14%	4	0.29%	0.494	0.055	4.411	UNSURE
Total	699	100.00%	1381	100.00%	1.000			

Table 4 shows the distribution of fatal intersection crashes by the month. The crashes are generally evenly spread within the year except for the months of February, March and April. The highest number of crashes in the month of February with the least number of days is noticeable. The higher occurrence of crashes during these months of early spring season could be possibly due to higher tourist volume in Florida or people moving out more due to better weather after winter months.

Table 4: Fatal Intersection Crashes by Month

Month	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
January	58	8.3%	121	8.8%	0.947	0.702	1.278	Unsure
February	77	11.0%	106	7.7%	1.435	1.086	1.897	Over
March	76	10.9%	133	9.6%	1.129	0.865	1.474	Unsure
April	63	9.0%	120	8.7%	1.037	0.775	1.388	Unsure
May	54	7.7%	157	11.4%	0.680	0.506	0.913	Under
June	40	5.7%	105	7.6%	0.753	0.529	1.071	Unsure
July	51	7.3%	87	6.3%	1.158	0.830	1.617	Unsure
August	66	9.4%	111	8.0%	1.175	0.878	1.571	Unsure
September	50	7.2%	98	7.1%	1.008	0.726	1.400	Unsure
October	53	7.6%	119	8.6%	0.880	0.645	1.200	Unsure
November	58	8.3%	91	6.6%	1.259	0.918	1.728	Unsure
December	53	7.6%	133	9.6%	0.787	0.580	1.068	Unsure
Total	699	100.0%	1381	100.0%	1.000			

Although not very obvious a trend can be seen in fatal intersection crashes over the different days of the week from Table 5. Highest number of crashes on Fridays indicates the possible aggressive tendency of drivers trying to get away for the weekend. Fatal crash occurrence at intersections is over represented during the start of the week while weekends show under representation of fatal intersection crashes.

Table 5: Fatal Intersection Crashes by Day of Week

Day Of Week	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
Monday	102	14.59%	168	12.17%	1.200	0.954	1.508	UNSURE
Tuesday	108	15.45%	170	12.31%	1.255	1.004	1.569	OVER
Wednesday	109	15.59%	155	11.22%	1.389	1.107	1.744	OVER
Thursday	87	12.45%	192	13.90%	0.895	0.707	1.134	UNSURE
Friday	115	16.45%	217	15.71%	1.047	0.851	1.288	UNSURE
Saturday	99	14.16%	261	18.90%	0.749	0.606	0.927	UNDER
Sunday	79	11.30%	218	15.79%	0.716	0.563	0.911	UNDER
Total	699	100.00%	1381	100.00%	1.000			

A study of the fatal intersection crashes by the hour of the day shows that the evening peak hour witnesses most number of crashes. This observation from Table 6 is as expected since the evening peak hour has maximum number of drivers trying to get home from work. Broadly looking, the daytime fatal intersection crashes are far more in number than those at nighttime. Intersections primarily experience daytime traffic and limited nighttime traffic, hence the trend. The daytime hours from 8 am to 2 pm experience a uniform average hourly crash rate of around 30 crashes per hour, which further increases to reach a maximum of 53 crashes in the hour of 6 pm to 7 pm. The average fatal intersection crashes per hour then decreases from 7 pm till 3 am after which the number starts to increase steadily till morning peak traffic hour.

Table 6: Fatal Intersection Crashes by Hour of the Day

Hour of Day	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
19	41	5.87%	66	4.78%	1.227	0.840	1.792	UNSURE
20	44	6.29%	80	5.79%	1.087	0.760	1.551	UNSURE
21	24	3.43%	78	5.65%	0.608	0.388	0.951	UNDER
22	34	4.86%	66	4.78%	1.018	0.679	1.523	UNSURE
23	16	2.29%	57	4.13%	0.555	0.321	0.958	UNDER
0	33	4.72%	65	4.71%	1.003	0.666	1.509	UNSURE
1	10	1.43%	55	3.98%	0.359	0.184	0.700	UNDER
2	13	1.86%	71	5.14%	0.362	0.202	0.648	UNDER
3	4	0.57%	68	4.92%	0.116	0.043	0.317	UNDER
4	18	2.58%	46	3.33%	0.773	0.451	1.322	UNSURE
5	15	2.15%	65	4.71%	0.456	0.262	0.793	UNDER
6	32	4.58%	68	4.92%	0.930	0.616	1.400	UNSURE

Table 6: Continued...

7	19	2.72%	40	2.90%	0.938	0.547	1.607	UNSURE
8	31	4.43%	48	3.48%	1.276	0.819	1.984	UNSURE
9	29	4.15%	36	2.61%	1.592	0.984	2.571	UNSURE
10	27	3.86%	46	3.33%	1.160	0.727	1.847	UNSURE
11	39	5.58%	35	2.53%	2.201	1.407	3.440	OVER
12	36	5.15%	45	3.26%	1.581	1.029	2.425	OVER
13	31	4.43%	55	3.98%	1.114	0.723	1.712	UNSURE
14	34	4.86%	62	4.49%	1.083	0.720	1.629	UNSURE
15	44	6.29%	66	4.78%	1.317	0.909	1.906	UNSURE
16	39	5.58%	53	3.84%	1.454	0.971	2.175	UNSURE
17	33	4.72%	54	3.91%	1.207	0.790	1.842	UNSURE
18	53	7.58%	56	4.06%	1.870	1.298	2.690	OVER

Table 7 indicates that the lighting conditions do not really affect the probability of fatal intersection crashes. More than 50% of the fatal intersection crashes occur in daylight conditions. The most prominent driver error issue in fatal intersection crashes is Inattention or Misjudging of gap, which isn't really affected by the lighting condition as even in dark conditions more number of fatal intersection crashes occurred when artificial street lighting was present. The number of fatal intersection crashes is same during dawn and dusk lighting conditions.

Table 7: Fatal Intersection Crashes by Lighting Condition

Lighting Conditions	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
Daylight	400	57.22%	577	57.22%	1.367	1.252	1.497	OVER
Dusk	16	2.29%	19	2.29%	1.664	0.860	3.213	UNSURE
Dawn	16	2.29%	38	2.29%	0.832	0.467	1.480	UNSURE
Dark (Streetlights)	155	22.17%	302	22.17%	1.014	0.854	1.202	UNSURE
Dark (No Streetlights)	107	15.31%	437	15.31%	0.484	0.399	0.585	UNDER
Unknown	5	0.72%	7	0.72%	1.411	0.449	4.427	UNSURE
Total	699	100.00%	1381	100.00%	1.000			

Table 8 and Figure 16 represent the distribution of fatal intersection crashes according to the ADT on the major road in the intersection. It may seem surprising to find that the roadway

carrying least ADT has the highest number of fatal intersection crashes but this is correlated with the fact that there is lesser number of intersections on roads with higher ADT volumes. There is maximum number of fatal intersection crashes on roadways in the ADT range of 10,000 – 20,000, which is around a quarter of the total fatal intersection crashes, which further declines as the ADT range increases to 20 – 30,000 and beyond. Roadways within ADT range 50 – 60,000 show around 6 – 7 % of fatal intersection crashes and the % of fatal intersection crashes at or due to intersections on roadways with ADT higher than 70,000 is minimal and scarcely observed.

Table 8: Fatal Intersection Crashes by ADT on Major Road

ADT Range	No. of Crashes
More than 190000	1
130000 - 190000	2
90000 - 130000	4
70000 - 90000	2
60000 - 70000	18
50000 - 60000	43
40000 - 50000	75
30000 - 40000	126
20000 - 30000	155
10000 - 20000	169
Unknown	104

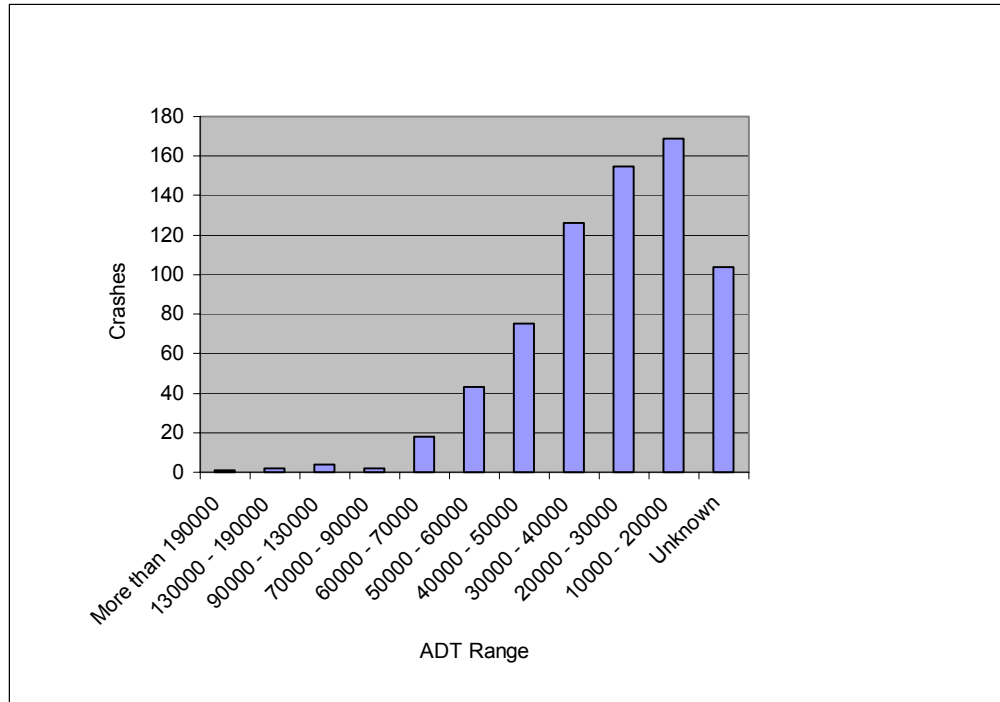


Figure 16: Fatal Intersection Crashes by ADT on Major Road

Table 9 shows the distribution of the fatal intersection crashes by the number of lanes on the major roadway. The 4 lane roads top the list of fatal intersection crashes by number of lanes with almost 50 % of fatal intersection crashes occurring at 4 lane roads followed by 6 lane roads and 2 lane roads with slightly over and slightly under 20 % of fatal intersection crashes occurring at each category. The high precedence of fatal intersection crashes on 4 lane roads may be due to the higher number of roads with 4 lanes statewide.

Table 9: Fatal Intersection Crashes by No. of Lanes on Major Roadway

No. of Lanes	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
4	335	47.93%	577	41.78%	1.147	1.039	1.267	OVER
6	158	22.60%	272	19.70%	1.148	0.965	1.365	UNSURE
2	136	19.46%	379	27.44%	0.709	0.596	0.843	UNDER
3	25	3.58%	30	2.17%	1.646	0.976	2.777	UNSURE

Table 9: Continued...

5	21	3.00%	21	1.52%	1.976	1.086	3.593	OVER
8	11	1.57%	45	3.26%	0.483	0.251	0.928	UNDER
7	8	1.14%	6	0.43%	2.634	0.918	7.562	UNSURE
1	4	0.57%	26	1.88%	0.304	0.106	0.867	UNDER
12	1	0.14%	4	0.29%	0.494	0.055	4.411	UNSURE
10	0	0.00%	20	1.45%	0.000			
9	0	0.00%	1	0.07%	0.000			

A further closer look into the fatal intersection crash distribution by number of lanes according to the roadway type being divided or undivided is shown by Figure 17. The figure shows that almost in each case the fatal intersection crashes on divided roadways is higher than those on undivided roadways. The 2 lane roadways stand out as an exception to this general trend with almost 80 % of the fatal intersection crashes on 2 lane roadways occurring on undivided roadways. Also fatal intersection crashes on 5 lane roadways are almost equally distributed over divided and undivided roadways. There are a few cases where the roadway type, whether divided or undivided, was not known and are also shown in Figure 17.

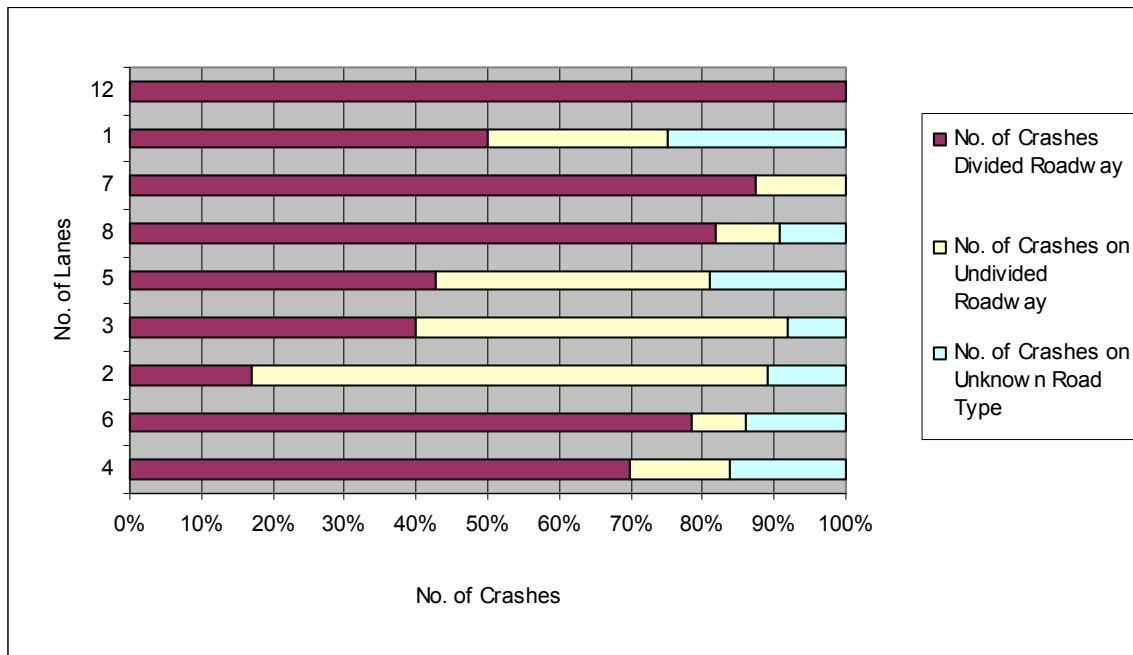


Figure 17: Fatal Intersection Crashes by No. of Lanes on Divided and Undivided Roadway

CHAPTER 5

FATAL INTERSECTION CRASHES BY GEOGRAPHICAL AREA

Fatal intersection crashes are distributed by geographical area in Table 10 and Figure 18. The fatal intersection crashes are significantly over represented in the suburban regions and the same are quite under represented in the rural areas. In the urban areas the fatal intersection crashes are almost on the border of being over represented with almost 40 % of total fatal intersection crashes occurring at or being influenced by urban intersections.

Table 10: Distribution of Fatal Intersection Crashes by Geographical Area

Geo. Area	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
Urban	275	39.34%	516	39.34%	39.34%	0.938	1.180	UNSURE
Suburban	233	33.33%	255	33.33%	33.33%	1.554	2.110	OVER
Rural	191	27.32%	610	27.32%	27.32%	0.540	0.707	UNDER

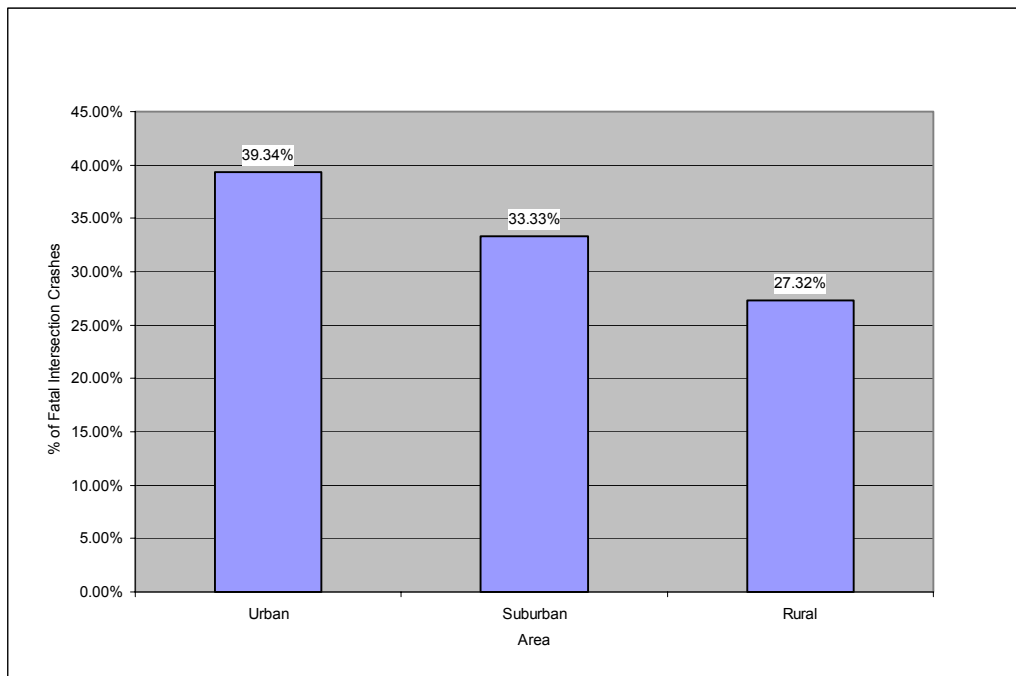


Figure 18: Fatal Intersection Crashes by Geographical Area

Table 11 and Figure 19 show the distribution of fatal intersection crashes within the geographical areas according to the traffic control. As expected the urban intersections have the highest percentage of crashes at or due to signal controlled intersections. Other traffic controls here include posted controls such as No U – Turn etc. that restrict the movements at intersections.

Table 11: Distribution of Fatal Intersection Crashes by Traffic Control in Geographical Area

Traffic Control	Total	Urban	Suburban	Rural
Traffic Signal	252	132	86	34
Stop Sign	187	54	69	67
Flashing Light	12	4	3	5
Yield Sign	7	0	3	4
Stop Sign and Flashing Light	19	5	6	9
Other	23	8	3	12
No Control	199	76	63	60

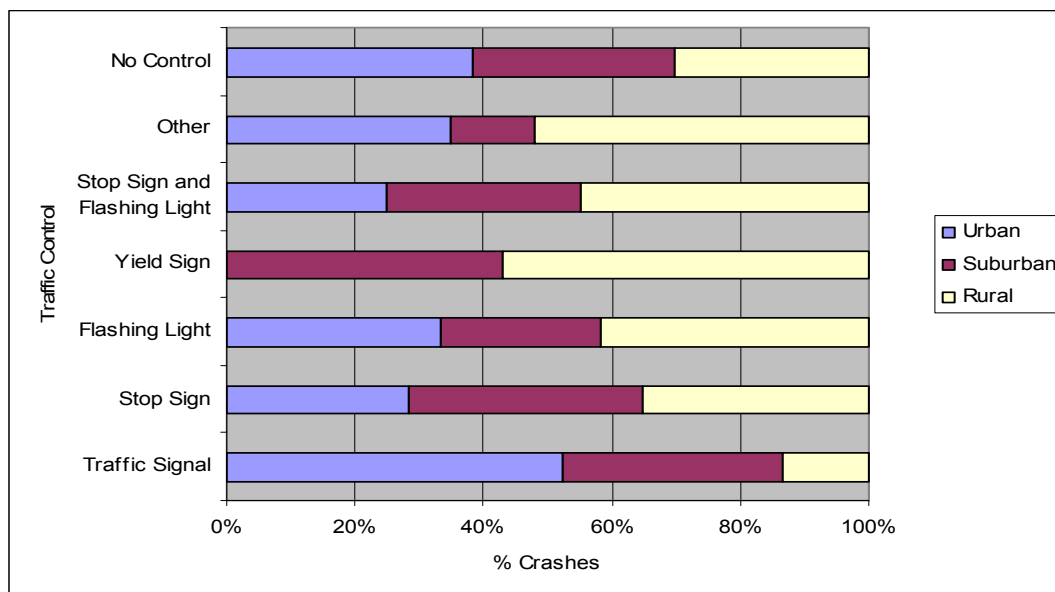


Figure 19: Fatal Intersection Crashes by Traffic Control in Geographical Area

Table 12 and Figure 20 show the distribution of fatal intersection crashes in geographical areas according to the crash hour. It can be noted that the morning peak hour suffers most fatal intersection crashes in the suburban areas with more than 55 % of the fatal intersection crashes within the morning peak hour occurring in the suburban areas. This observation can be validated with the fact that during that hour most people are driving from residential, generally rural area, to business area and get into a crash on their way, which more often happens to be in the suburban areas. On similar grounds the higher proportion of fatal intersection crashes in rural areas in the earlier morning hours of 6 am can be explained. Thus also, the almost 50 % fatal intersection crashes in urban areas in the later part of morning peak, 9 am to 10 am, can be explained. This trend of fatal intersection crashes in rural – suburban – urban areas from earlier in the morning to later in the morning till start of office hours is in consistency of the commute of drivers from residential to urban areas during those hours. Similar trend cannot be observed though for evening hours for drivers returning from urban to rural area.

Table 12: Fatal Intersection Crashes by Hour of Day in Geographical Area

Day	Total At Intersections		Urban		Suburban		Rural	
	Num.		Num.	Per.	Num.	Per.	Num.	
19	41	5.87%	20	7.27%	9	3.86%	12	6.28%
20	44	6.29%	17	6.18%	13	5.58%	14	7.33%
21	24	3.43%	14	5.09%	3	1.29%	7	3.66%
22	34	4.86%	13	4.73%	14	6.01%	7	3.66%
23	16	2.29%	7	2.55%	6	2.58%	3	1.57%
0	33	4.72%	11	4.00%	12	5.15%	10	5.24%
1	10	1.43%	2	0.73%	6	2.58%	2	1.05%
2	13	1.86%	9	3.27%	4	1.72%	0	0.00%
3	4	0.57%	1	0.36%	1	0.43%	2	1.05%
4	18	2.58%	8	2.91%	6	2.58%	4	2.09%
5	15	2.15%	8	2.91%	2	0.86%	5	2.62%
6	32	4.58%	9	3.27%	7	3.00%	16	8.38%
7	19	2.72%	7	2.55%	6	2.58%	6	3.14%
8	31	4.43%	5	1.82%	17	7.30%	9	4.71%
9	29	4.15%	14	5.09%	9	3.86%	6	3.14%
10	27	3.86%	11	4.00%	9	3.86%	7	3.66%
11	39	5.58%	17	6.18%	9	3.86%	13	6.81%
12	36	5.15%	15	5.45%	14	6.01%	7	3.66%
13	31	4.43%	9	3.27%	12	5.15%	10	5.24%
14	34	4.86%	11	4.00%	17	7.30%	6	3.14%
15	44	6.29%	19	6.91%	16	6.87%	9	4.71%

Table 12: Continued...

16	39	5.58%	17	6.18%	12	5.15%	10	5.24%
17	33	4.72%	14	5.09%	11	4.72%	8	4.19%
18	53	7.58%	17	6.18%	18	7.73%	18	9.42%
Total	699	100%	275	100%	233	100%	191	100%

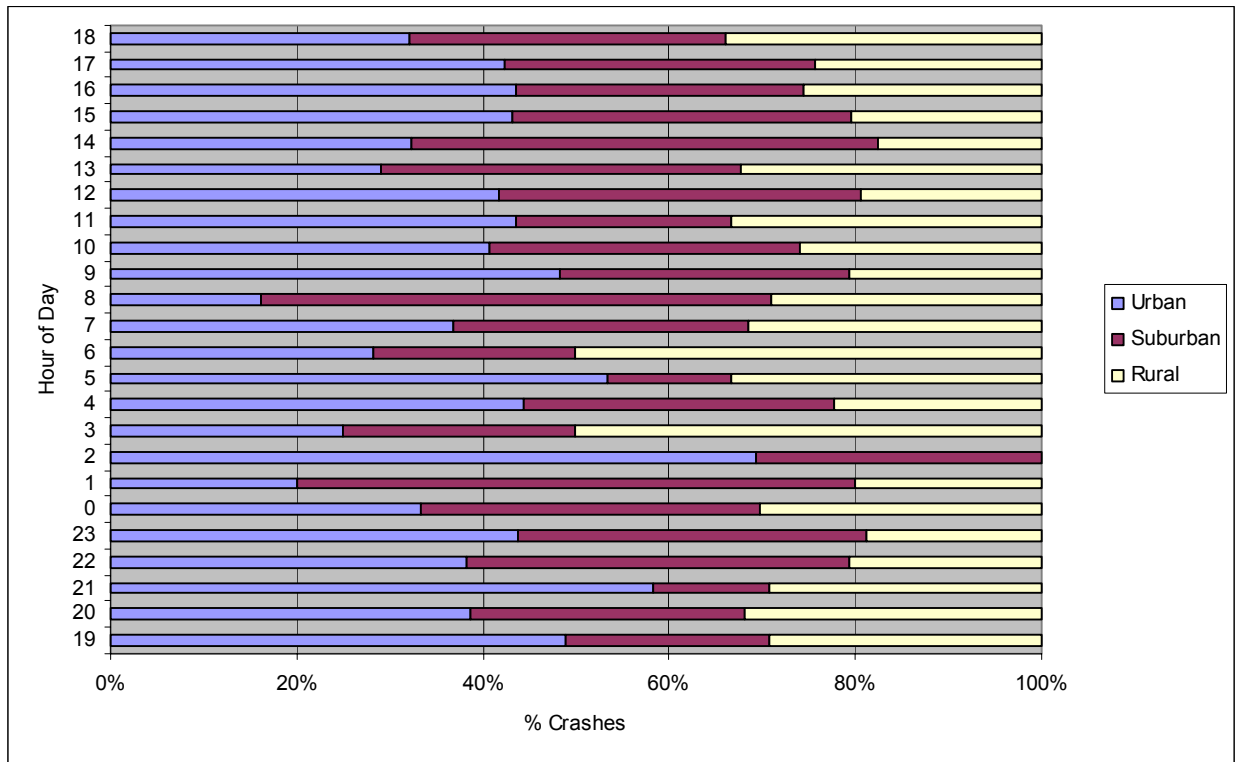


Figure 20: Fatal Intersection Crashes in Geographical Area by Crash Hour

Table 13 and Figure 21 show the distribution of fatal intersection crashes in rural and urban areas by lighting conditions. The geographical area here is more broadly classified in just two categories of rural and urban. As for total fatal intersection crash distribution in rural and urban areas, the fatal intersection crashes are over represented in rural areas for almost all lighting conditions except the ones in dark with streetlights, which is as expected since more number of intersections in urban area will be artificially lighted than in rural areas.

Table 13: Fatal Intersection Crashes in Rural and Urban Area by Lighting Conditions

Lighting Condition	Rural		Urban		Rural ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Daylight	221	55.7%	179	59.3%	0.939	0.826	1.068	Unsure
Dusk	11	2.8%	5	1.7%	1.674	0.588	4.766	Unsure
Dawn	13	3.3%	3	1.0%	3.296	0.948	11.465	Unsure
Dark (Streetlights)	63	15.9%	92	30.5%	0.521	0.392	0.692	Under
Dark (No Streetlights)	87	21.9%	20	6.6%	3.309	2.084	5.255	Over
Unknown	2	0.5%	3	1.0%	0.507	0.085	3.016	Unsure
All Not Daylight	176	44.3%	123	40.7%	1.088	0.914	1.297	Unsure
Total	397	100.0%	302	100.0%	1.000			

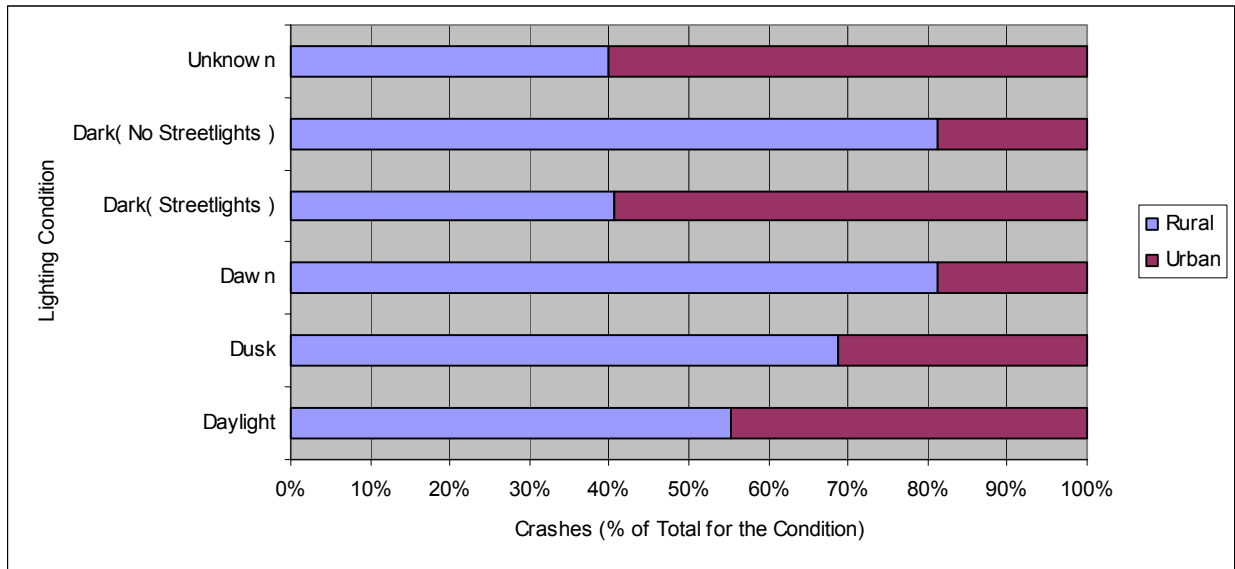


Figure 21: Fatal Intersection Crashes in Rural and Urban Areas by Lighting Conditions

CHAPTER 6

CRASH TYPE AND VEHICLE MOVEMENT

This chapter deals with the various vehicle movements involved in the fatal intersection crashes. Table 14 shows the distribution of fatal intersection crashes classified broadly by crash type. The crash types mentioned in the table are self-explanatory and aren't separately defined here. The table shows that fatal intersection crashes are primarily dominated by Angled Collisions. Almost 10 % of fatal intersection crashes are those that involve pedestrians; these are ranked second followed by rear end collisions, which account for around 8 % of total fatal intersection crashes. There are negligible head on collisions at or due to intersections.

Table 14: Fatal Intersection Crashes Classified Broadly by Crash Type

Broad Crash Type	No. of Crashes
Angled Collision	540
Rear End	60
Head On	3
Pedestrian	69
Bicycle	27

The fatal intersection crashes are further looked at according to the crash type at much detailed level and the distribution of fatal intersection crashes by crash type is shown in Table 15. The pedestrian crashes are grouped together and the sub classification in the group is not shown since the pedestrian crashes have whole different chapter dedicated to their analysis. A closer look at the distribution some vital information about the fatal intersection crashes. It should be noted that more than 50 % of fatal intersection crashes occur within the crash type group Change Traffic Way / Turning. The Intersecting Paths crash group constitutes around 25 % of the fatal intersection crashes.

Within the Change Traffic Way / Turning crash group from Table 15, the Initial Opposite Directions/Oncoming Traffic, that is left turn oncoming crashes are highly over represented with more than 50 % of fatal intersection crashes of the type within the crash group. Also, the Turn into Opposite Direction / Cross Traffic is highly over represented with around 40 % of fatal intersection crashes of the type within the group. It is worth noting here that both these highly over represented crash types, involve left turning movement by at least one of the vehicles involved in the crash. Since these two crash types mentioned form more than 90 % of the fatal intersection crashes within their crash group, which represents more than 50 % of the total fatal intersection crashes, it can be said that in more than 50 % of the fatal intersection crashes a left turning vehicle is involved. A revealing observation is that in the Change Traffic Way / Turn crash group, the number of crashes of type Turn into Opposite Direction / Cross Traffic is far more than those of type Turn / Merge into Same Direction. This indicates that when the drivers are turning left across a roadway, they are more often hit by vehicle in the near lanes on the cross road than the far lanes where they want to merge. This may be because drivers check for far lane traffic where they are merging and are inattentive or fail to judge the gap adequately for vehicles in the near lanes. In the Intersecting Paths crash group from Table 15, it can be seen that the not at fault approaching from left and right are almost equally distributed within the category. There is just a scattered occurrence of vehicle backing into the intersecting path of a vehicle.

Table 15: Fatal Intersection Crashes by Crash Type

Crash Type Group	Crash Type	No. of Crashes	% of Total Crashes
Pedestrian	Pedestrian Crash At or Influenced by Intersection	69	9.87%
Run Off Road / Single Vehicle	Right Roadside Departure	4	0.57%
	Right Roadside Departure With Control Loss	9	1.29%
	Left Roadside Departure	1	0.14%
	Left Roadside Departure With Control Loss	3	0.43%
	Forward Impact	4	0.57%
	Other	1	0.14%
Same Direction	Rear End	56	8.01%
	Rear End With Avoid Impact	2	0.29%
	Sideswipe Angle	1	0.14%

Table 15: Continued...

Opposite Direction	Head-On	2	0.29%
	Forward Impact With Control Loss	1	0.14%
Change Traffic way / Turning	Initial Opposite Directions/Oncoming Traffic	197	28.18%
	Initial Same Direction	15	2.15%
	Turn/Merge Into Same Direction	14	2.00%
	Turn Into Opposite Directions/Cross Traffic	148	21.17%
	Evasive Action To Avoid Turning/Merging Vehicle	1	0.14%
Intersecting Paths	Not At Fault Approaching from Left	82	11.73%
	Not At Fault Approaching from Right	85	12.16%
	Backing	4	0.57%

Table 16 below shows the distribution of the fatal intersection crashes according to the movements of the vehicles involved in a crash. The table says that there is maximum number of fatal intersection crashes when both the vehicles in the crash are moving straight across the intersection followed by left turn oncoming movements. However on a closer look, it can be noticed that most fatal intersection crashes occur when one of the vehicles involved in the crash is making a left turn. Thus left turners contribute to more than 50 % of fatal intersection crashes.

Table 16: Distribution of Fatal Intersection Crashes According to the Relative Movements of Vehicles Involved in a fatal intersection crash

General Movement of Vehicles Involved in Crash	No. Of Crashes
Left Turn Vs. Oncoming	190
Left Turn Vs. Crossing	138
Straight Vs. Straight	238
Rear End	62
Other	69

Table 17 and Figure 22 represent the distribution of vehicles involved in fatal intersection crashes by the vehicle movement and the driver fault involvement. It shows that a turning vehicle involved in a fatal intersection crash is much more likely to be at fault than it being not at fault in the fatal intersection crash. A left turning or U-Turning vehicle is at fault more than 80 % of the

times when it is involved in a fatal intersection crash while a right turning is at fault around 70 % of the times when involved in a fatal intersection crash. A straight-ahead vehicle has not at fault to at fault distribution as almost 60 – 40. The absence of a bar for properly parked vehicle is obvious.

Table 17: Fatal Intersection Crashes by Vehicle Movement

Vehicle Movement	No. of Vehicles	Driver At Fault	Driver Not At Fault	Unknown
Straight Ahead	941	352	579	10
Slowing / Stopped / Stalled	115	10	104	1
Making Left Turn	313	256	55	2
Backing	2	2	0	0
Making Right Turn	28	19	9	0
Changing Lanes	5	5	0	0
Properly Parked	7	0	0	0
Making U - Turn	13	12	1	0
Passing	4	2	2	0
All Other	29	21	7	1
Unknown	4	2	1	1

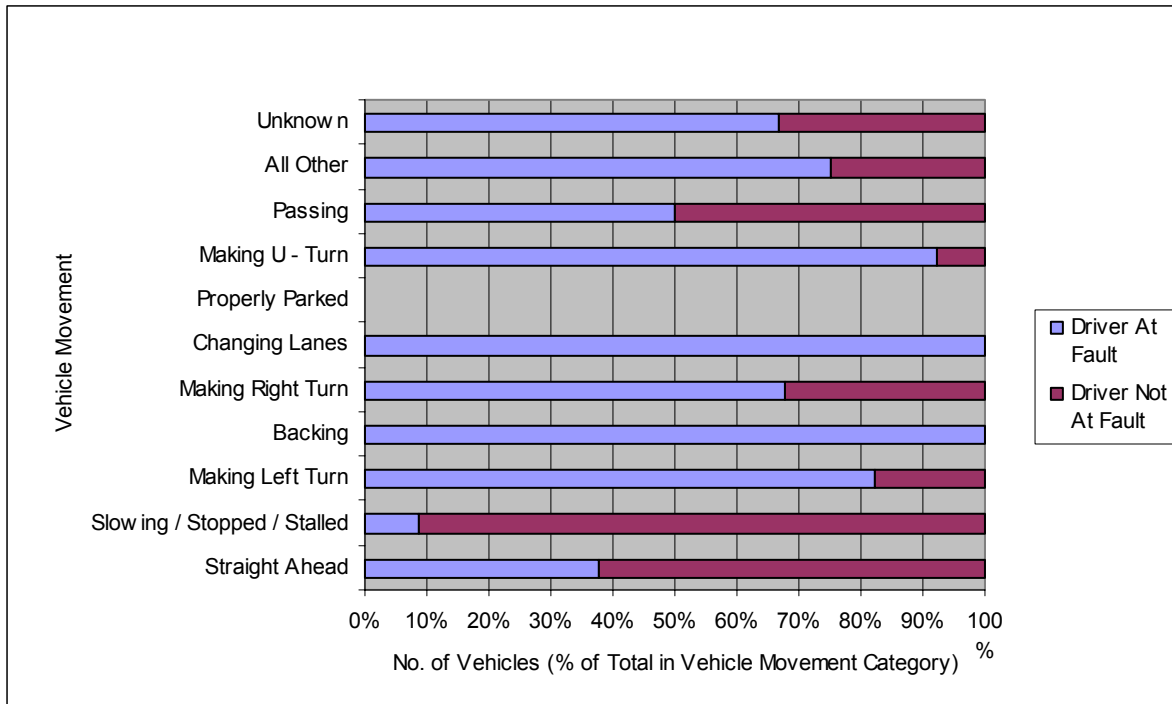


Figure 22: Fatal Intersection Crashes by Vehicle Movement

Table 18 and Figure 23 show the distribution of vehicles involved in fatal intersection crashes according to the point of impact for the vehicle with the driver fault involvement. Almost 65 % of the times a vehicle with point of impact as the front end is not at fault in a fatal intersection crash as this point of impact mostly suggests the vehicle movement as straight ahead striking a turning or crossing vehicle. The times when the vehicle with front end impact is at fault is when it rear ends another vehicle or may be when the crossing vehicle strikes the side of a crossing straight ahead or oncoming vehicle, which is likely only in 35 % of the vehicle with front end impact in fatal intersection crashes. The numbers for other point of impacts are also in consistency with the vehicle movement numbers in fatal intersection crashes. Table 18 and Figure 23 also show that a vehicle when rear-ended is least likely to be at fault in a fatal intersection crash.

Table 18: Vehicles Involved in Fatal Intersection Crashes by Point of Impact

Point of Impact	No. of Vehicles	Driver At Fault	Driver Not At Fault	Unknown
Front End	549	193	352	4
Right Front Corner	102	37	62	3
Right Front Quarter Panel	58	33	22	3
Right Front Door	153	118	34	1
Right Rear Door	35	23	11	1
Right Rear Quarter Panel	15	8	7	0
Right Rear Corner	11	6	4	1
Rear End	41	5	36	0
Left Rear Corner	11	5	5	1
Left Rear Quarter Panel	19	10	9	0
Left Rear Door	30	16	14	0
Left Front Door	143	99	42	2
Left Front Quarter Panel	58	31	24	3
Left Front Corner	124	40	81	3
Hood	6	2	4	0
Roof	7	2	5	0
Under Carriage	10	2	8	0
Overturn	11	8	3	0
Windshield	3	1	2	0
Trailer	48	25	23	0
Unknown	27	17	10	0

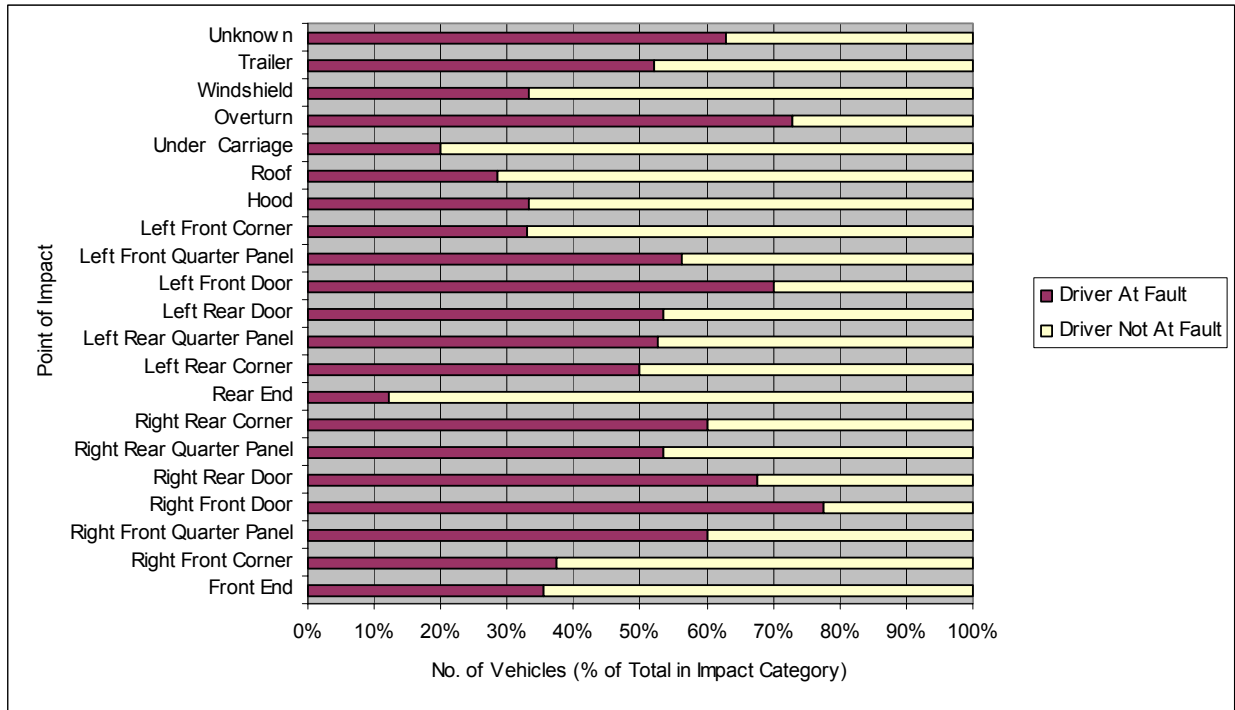


Figure 23: Driver Fault Distribution by Point of Impact of Vehicles Involved in Fatal Intersection Crashes

CHAPTER 7

ROADWAY CHARACTERISTICS AND ISSUE

This chapter looks at the various roadway characteristics and their distribution for fatal intersection crashes and then goes on to discuss the various roadway issues that have a contribution in the occurrence of the fatal intersection crashes. Figure 24 shows the distribution of fatal intersection crashes according to the maximum posted speed limit on the intersecting roadways. Around 40 % of the fatal intersection crashes occurred at or due to intersections with maximum posted speed limit of 45 MPH and a little over 20 % occurred at or due to intersections with maximum posted speed limit of 55 MPH. Speed limit on the road plays a vital role on the driver behavior and so also the stopping sight distance. A roadway with higher speed limit should have proper signage for the presence of an intersection or an access point in the roadway and the driver on the major roadway should be alerted and expect cross traffic.

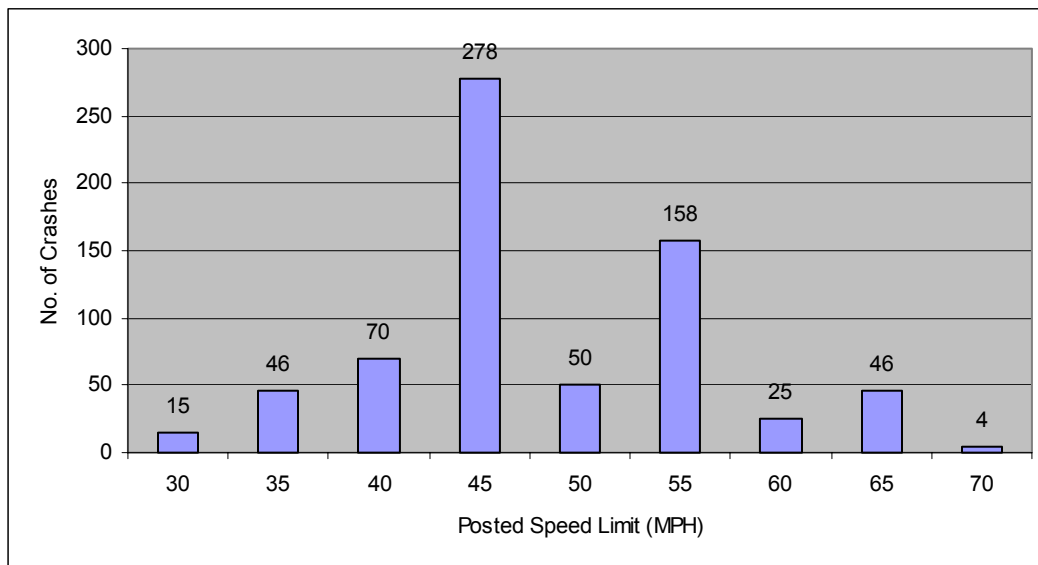


Figure 24: Fatal Intersection Crashes by Maximum Posted Speed Limit

Table 19 shows the distribution of fatal intersection crashes according to the difference in the posted speed limits on the intersecting roads. It is evident that majority of the crashes occurred at intersections where the involved vehicles had the same posted speed limit. This includes the left turn oncoming and rear end crashes which primarily occur for vehicles on the same roadway. These also include the pedestrian crashes where only one vehicle is involved. There are also noticeable numbers of fatal intersection crashes that occurred on intersecting roadways with posted speed limits differing by 10 – 20 MPH. The higher differences of 40 – 45 MPH are on ramp junctions, with intersecting roadway being a freeway or other limited access, high speed facility.

Table 19: Distribution of Fatal Intersection Crashes According to Difference in Posted Speed Limits on Intersecting Roads

Posted Speed Difference on Intersecting Roads	No. of Crashes
0	581
5	17
10	24
15	28
20	20
25	13
30	9
35	1
40	2
45	4

Traffic control plays a vital role in the intersection crashes with highest number of fatal intersection crashes occurring at or due to signal controlled intersections. Table 20 and Figure 25 show the distribution of fatal intersection crashes according to the traffic control present at the intersection. The fatal intersection crashes at signalized intersections comprise almost 35 % of the total fatal intersection crashes. Around 30 % of the fatal intersection crashes occurred at or due to uncontrolled intersections. Stop Sign controlled intersections contribute around another 30 % to the fatal intersection crashes. The portion of fatal intersection crashes at or due to intersections controlled by other traffic control devices is not too large and makes up the

remaining 5 %. The other traffic controls include such controls as no passing zones, posted No U – Turn Signs, special restricted speed limits. Table 20 shows the distribution of fatal intersection crashes by traffic control at the intersection. It should be noted here that this is generally the control on the movement of the at-fault vehicle for example uncontrolled in left turn oncoming crashes often have stop signs on the other movement, or it could be a driveway, which is completely uncontrolled with only an implicit expected driver action of yielding to traffic on the main roadway.

Table 20: Fatal Intersection Crashes by Traffic Control

Traffic Control	No. of Crashes	% Crashes
Traffic Signal	252	36.05%
Stop Sign	187	26.75%
Flashing Light	12	1.72%
Yield Sign	7	1.00%
Stop Sign and Flashing Light	19	2.72%
Other	23	3.29%
No Control	199	28.47%

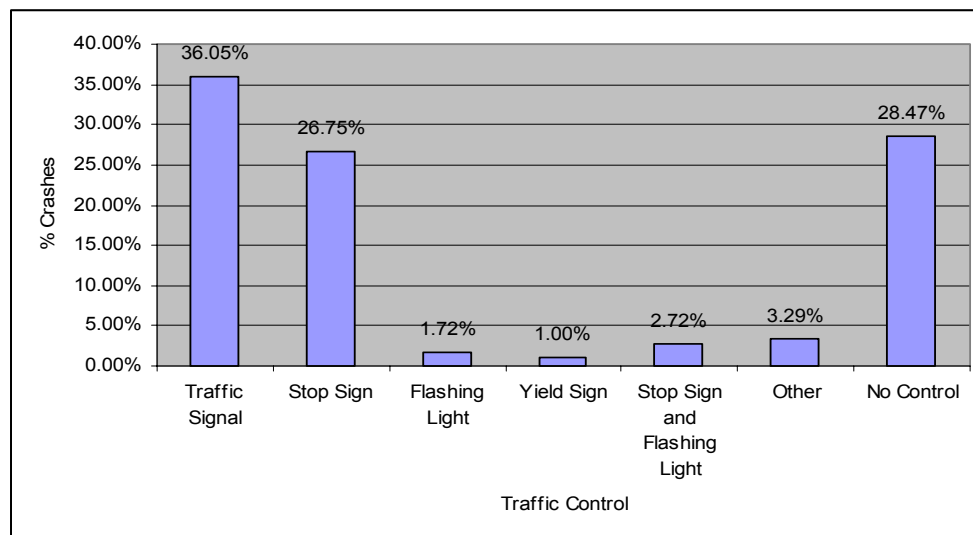


Figure 25: Distribution of Fatal Intersection Crashes by Traffic Control

Table 21 below shows the distribution of the fatal intersection crashes according to the class and category of the roadway on which the crash occurred. The categories of roadway used here are same as for the report except the category Ramp Junctions / Other in the table is a combined category for ramp junctions on Rural, Urban Interstates and Urban Toll Roads and Other Limited Access Roads because of the scattered few instances of fatal intersection crashes on these roadway class categories. For the non-intersection crashes the Ramp Junctions / Other category also includes all the limited access roadways that these ramp junctions are on. The fatal intersection crashes occurring within this category of “Ramp Junctions / Other” are chiefly ramp junction crashes behaving as fatal intersection crashes. It is evident from the table that suburban 4 – 5 divided roadways with a raised median witness the most number of fatal intersection crashes, almost a 20 %. Generally noticing the fatal intersection crashes are mostly concentrated on 4 – 5 lane divided roadways. Within the 4 – 5 lane roadways, the suburban class roadways experience maximum number of fatal intersection crashes followed by urban class roadways with rural class roadways not lagging too far behind in number of fatal intersection crashes. Also, 6 + lanes urban class divided roadways contribute almost another 20 % of total fatal intersection crashes. In the undivided roadways, the rural 2 – 3 lane roadways have the most number of fatal intersection crashes with almost a 70 % of the fatal intersection crashes on undivided roadways occurring on this category of roadway. This observation indicates two possibilities that in addition to there being most number of 2 – 3 lane undivided roadway intersections in rural areas, these intersections may need more forgiving roadway design in terms of speed limits and sight distances.

Table 21: Distribution of Fatal Intersection Crashes by Crash Road Class Category

Road Category	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
Ramp Junctions / Other	12	1.72%	516	37.36%	0.046	0.026	0.081	UNDER
Urban 2-3ln 2wy Divided Raised	1	0.14%	0	0.00%				
Urban 2-3ln 2wy Divided Paved	4	0.57%	2	0.14%	3.951	0.726	21.520	UNSURE
Urban 2-3ln 2wy Undivided	1	0.14%	7	0.51%	0.282	0.035	2.289	UNSURE
Suburban 2-3ln 2wy Divided Raised	1	0.14%	0	0.00%				

Table 21: continued...

Suburban 2-3In 2wy Divided Paved	16	2.29%	9	0.65%	3.512	1.560	7.908	OVER
Suburban 2-3In 2wy Undivided	17	2.43%	64	4.63%	0.525	0.310	0.889	UNDER
Rural 2-3In 2wy Divided Raised	2	0.29%	1	0.07%	3.951	0.359	43.501	UNSURE
Rural 2-3In 2wy Divided Paved	14	2.00%	13	0.94%	2.128	1.006	4.502	OVER
Rural 2-3In 2wy Undivided	62	8.87%	228	16.51%	0.537	0.412	0.701	UNDER
Urban 4-5In 2wy Divided Raised	56	8.01%	40	2.90%	2.766	1.863	4.107	OVER
Urban 4-5In 2wy Divided Paved	56	8.01%	56	4.06%	1.976	1.380	2.829	OVER
Urban 4-5In 2wy Undivided	11	1.57%	13	0.94%	1.672	0.753	3.712	UNSURE
Suburban 4-5In 2wy Divided Raised	142	20.31%	117	8.47%	2.398	1.911	3.009	OVER
Suburban 4-5In 2wy Divided Paved	12	1.72%	11	0.80%	2.155	0.956	4.860	UNSURE
Rural 4-5In 2wy Divided Raised	96	13.73%	112	8.11%	1.693	1.310	2.190	OVER
Urban 6+Ln 2wy Divided Raised	111	15.88%	108	7.82%	2.031	1.583	2.604	OVER
Urban 6+Ln 2wy Divided Paved	19	2.72%	18	1.30%	2.085	1.102	3.948	OVER
Suburban 6+Ln 2wy Divided Raised	46	6.58%	45	3.26%	2.020	1.353	3.015	OVER
Suburban 6+Ln 2wy Divided Paved	1	0.14%	1	0.07%	1.976	0.124	31.539	UNSURE
Rural 6+Ln 2wy Divided Raised	6	0.86%	2	0.14%	5.927	1.199	29.290	OVER
One Way	13	1.86%	18	1.30%	1.427	0.703	2.895	UNSURE
Total	699	100 %	1381	100 %				

Median width of the road at an intersection affects the sight triangles and as such is a potential factor when it comes to fatal intersection crashes. Table 22 shows the distribution of the fatal intersection crashes according to the median width of the major roadway in the fatal intersection crash. It can be seen that roadways with a median width in the range 20 – 30 feet suffer from lesser number of fatal intersection crashes as compared to the ranges above and below it in Table 22. It could be worthwhile to note here that the number of fatal intersection crashes for median width range of 30 – 40 feet is overly represented since there are not so many roadways with 40 feet of median.

Table 22: Distribution of Fatal Intersection Crashes by Median Widths of the Major Roadway

Median Width Range	No. Of Crashes
5 - 10 Feet	31
10 - 20 Feet	211
20 - 30 Feet	114
30 - 40 Feet	140
40 - 50 Feet	60
More Than 50 Feet	40
Unknown	103

As mentioned earlier a fatal intersection crash is not the result of an isolated driver error or an isolated roadway issue. More often it is a combination of driver errors and if there is a roadway issue, it adds to the probability of crash occurrence.

Table 23 shows the driver error issue distribution in the fatal intersection crashes coupled with a roadway issue for that crash. The numbers in the boxes indicate number of crashes due to a particular driver error added with the contribution of a Roadway Issue. Thus, for example, the first column of Table 23 shows the crashes that had DUI as a Driver Error Issue and which were coupled with a Sight Distance or Roadway Geometry or a Traffic Operation Issue. It is seen that there are 14 fatal intersection crashes with a potential sight distance issue while the driver was DUI, whereas in 149 fatal intersection crashes there was no roadway issue involved that contributed to the occurrence of the crash, there could be other driver issues involved in such crashes. The numbers do not add up as columns to give total number of fatal intersection crashes since a particular crash may involve a combination of Driver Error and Roadway Issues and as such the number should be looked at as individual figures in the table. Table 24 shows the percentage of crashes with a particular driver error that had the listed roadway issue. The roadway issues contributing to 10% or more of the fatal intersection crashes with a driver error issue have been highlighted. Thus the table reveals that in 31% of the fatal intersection crashes when a rear end collision was involved, traffic operation issues contributed to the crash to a certain extent. The primary traffic operation issue observed in the rear end crashes is the absence of a turning lane or excess amount of access on a high-speed road. So also 14% of the fatal intersection crashes when the driver misjudged a gap, a sight distance issue contributed to the crash.

Table 23: Driver Issues with Roadway Issues in Fatal Intersection Crashes

	DUI	Speeding	Inattention / Careless	Improper Turn	Ran Red Light	Ran Stop Sign	Rear End	Misjudged Gap
Sight Distance Issue	14	17	35	3	4	7	4	36
Roadway Geometry Issue	4	8	19	4	7	3	6	18
Traffic Operation Issue	8	19	32	10	11	7	19	21
Signalization Issue	2	7	13	1	10	2	0	7
Signage Issue	5	5	15	3	2	10	2	7
Environment Issue	11	8	24	2	4	4	2	12
Pedestrian Facility Issue	9	2	7	0	2	1	0	5
Non Issue	149	132	338	45	92	55	35	193

Table 24: Percentage Comparison of Driver Issues and Roadway Issues

	DUI	Speeding	Inattention / Careless	Improper Turn	Ran Red Light	Ran Stop Sign	Rear End	Misjudged Gap
Sight Distance Issue	8%	10%	8%	5%	3%	9%	6%	14%
Roadway Geometry Issue	2%	5%	4%	7%	6%	4%	10%	7%
Traffic Operation Issue	4%	11%	7%	17%	9%	9%	31%	8%
Signalization Issue	1%	4%	3%	2%	8%	3%	0%	3%
Signage Issue	3%	3%	4%	5%	2%	14%	3%	3%
Environment Issue	6%	5%	6%	3%	3%	5%	3%	5%
Pedestrian Facility Issue	5%	1%	2%	0%	2%	1%	0%	2%
Non Issue	82%	75%	79%	75%	78%	74%	56%	75%

Table 25 shows the roadway issue in fatal intersection crashes. These numbers again like mentioned in the earlier paragraph do not add up and should be looked at as individual figures. For example, the figure 68 in Table 25 indicates that there are 68 fatal intersection crashes that

involved a sight distance issue (not in isolation). Thus, it says that almost 10 % of the fatal intersection crashes have a potential sight distance issue, which may or may not be coupled with any other Roadway Issue. Similarly, the number “27” in the first row of Table 25 indicates that there are 27 fatal intersection crashes with a potential Sight Distance Issue coupled with or due to a Roadway Geometry issue. Table 26 shows the percentage of fatal intersection crashes with roadway issues. Thus the first row of Table 26 shows that 10% of fatal intersection crashes had a sight distance issue and that 4% of fatal intersection crashes had a sight distance issue coupled with a roadway geometry issue.

Table 25: Roadway Issues in Fatal Intersection Crashes

	Sight Distance Issue	Roadway Geometry Issue	Traffic Operation Issue	Signalization Issue	Signage Issue	Environment Issue	Pedestrian Facility Issue
Sight Distance Issue	68	27	13	0	4	17	4
Roadway Geometry Issue		37	13	2	3	2	0
Traffic Operation Issue			70	15	15	4	5
Signalization Issue				28	5	0	3
Signage Issue					24	2	1
Environment Issue						44	7
Pedestrian Facility Issue							27

Table 26: Percentage of Fatal Intersection Crashes with Roadway Issues

	Sight Distance Issue	Roadway Geometry Issue	Traffic Operation Issue	Signalization Issue	Signage Issue	Environment Issue	Pedestrian Facility Issue
Sight Distance Issue	10%	4%	2%	0%	1%	2%	1%
Roadway Geometry Issue		5%	2%	0%	0%	0%	0%
Traffic Operation Issue			10%	2%	2%	1%	1%
Signalization Issue				4%	1%	0%	0%
Signage Issue					3%	0%	0%
Environment Issue						6%	1%
Pedestrian Facility Issue							4%

Table 27 shows the distribution of contributing cause factors according to their significance in the occurrence of the fatal intersection crashes. It is not too surprising to note after all the case reviews that the primary contributing cause in almost all the fatal intersection

crashes is a human factor. The scattered instances when a roadway factor was a primary contributing factor were due to either a signalization issue or in a couple of cases a sight distance issue. The signals were not functioning properly at the time of crash and had conflicting movements permitted. In the instance of DHSMV crash number 57580668, a very wide intersection, with 7 lanes and a median to cross, permits a through pedestrian movement and a left turning vehicle movement. Such signalization compels the driver to divert attention from the vehicles to look for pedestrian and can cause a vehicular crash or if the driver is attentive towards vehicles, a potential pedestrian crash is in the making. Figure 26 below shows the crash reconstruction diagram for the fatal intersection crash mentioned above. It may be noted here that since the intersection has a mall at one corner and a major grocery store at the other, there is definitely significant pedestrian and vehicular movement at the crosswalks. Also, the fact that the pedestrian was 87 years of age should not offset the attention from the primary issue that lead to the crash.

Table 27: Fatal Intersection Crashes by Contributing Causes

Contributing Factor	No. of Crashes With Factor as Primary	No. of Crashes With Factor as Secondary	No. of Crashes With Factor as Tertiary
ROADWAY	6	67	59
ENVIRONMENT	3	46	43
VEHICLE	6	47	36
HUMAN	678	307	88
OTHER/UNKNOWN	6	0	0
NONE	0	232	473

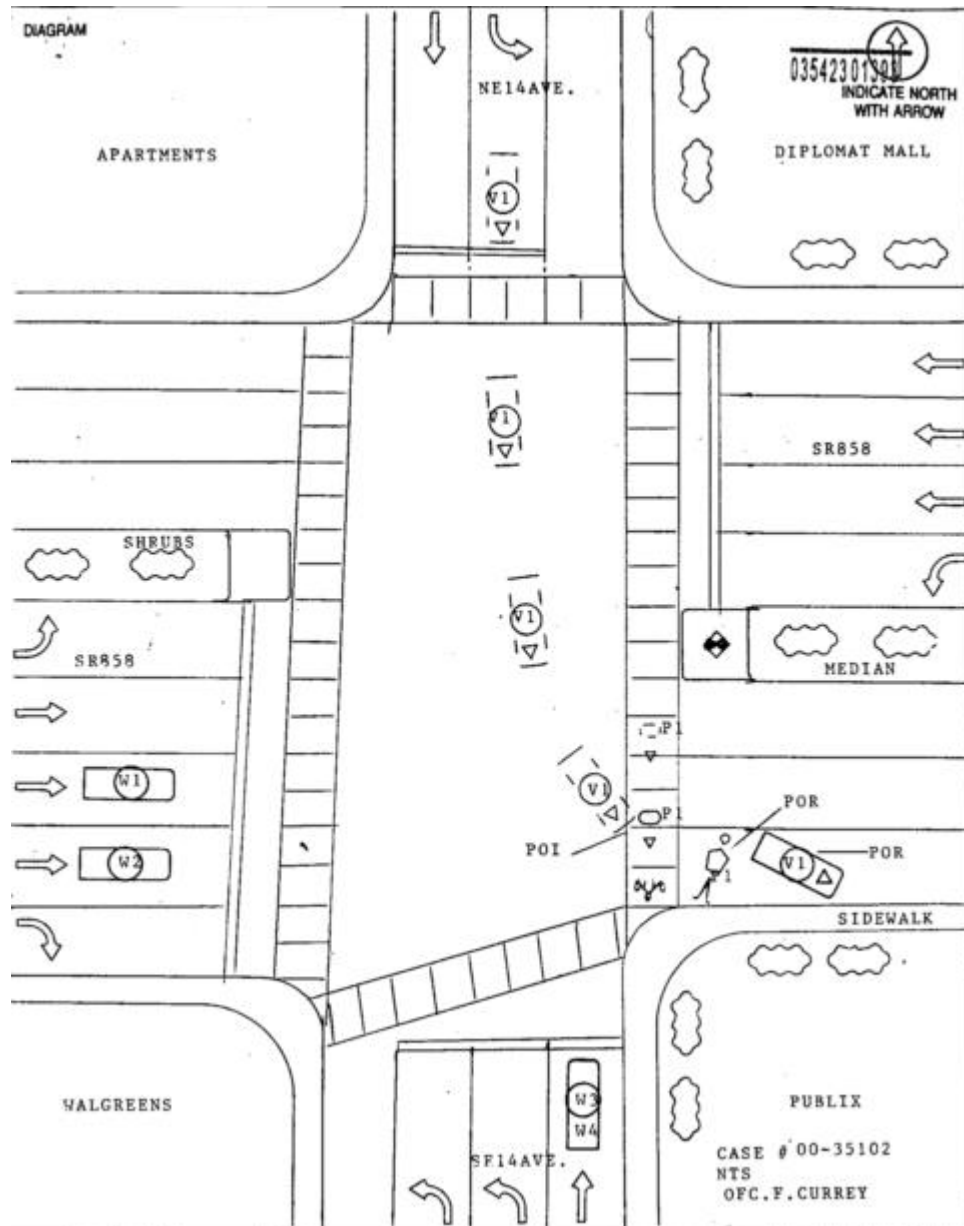


Figure 26: Crash Diagram for DHSMV Crash Number 57580668, Showing Improper Signalization Leading to a Fatal Intersection Crash

Table 28 below shows the distribution of the primary contributing factors in the crashes with the factor details. It can be seen that inattention on the account of the driver is the most prevalent primary contributing factor in fatal intersection crashes followed by driving under the influence of alcohol or drugs or both. The human contributing factors as such have already been talked about in the driver characteristics section. Looking at the roadway related primary

contributing factors, signs/ signalization is a major cause of concern as explained earlier with reference to Figure 26 above.

Table 28: Distribution of Fatal Intersection Crashes by Primary Contributing Factors

Primary Contributing Factor Class	Detail	No. Of Crashes
Human	Inattention	271
	DUI	147
	Decision	130
	Perception	40
	Speed	25
	Aggression	9
	Medical/ Mental	7
	Other	56
Roadway	Sign/ Signal	6
	Sight Distance	2
Environment	Wet Slippery	3
	Dark	1
Vehicle	Brakes/ Other	2

A look into the secondary contributing factors to the fatal intersection crashes in Table 27, it is seen that roadway issues had a secondary contribution in a little over 10 % of the fatal intersection crashes. Hence, a closer look is presented in Table 29 showing the various roadway factors acting as secondary contributing causes in the fatal intersection crashes. As mentioned earlier, adequate sight distance and a clear line of sight is very important for the safe functioning of an intersection, and as such an inadequacy of the same is found to be the most prevalent roadway factor contributing secondarily in the causation of fatal intersection crashes. Traffic operations issues also are significant secondary contributors towards the fatal intersection crashes. Traffic operations issues, as defined earlier are a combination of issues such as lane usage, pavement markings, posted speed limits on roadways and other factors, which are essential for smooth operations on a roadway. Traffic control, signage and signalization as such form a part of traffic operations but are looked at separately due to their significant proportion within the group. Inadequate or improper signage or signalization also contributes secondarily in more than a dozen fatal intersection crashes in Florida.

Table 29: Various Secondary Contributing Roadway Factors in Fatal Intersection Crashes

Roadway Contributing Factor	No. Of Crashes
Sight Distance	27
Traffic Operations	21
Signage / Signalization	14
Roadway Geometry	7
Access Management	3
Pedestrian Facility	3
Construction	1

The tertiary contributing roadway factors in fatal intersection crashes are shown in Table 30. As for the secondary contributing roadway factors, sight distance issue is the leading tertiary contributing roadway factor in fatal intersection crashes. An overall look at the sight distance issue reveals that sight distance issue is a contributing factor, either primary or secondary or tertiary, in almost 8 % of the total fatal intersection crashes and as such is a cause of concern for improving the safety of intersections in Florida. Various treatments to countermeasure this issue have been illustrated in the countermeasures section of the chapter.

Table 30: Various Tertiary Contributing Roadway Factors in Fatal Intersection Crashes

Roadway Contributing Factor	No. Of Crashes
Sight Distance	27
Traffic Operations	14
Signage / Signalization	16
Roadway Geometry	14
Access Management	10
Pedestrian Facility	8
Construction	1

CHAPTER 8

DRIVER CHARACTERISTICS

The distribution of fatal intersection crashes by driver error issues, as mentioned earlier in this chapter, is shown in Table 31. Inattention is the most prevalent driver error issue in the fatal intersection crashes followed by misjudging of the gap, which form around 60 % and 40 % of the total fatal intersection crashes. It should be mentioned here that fatal intersection crashes do not occur due to one isolated driver error or roadway issue but is a combination of issues of both and as such the same crash, which may have a driver error of DUI may be coupled with speeding as well. Hence the number of crashes does not add up to the total fatal intersection crashes as there may be repetition of crashes in driver errors. The percentages shown are for 5 crashes with that particular driver error. Table 31 also shows that DUI and Speeding are also highly dominant driver issues in fatal intersection crashes. Almost 10 % of the crashes involved a driver making an Improper Turn and another almost 20 % of them involved red light running. There are around 14 crashes that primarily occurred due to no error involved on part of the driver and are a disturbing fact for a transportation engineer.

Table 31: Fatal Intersection Crashes by Driver Error

Driver Error	No. of Crashes	% Crashes
DUI	182	26.04%
Speeding	176	25.18%
Inattention	428	61.23%
Improper Turn	60	8.58%
Ran Red Light	118	16.88%
Ran Stop Sign	74	10.59%
Rear End	62	8.87%
Misjudged Gap	259	37.05%
No Error	14	2.00%

Figure 27 shows the distribution of fatal intersection crashes by driver error issue with and without involvement of DUI. It is seen that speeding is almost equally likely with DUI as it is without DUI. Other Driver Error Issues with alcohol are under represented as compared to without DUI within the issue.

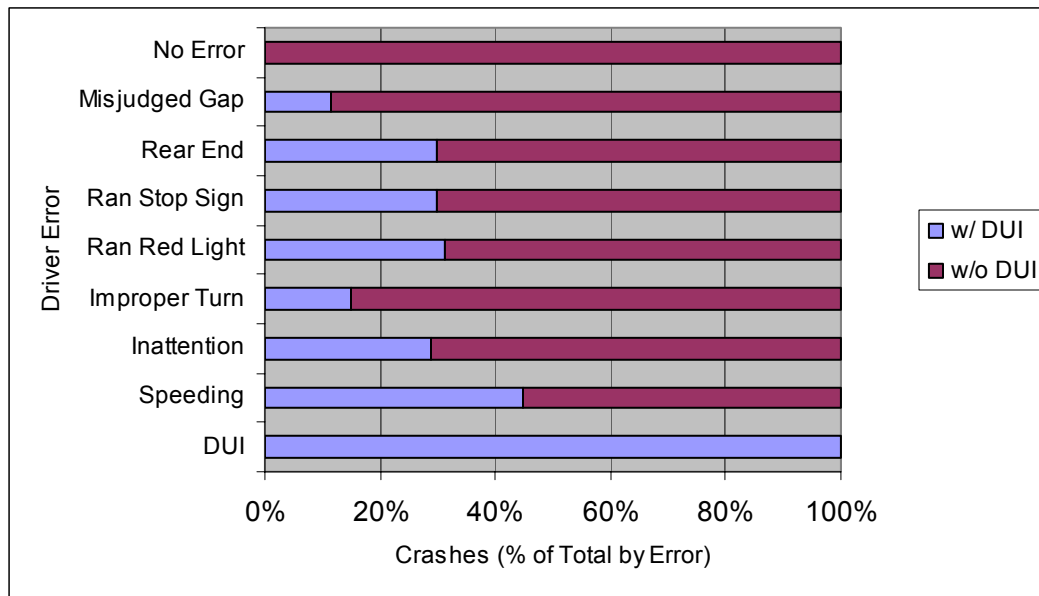


Figure 27: Driver Error in Fatal Intersection Crashes with DUI Involvement

Table 32 shows the distribution of drivers involved in fatal intersection crashes by the driver action as defined for general terms of the report. The table shows 25 instances of a hit and run driver involved in fatal intersection crashes while 13 instances of a phantom driver having contributed to the fatal intersection crash.

Table 32: Fatal Intersection Crashes by Driver Action

Driver Action	No. of Vehicles
Phantom	13
Hit And Run	25
N/A	1423

Table 33 shows the distribution of fatal intersection crashes according to driver age groups. The older driver group (above 65 years) is involved in almost 40 % of the fatal intersection crashes, whereas the total number of drivers driving on roads in older driver group is far less than that, around 18 %. (Florida Crash Statistics Report, 2003) Similar relation is for young driver group (Under 25 years). The licensed drivers under the age of 25 are just about 13 % of total licensed drivers in the state of Florida while according to the data studied more than 18% of them are involved in fatal intersection crashes. (Florida Crash Statistics Report, 2003)

Table 33: Drivers by Driver Age Groups in Fatal Intersection Crashes

Age Group	No. of Drivers	% Drivers
Above 5 - Under 15	2	0.14%
Above 15 - Under 25	262	17.92%
Above 25 - Under 35	275	18.81%
Above 35 - Under 45	291	19.90%
Above 45 - Under 55	214	14.64%
Above 55 - Under 65	116	7.93%
Above 65 - Under 75	109	7.46%
Above 75 - Under 85	114	7.80%
Above 85 - Under 95	46	3.15%
Above 95	2	0.14%
Unknown	31	2.12%

Figure 28 and Figure 29 show the driver fault distribution within the age group for fatal intersection crashes. As seen from Figure 28 and curve in Figure 29 there is a typical trend in the driver being at fault according to age group. For drivers involved in fatal intersection crashes, drivers above 65 are more likely to be at fault in a fatal intersection crash than not at fault and as the ages increase the likelihood of them being at fault in a fatal intersection crash increases. Young drivers are almost equally likely to be at fault as they are not at fault when involved in a fatal intersection crash.

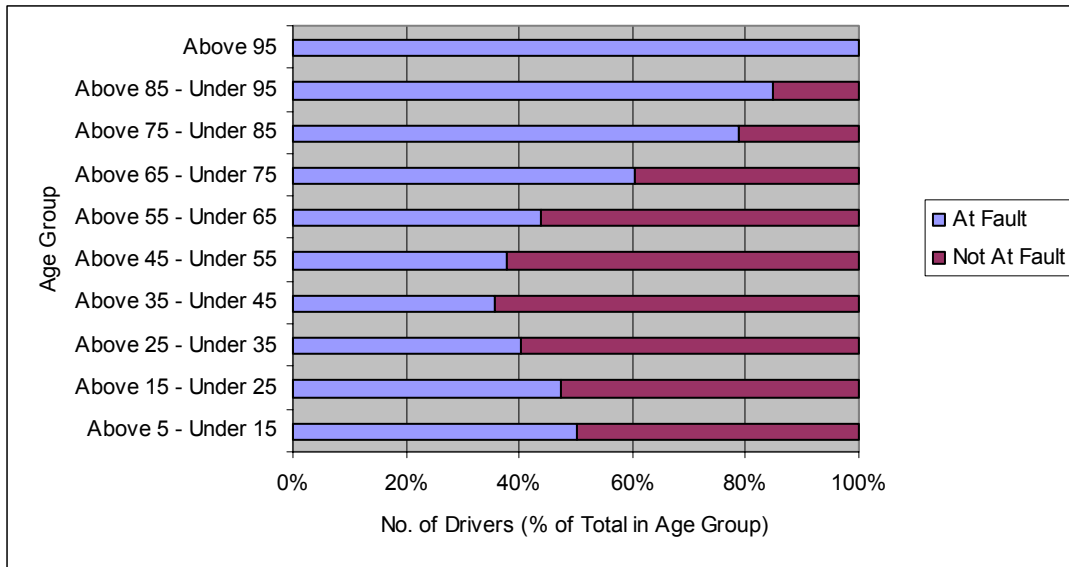


Figure 28: At Fault Distribution in Driver Age Groups for Fatal Intersection Crashes

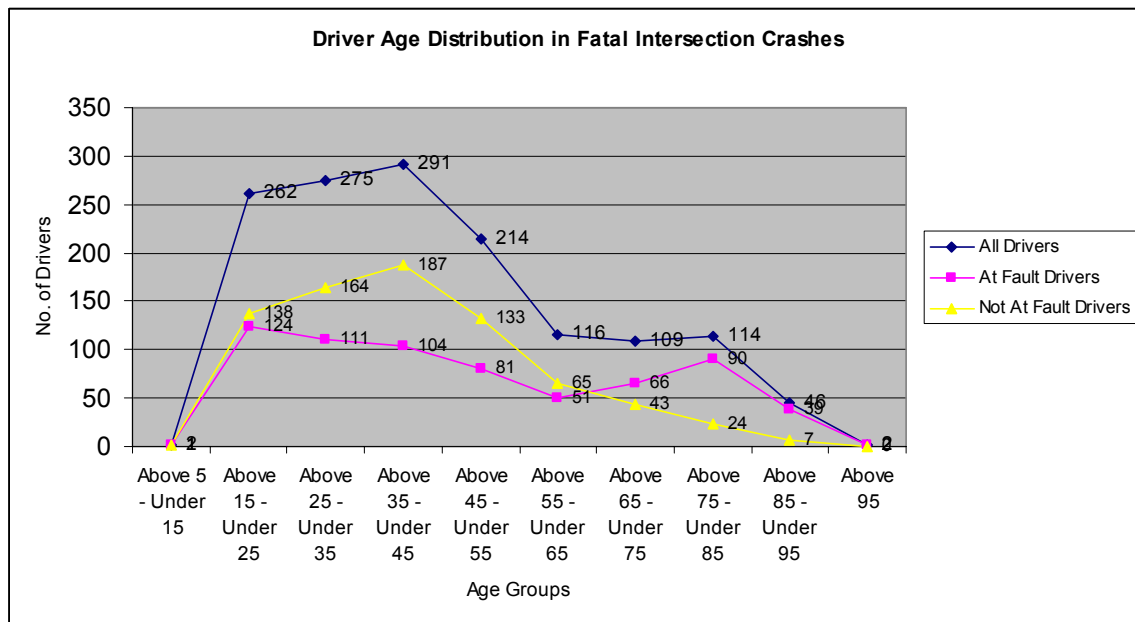


Figure 29: Driver Age Distribution in Fatal Intersection Crashes

Figure 30 shows the distribution of drivers by driver sex in fatal intersection crashes. Note that males account for almost three-quarters of the drivers involved in fatal intersection crashes. However, Figure 31 shows that a female driver, if involved in a fatal intersection crash,

is equally likely to be at fault as she is likely to be not at fault while a male driver, if involved in a fatal intersection crash, is slightly less likely to be at fault than not at fault.

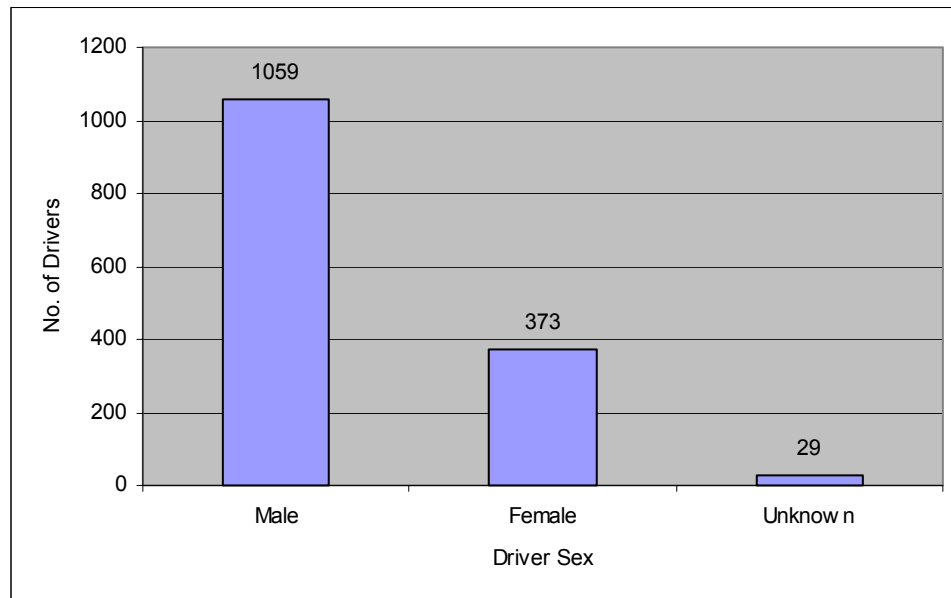


Figure 30: Drivers Involved in Fatal Intersection Crashes by Driver Sex

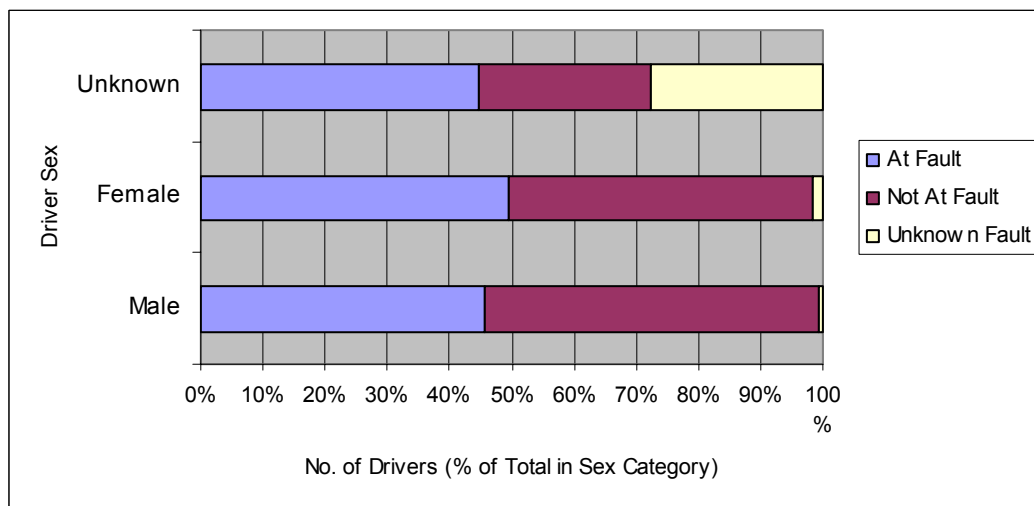


Figure 31: At Fault Driver Distribution by Driver Sex in Fatal Intersection Crashes

Table 34 and Figure 32 show the distribution of drivers involved in fatal intersection crashes by driver race with At Fault and Not at Fault classification within the race.

Table 34: Distribution of At Fault Drivers within Driver Race for Drivers Involved in Fatal Intersection Crashes

Race	At Fault		Not At Fault		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
White	511	75.04%	556	73.35%	1.023	0.963	1.087	UNSURE
Black	82	12.04%	109	14.38%	0.837	0.642	1.094	UNSURE
Hispanic	70	10.28%	79	10.42%	0.986	0.729	1.337	UNSURE
Other	5	0.73%	6	0.79%	0.928	0.287	3.026	UNSURE
Unknown	13	1.91%	8	1.06%	1.809	0.758	4.337	UNSURE

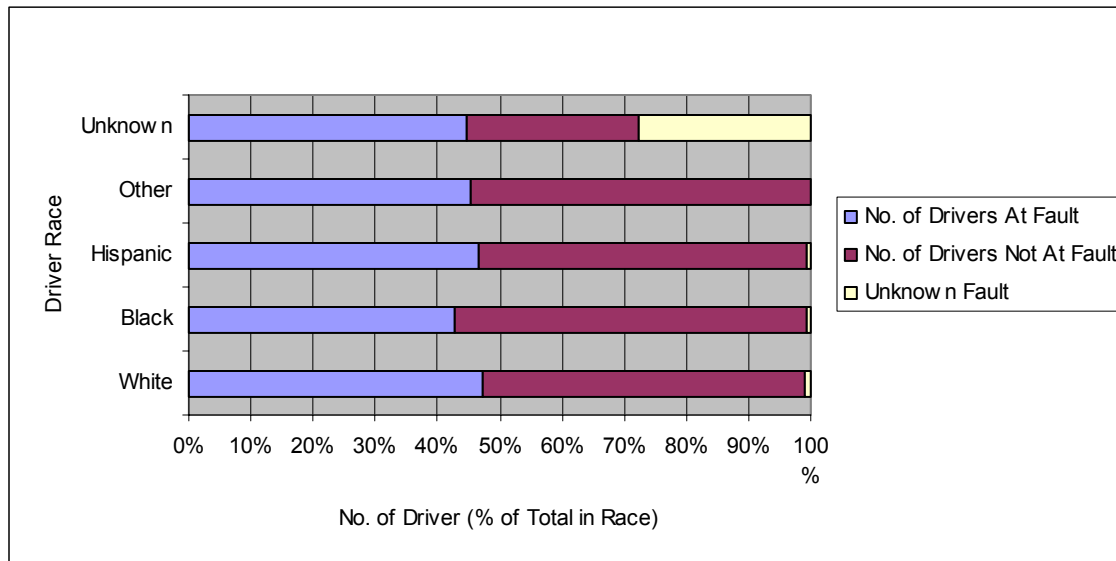


Figure 32: Distribution of At Fault Drivers within Driver Race for Drivers Involved in Fatal Intersection Crashes

Table 35 and Figure 33 show the distribution of drivers involved in fatal intersection crashes according to the residence of the driver and the fault involvement of the driver. The data

shows that a driver residing elsewhere in state is more likely to be at fault than not at fault if the driver is involved in a fatal intersection crash. Similar is the case for foreign drivers, which is quite as expected due to the unfamiliarity of the roadway to the driver. For other driver residence categories it is the other way round.

Table 35: Driver Distribution by Driver Residence of Drivers Involved in Fatal Intersection Crashes

Residence	At Fault		Not At Fault		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
County of Crash	511	75.04%	532	70.18%	1.069	1.004	1.139	OVER
Elsewhere in State	104	15.27%	169	22.30%	0.685	0.550	0.855	UNDER
Non Resident of State	47	6.90%	41	5.41%	1.276	0.852	1.915	UNSURE
Foreign	5	0.73%	5	0.66%	1.113	0.326	3.828	UNSURE
Unknown	14	2.06%	11	1.45%	1.417	0.650	3.099	UNSURE

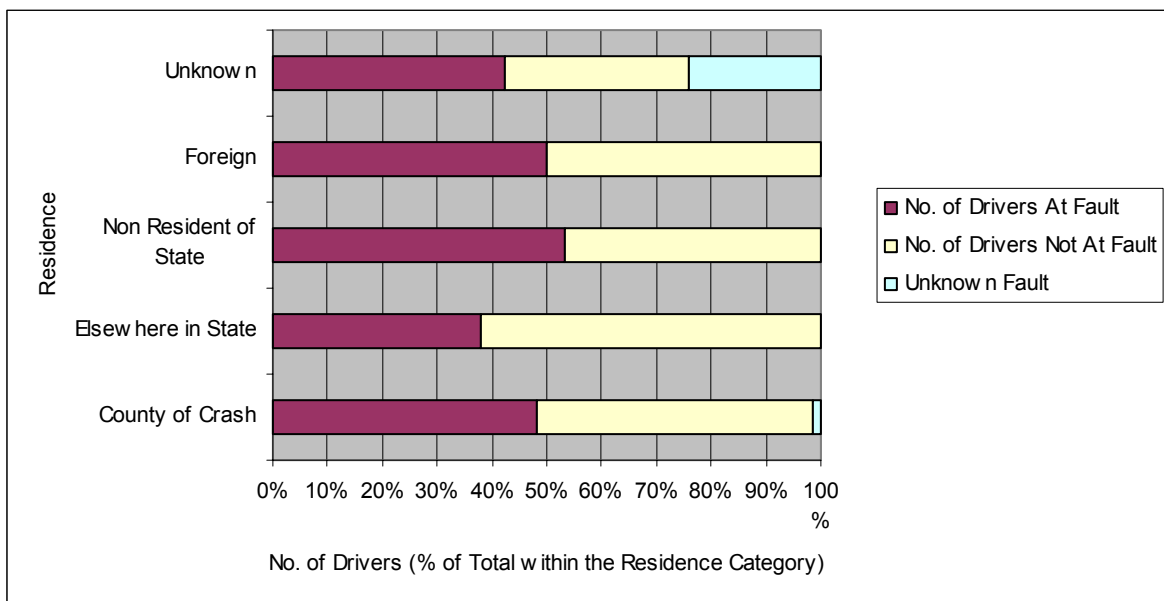


Figure 33: Distribution of Drivers in Fatal Intersection Crashes by Residence with Fault

Table 36 and Figure 34 show the distribution of drivers involved in fatal intersection crashes according to the injury severity and the fault involvement. The data shows that almost 30 % of the time a driver not at fault in a fatal intersection crash suffered fatal injuries as a result of the crash.

Table 36: Injury Severity to Drivers Involved in Fatal Intersection Crashes

Injury Severity	Total		At Fault		Not At Fault		Unknown	
	Num.	Per.	Num.	Per.	Num.	Per.	Num.	Per.
None	453	31.01%	150	22.03%	302	0.39842	1	4.55%
Possible	123	8.42%	35	5.14%	84	0.11082	4	18.18%
Non Incapacitating	198	13.55%	72	10.57%	126	0.16623	0	0.00%
Incapacitating	160	10.95%	71	10.43%	83	0.1095	6	27.27%
Fatal (Within 90 Days)	503	34.43%	345	50.66%	155	0.20449	3	13.64%
Unknown	24	1.64%	8	1.17%	8	0.01055	8	36.36%

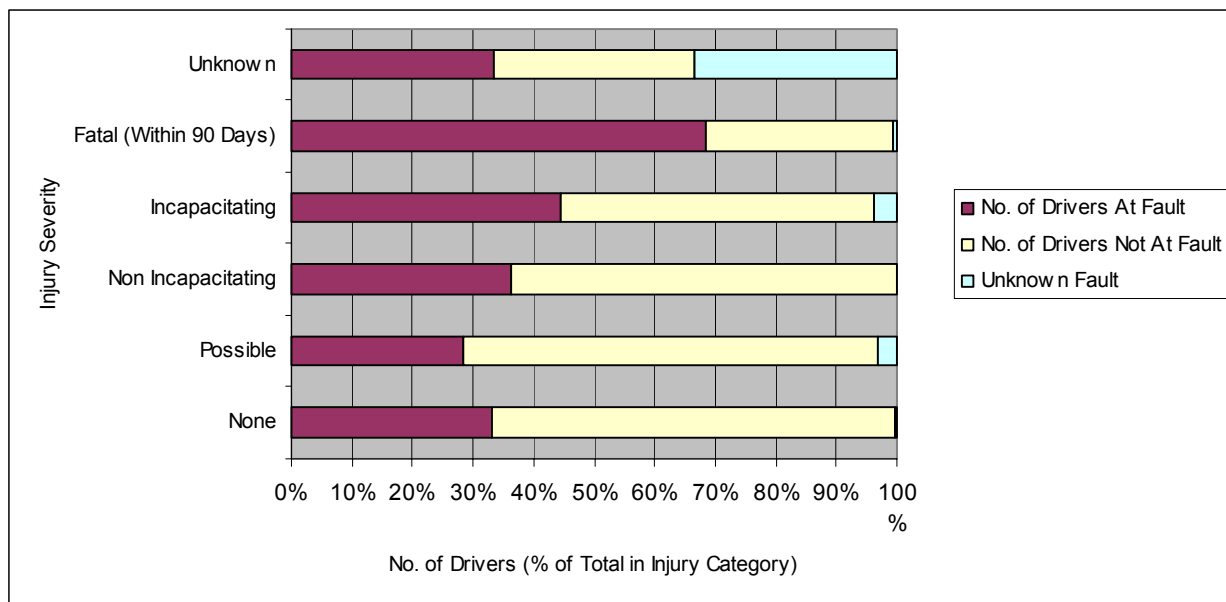


Figure 34: Injury Severity by Fault of Drivers Involved in Fatal Intersection Crashes

Table 37 shows the distribution of injury severity in drivers according to the safety equipment use. It can be seen that with no safety equipment in use, the number of fatal injuries is the highest and it should be noted that more than 20% of the drivers were not using any safety equipment at the time of the crash. With seat belt in use the fatalities is around 1/3rd of the total driver using seat belt as the safety equipment. The table includes at fault and not at fault drivers. The unknown/ other category of safety equipment use includes the unknown and also the motorcycle drivers using either a helmet or eye protection or both and the percentages for the same aren't shown for obvious reason that in a motor cycle fatal intersection crash with a car or truck, the motorcyclist suffers fatal injuries irrespective of safety equipment use. A comment cannot be made regarding the air bag usage and the injury severity from this data and other studies looking at effectiveness of air bags can be referred for more information on the same.

Table 37: Injury Severity Vs. Total Safety Equipment Use

Safety Equipment	Injury severity					Total	%
	1	2	3	4	5		
Not In Use	32	14	37	29	198	310	21.40%
Seat Belt / Shoulder Harness	339	67	91	61	121	679	46.90%
Child Restraint	0	0	0	0	0	0	0.00%
Air Bag	2	5	5	18	42	72	5.00%
Unknown / Other	21	18	12	8	58	112	--
Seat Belt And Child Restraint	0	0	0	0	0	0	0.00%
Seat Belt And Air Bag	61	37	58	46	74	276	19.00%
Total	455	141	203	162	503	1449	100%
%	31.40%	9.70%	14.00%	11.20%	34.70%	100%	

CHAPTER 9

LEFT TURNING CRASHES

As seen earlier in the section for crash type and vehicle movements, left turning is involved in more than 50 % of the fatal intersection crashes. Hence, a closer look at the various contributing factors involved in fatal intersection crashes involving a left turning movement by one of the vehicles is offered in this section.

For left turn vs. oncoming vehicle movements the distribution of fatal intersection crashes according to median width is shown in Table 38. It can be seen that the left turn oncoming crashes are significantly over represented for low and higher median widths except for very wide medians with width more than 50 feet. A narrow median may lead to perception error by the turning driver leading into a crash while a wider median may increase the turning time and thereby the probability of misjudging the safe available gap to cross the intersection.

Table 38: Distribution of Left Turn Vs. Oncoming Fatal Intersection Crashes by Median Width

Median Width Range	Total No. Of Crashes	Left Turn Vs. Oncoming Crashes	% Left Turn Vs. Oncoming
5 - 10 Feet	31	12	38.71%
10 - 20 Feet	211	55	26.07%
20 - 30 Feet	114	42	36.84%
30 - 40 Feet	140	42	30.00%
40 - 50 Feet	60	22	36.67%
More Than 50 Feet	40	8	20.00%
Unknown	103	9	8.74%
Total	699	190	27.18%

Figure 35 below illustrates the distribution of primary and secondary contributing factors for fatal intersection crashes involving a left turning and oncoming vehicle movements. As the figure shows the crashes are primarily caused due to human contributing factors sometimes but

not too often coupled with a secondary contributing factor due to a roadway issue or a vehicle defect or may be an environment issue.

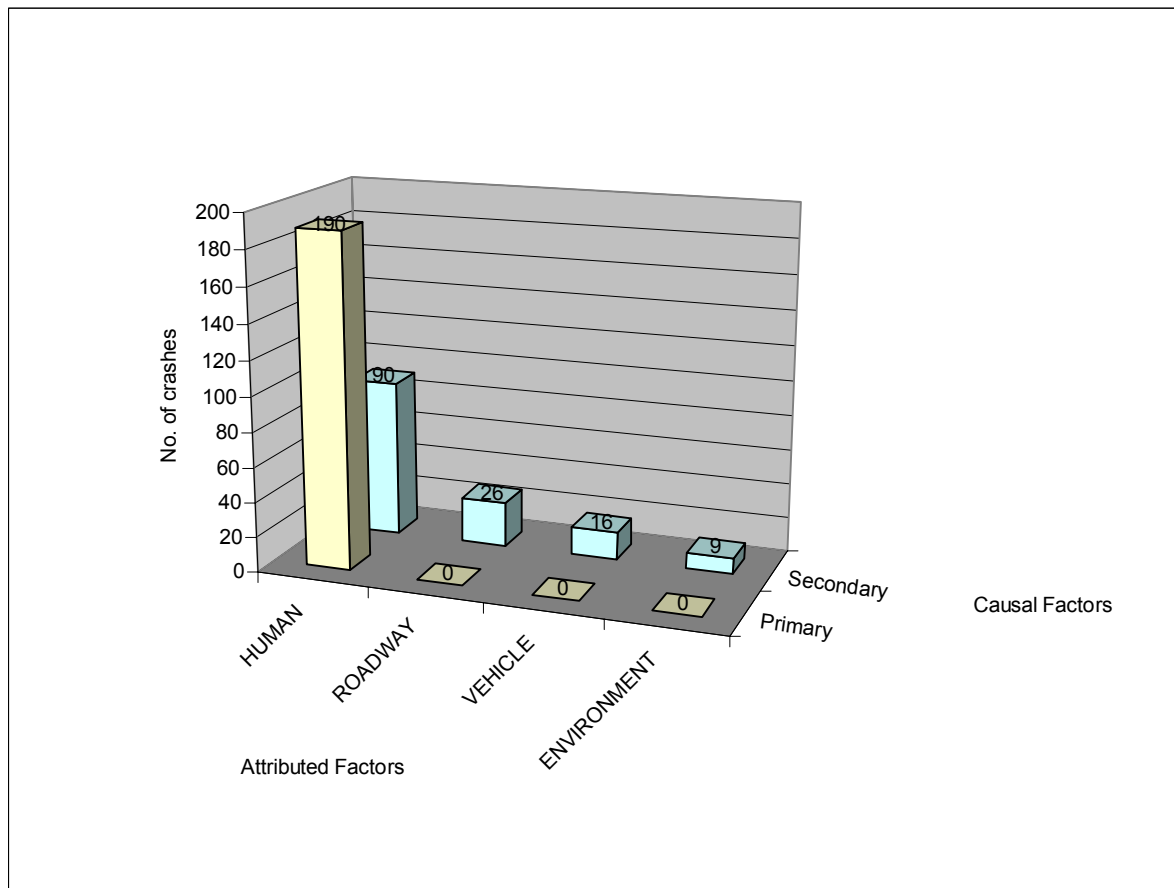


Figure 35: Distribution of Primary and Secondary Contributing Causes for Left Turn Oncoming Fatal Intersection Crashes

As seen in Figure 35 Human factors is the primary contributing factor in left turn oncoming fatal intersection crashes. Figure 36 below shows the distribution of various Human factors that primarily and secondarily contribute towards the left turn oncoming fatal intersection crashes. As can be seen clearly from the bar graphs, while Inattention on the part of driver is the most significant primary human error, a decision error is the most significant secondary human factor that contributes towards left turn oncoming fatal intersection crashes. It may be noted here

that speeding is shown as the secondary human factor in more than 10 % of the left turn oncoming fatal intersection crashes. This may lead to the implication that the judgment error on the part of the left turning driver may be coupled with unexpected speeding on the part of the oncoming driver.

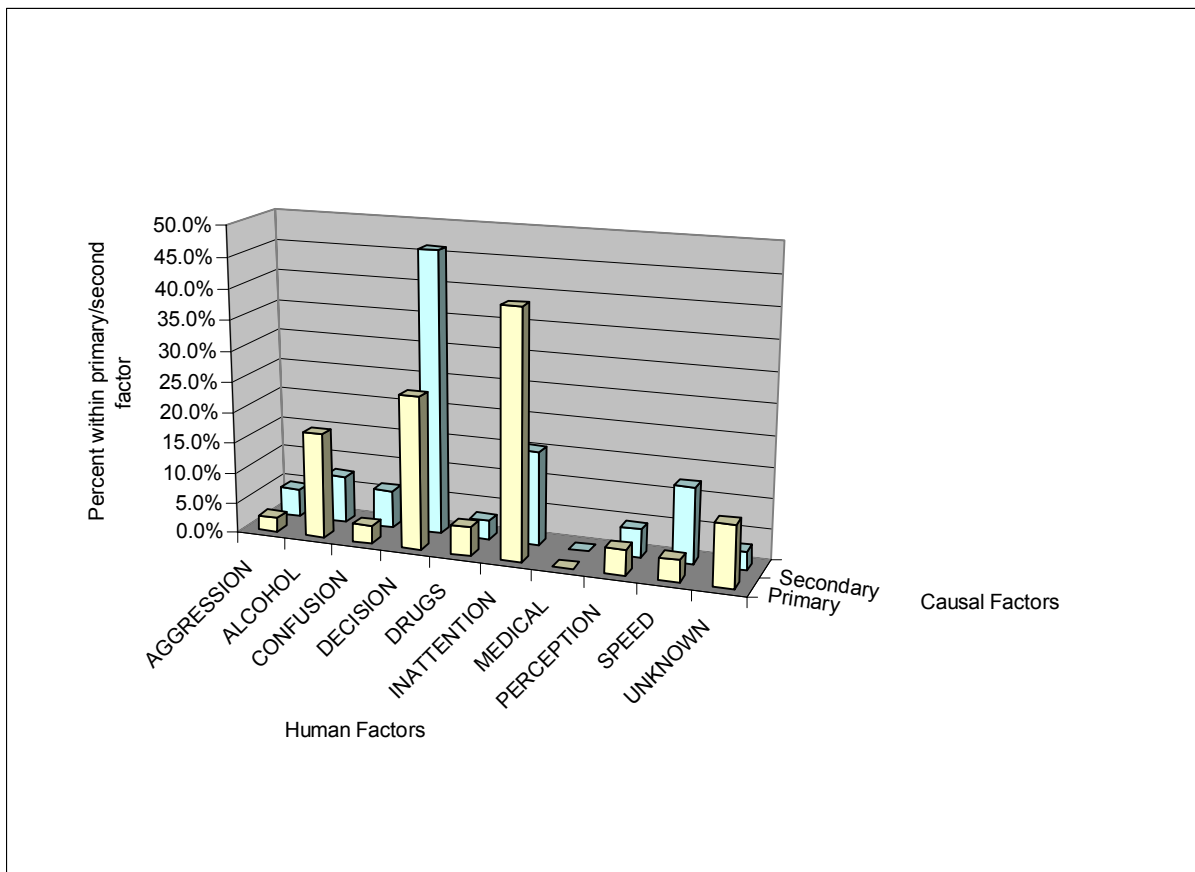


Figure 36: Distribution of Various Human Factors Involved in Left Turn Oncoming Fatal Intersection Crashes

Table 39 below shows the driver age distribution of the at fault drivers in left turn oncoming crashes on divided roadways with the total drivers involved in fatal crashes in the state of Florida. While studying the driver age distribution all those drivers were eliminated which had a red light running involved in order to get the trend of judgment errors made by drivers while

making a left turn in front of oncoming traffic on a divided roadway. The primary purpose of this tale is to look for a trend in age of the drivers at fault where they are needed to make a judgment decision to turn in front of oncoming traffic on a divided roadway. It is notable that more than 30 % of the drivers at fault in left turn oncoming crashes are older drivers with more than 65 years of age, which leads us to understand that older drivers are highly likely to make a judgmental error while making a left turn in front of oncoming traffic. Also, almost 15 % of the total drivers involved in fatal crashes above 65 years of age, are at fault in a left turn oncoming crash on a divided roadway, whereas the drivers between the ages 25 – 65 years form just about 3 % of this group.

Table 39: Driver Age Distribution of At Fault Drivers for Left Turn Oncoming Crashes on Divided Roadways

Age Group	No. of Drivers At Fault	% Drivers At Fault	Total Drivers in Fatal Crashes	% Total Drivers
5	0		2	0%
15	33	17%	680	18%
25	22	12%	758	20%
35	38	20%	791	21%
45	23	12%	609	16%
55	13	7%	347	9%
65	22	12%	232	6%
75	26	14%	181	5%
85	12	6%	59	2%
95	2	1%	2	0%
Unknown	0	0%	167	4%

Table 40 below shows the distribution of fatal intersection crashes for left turn vs. crossing vehicle movements. It can be seen that as the median width increases the percentage of fatal intersection crashes with left turn vs. crossing movement increase except for very wide medians of more than 50 feet. As the median width increases the time required to negotiate the left turn increases and as such the chances of the driver misjudging the gap increases. Also, the sight triangle is greatly affected by median width and as such knowing an adequate median width is very important while attempting to reduce the fatal intersection crashes.

Table 40: Distribution of Left Turn vs. Crossing Fatal Intersection Crashes by Median Width

Median Width Range	Total No. Of Crashes	Left Turn Vs. Crossing Crashes	% Left Turn Vs. Crossing
5 - 10 Feet	31	4	12.90%
10 - 20 Feet	211	51	24.17%
20 - 30 Feet	114	15	13.16%
30 - 40 Feet	140	32	22.86%
40 - 50 Feet	60	15	25.00%
More Than 50 Feet	40	5	12.50%
Unknown	103	16	15.53%
Total	699	138	19.74%

As seen in figures for left turn oncoming crashes, similarly Figure 37 shows the distribution of primary and secondary contributing factors for left turn crossing fatal intersection crashes and as expected the human error is the primary contributing factor for left turn crossing fatal intersection crashes coupled with a secondary roadway or environment or vehicle factor. From Figure 37 almost 20 % of left turn-crossing fatal intersection crashes have a roadway factor making a secondary contribution towards the crash.

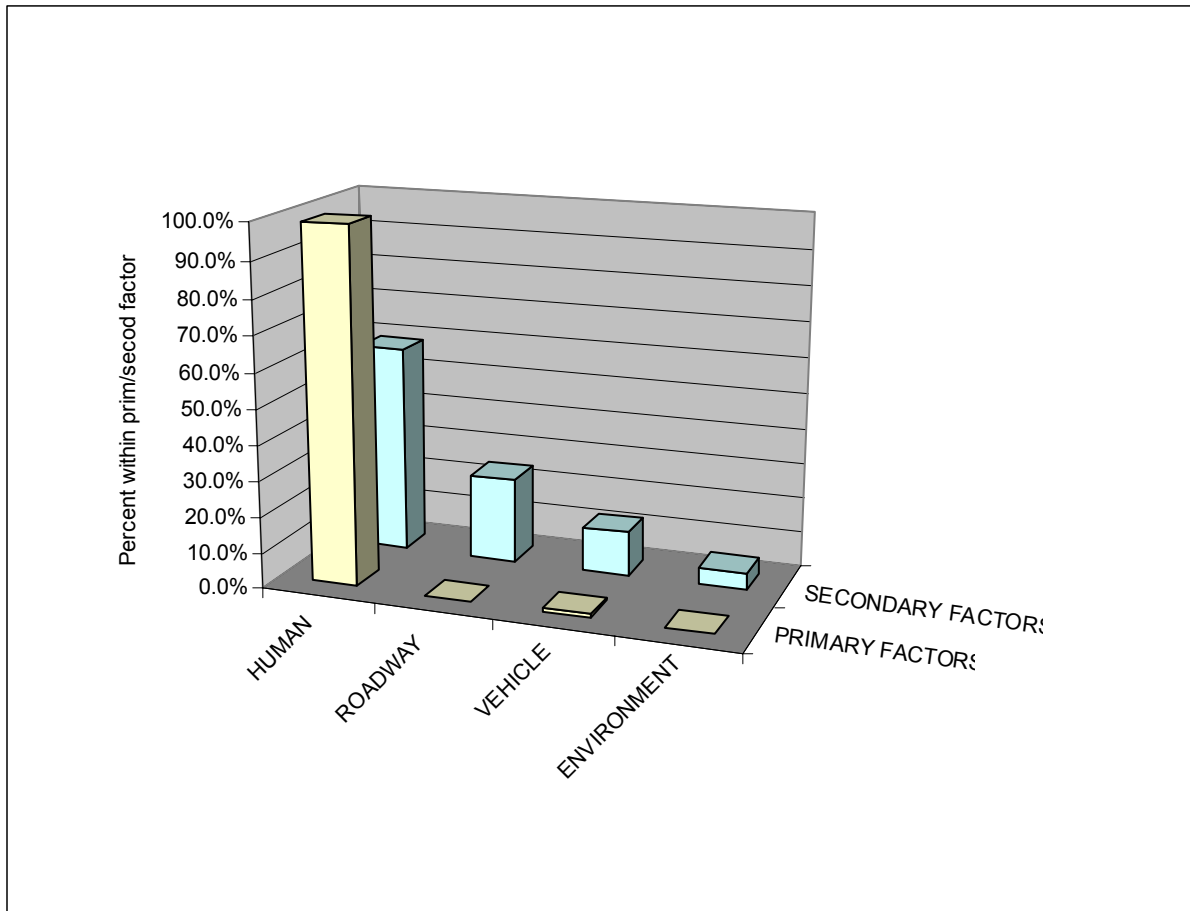


Figure 37: Distribution of Primary and Secondary Contributing Causes for Left Turn vs. Crossing Fatal Intersection Crashes

Figure 38 shows the distribution of various human factors that primarily and secondarily contribute towards the left turn crossing fatal intersection crashes. It can be seen that in secondary human contributing factors, perception decision and speeding show up prominently in the figure. Perception and decision plays an important role in fatal intersection crashes involving left turn crossing vehicle movements due to the different travel speeds on the intersecting roads. Also Inattention shows up as the most significant primary human factor in the chart as for most of the fatal intersection crashes.

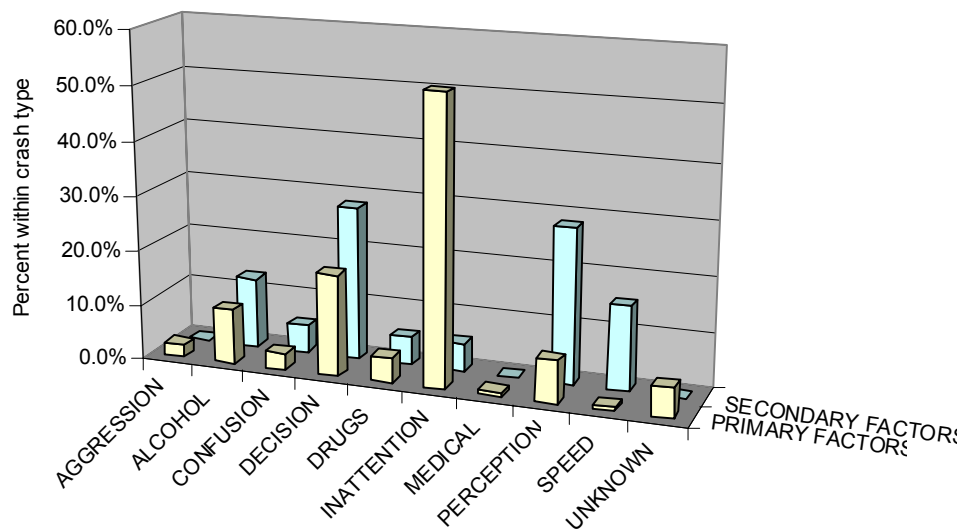


Figure 38: Distribution of Various Human Factors Involved in Left Turn Crossing Fatal Intersection Crashes

CHAPTER 10

REAR END CRASHES

This chapter offers a closer look at the crash contributing factors and the distribution of rear end fatal intersection crashes. Table 41 shows the distribution of the Rear End Crashes in fatal intersection crashes by the traffic control. Primarily the rear end crashes occur at uncontrolled intersections forming little over 40 % of the fatal intersection crashes within the rear end crash class for fatal intersection crashes. Rear end crashes are also predominant on signalized intersections as noted earlier. Table 42 shows the distribution of rear end crashes by driver age groups. It appears that younger to middle age drivers are over represented within the rear end crashes in fatal intersection crashes.

Table 41: Rear End Crashes in Fatal Intersection Crashes by Traffic Control

Traffic Control	No. of Crashes
Traffic Signal	21
Stop Sign	2
Other	10
No Control	24

Table 42: Rear End Crashes in Fatal Intersection Crashes by Driver Age Groups

Age Group	No. of Crashes
Above 15 - Under 25	12
Above 25 - Under 35	16
Above 35 - Under 45	9
Above 45 - Under 55	5
Above 55 - Under 65	4
Above 65 - Under 75	4
Above 75 - Under 85	5
Above 85 - Under 95	2

Figure 39 shows the distribution of contributing causes primarily and secondarily affecting the rear end fatal intersection crashes. Although primarily human factors contribute towards the rear end fatal intersection crashes it can be seen that a significant, almost 30 %, of crashes in this group have a secondary roadway issue contributing towards the crash. Eliminating or alleviating these roadway issues shall certainly reduce the probability or severity of rear end crashes at or influenced by intersections. Figure 40 shows the distribution of various human factors primarily and secondarily contributing towards the occurrence of rear end fatal intersection crashes. It shows that primarily inattention coupled with a secondary human factor of perception and speeding contributes to the causation of rear end fatal intersection crashes.

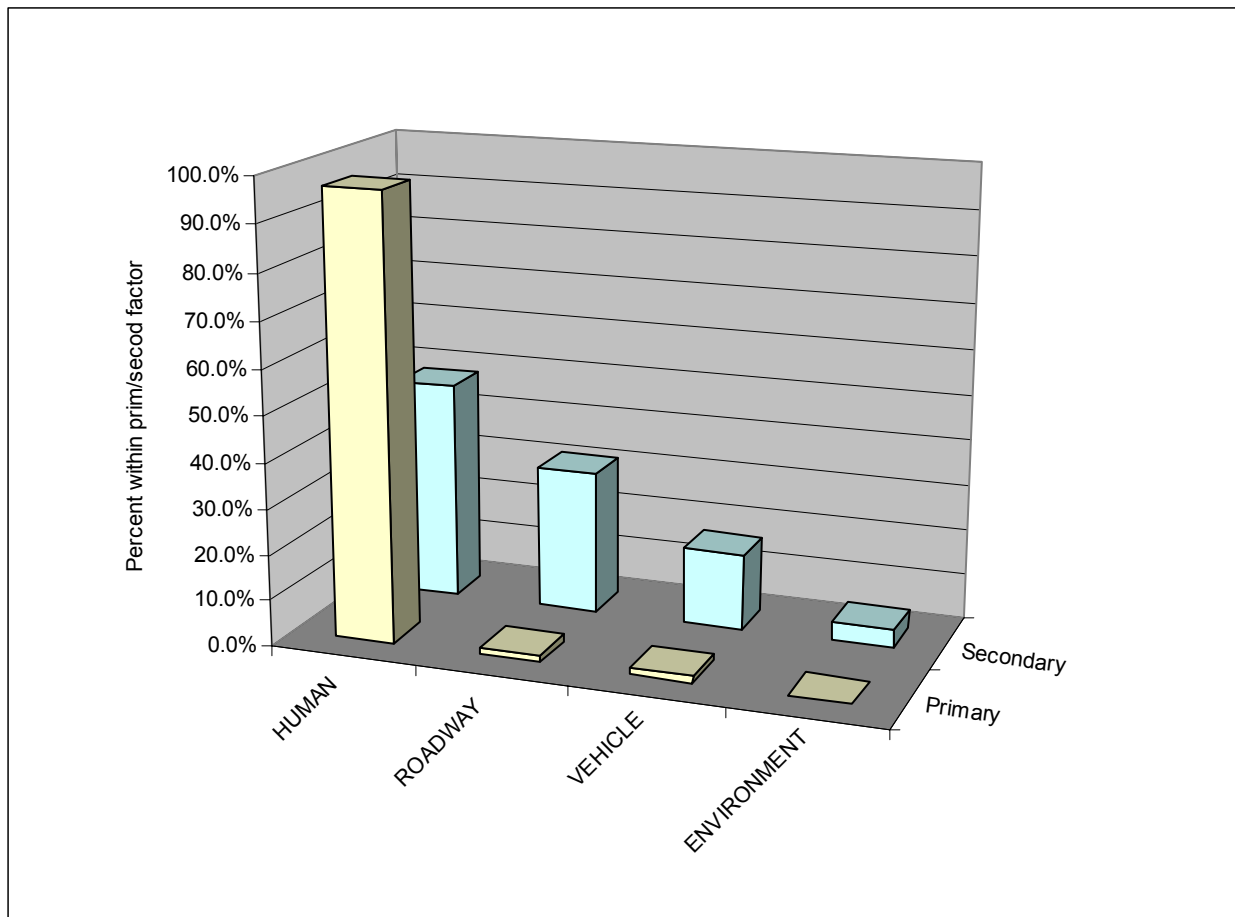


Figure 39: Distribution of Primary and Secondary Contributing Causes for Rear End Fatal Intersection Crashes

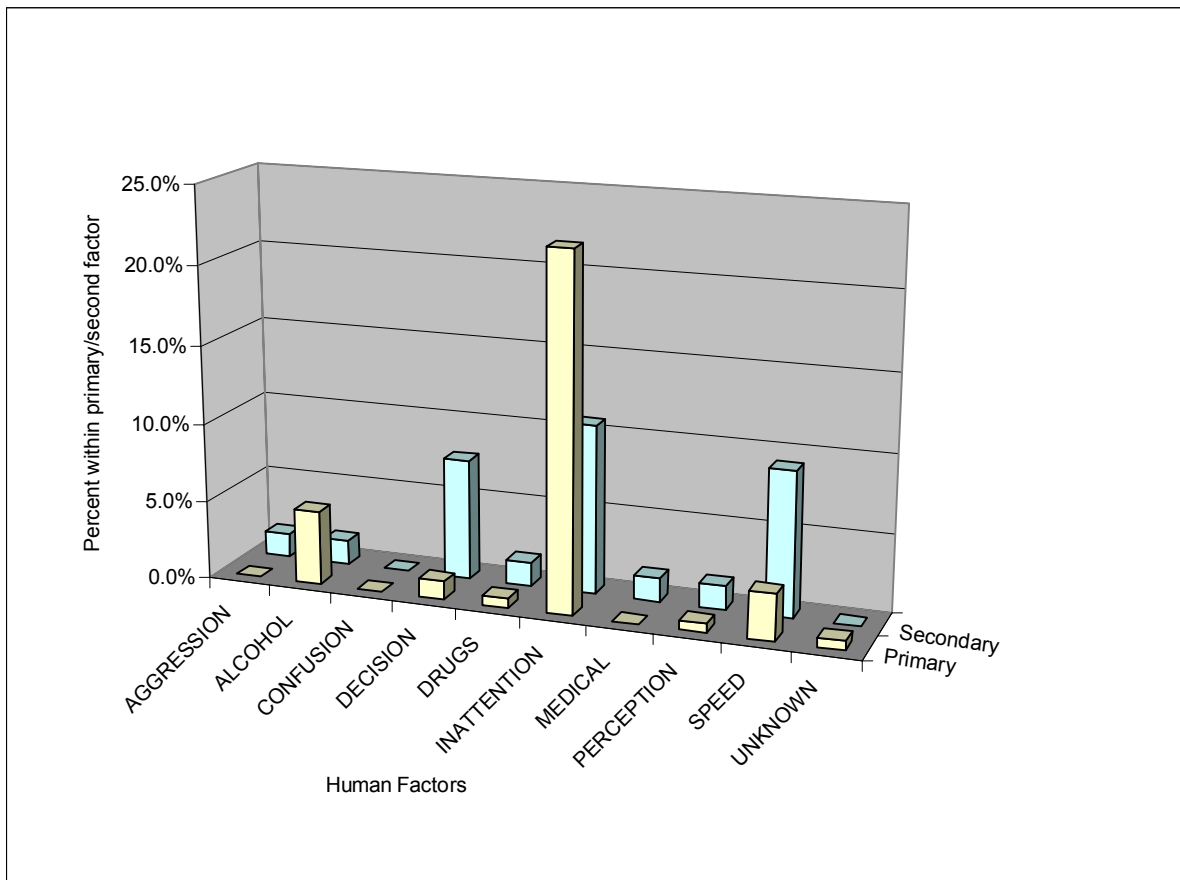


Figure 40: Distribution of Various Human Factors Involved in Rear End Fatal Intersection Crashes

CHAPTER 11

SIGNALIZED INTERSECTIONS

Almost 35 % of the total fatal intersection crashes occur at Signalized Intersections and as such a separate analysis of the fatal intersection crashes at Signalized Intersections is demanded. Table 43 shows the distribution of fatal intersection crashes at signalized intersections according to the crash type. The left turn oncoming crashes form almost 40 % of the fatal intersection crashes at signalized intersections. These are mostly crashes with a right of way violation by the driver with a permissive green at a signalized intersection. Pedestrian crashes with pedestrian crossing in a cross walk add almost 10 % of the fatal intersection crashes at signalized intersections, which is a issue that needs to addressed and is looked much in-depth in the chapter of the report dealing with exclusively Pedestrian Crashes. Rear End crashes are also quite prominent in fatal intersection crashes at signalized intersections.

Table 43: Fatal Intersection Crashes by Crash Type at Signalized Intersections

Crash Type Group	Crash Type	No. of Crashes
Pedestrian	Pedestrian Crash At or Influenced by Intersection	30
Run Off Road / Single Vehicle	Right Roadside Departure	1
	Right Roadside Departure With Control Loss	4
	Left Roadside Departure With Control Loss	1
	Forward Impact	1
Same Direction	Rear End	21
	Rear End With Avoid Impact	1
	Sideswipe Angle	1
Change Traffic Way / Turning	Initial Opposite Directions/Oncoming Traffic	94
	Initial Same Direction	3
	Turn/Merge Into Same Direction	3
	Turn Into Opposite Directions/Cross Traffic	17
Intersecting Paths	Not At Fault Approaching From Left	25
	Not At Fault Approaching From Right	40
	Not At Fault Unknown Approach Direction	5

The distribution of fatal intersection crashes at signalized intersections is shown in Table 44. The numbers in the table are consistent with the numbers in Table 31, except that 100 % of the Red Light Running involved in fatal intersection crashes occurs at signalized intersections, which is only natural. Also misjudging of gap is under represented in fatal intersection crashes at signalized intersections as compared to total fatal intersection crashes. Fatal intersection crashes at signalized intersections form almost a 40 % of total fatal intersection crashes, and misjudging of gap as a driver error issue in fatal intersection crashes at signalized intersections occurs in around 20 % of the total fatal intersection crashes which again is as expected since a requirement of a decision on part of driver is significantly reduced at a well signal controlled intersection. Figure 41 shows the DUI involvement within a driver error issue.

Table 44: Fatal Intersection Crashes by Driver Error at Signalized Intersections

Driver Error	No. of Crashes
DUI	69
Speeding	68
Inattention	163
Improper Turn	18
Ran Red Light	118
Ran Stop Sign	0
Rear End	21
Misjudged Gap	49
No Error	7

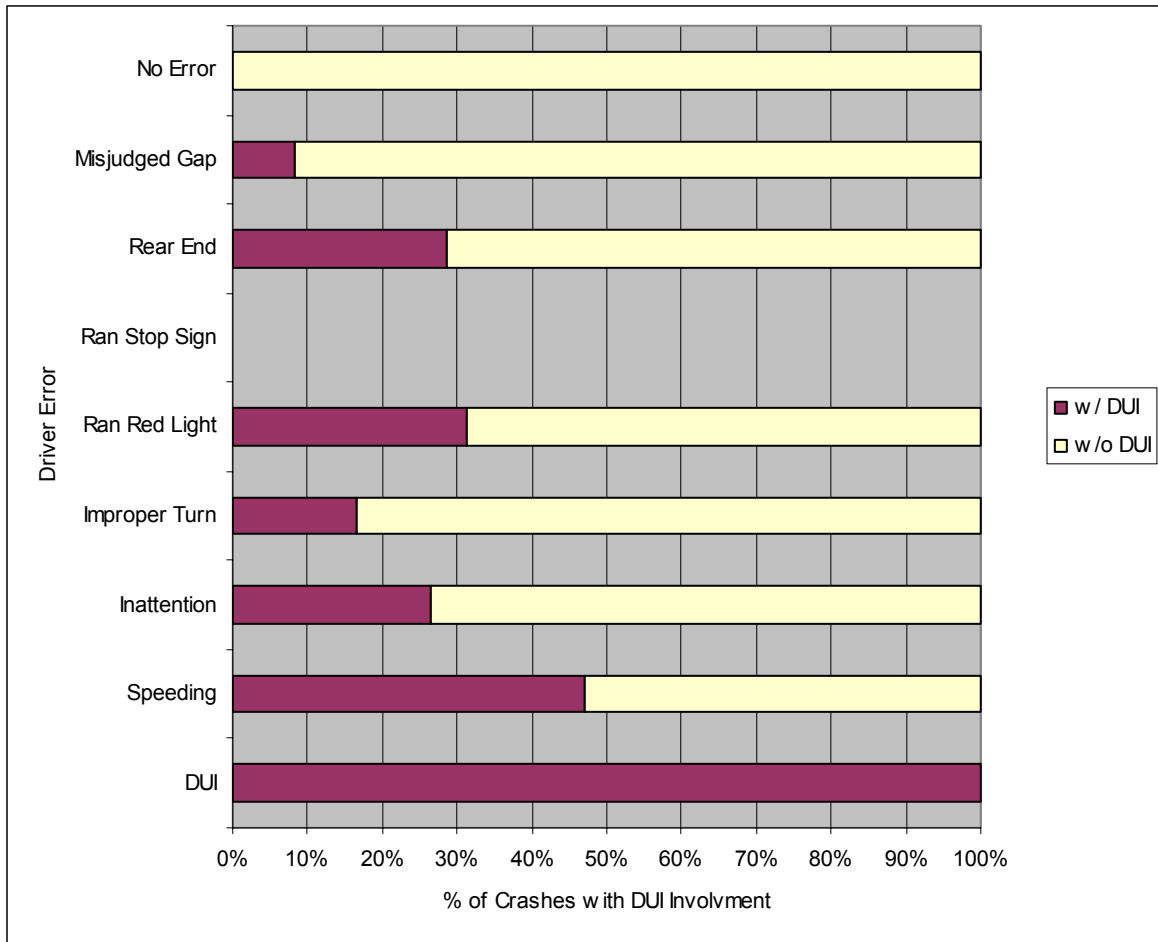


Figure 41: Fatal Intersection Crashes by Driver Error and DUI Involvement at Signalized Intersection

The numbers of Table 45, which shows the distribution of fatal intersection crashes at signalized intersections, are in consistency with the numbers of Table 9, which shows the distribution of total fatal intersection crashes. The number of fatal intersection crashes at signalized intersections at roadways with 2 lanes is under represented as compared to total number of fatal intersection crashes since the number of 2 lane roadways that are signalized is less than those that are not. Table 46 and Figure 42 show the distribution of fatal intersection crashes at signalized intersections by number of lanes and roadway type as in divided or undivided.

Table 45: Fatal Intersection Crashes by No. of Lanes at Signalized Intersection

No. of Lanes	No. of Crashes
4	111
6	84
2	18
3	13
5	10
8	5
7	4
1	1
12	1

Table 46: Fatal Intersection Crashes by Road Type and No. of Lanes at Signalized Intersections

No. of Lanes	No. of Crashes Divided Roadway	No. of Crashes on Undivided Roadway	No. of Crashes on Unknown Road Type	Total No. of Crashes
4	75	23	13	111
6	66	4	14	84
2	6	11	1	18
3	6	7	0	13
5	5	2	3	10
8	4	0	1	5
7	4	0	0	4
1	1	0	0	1
12	1	0	0	1

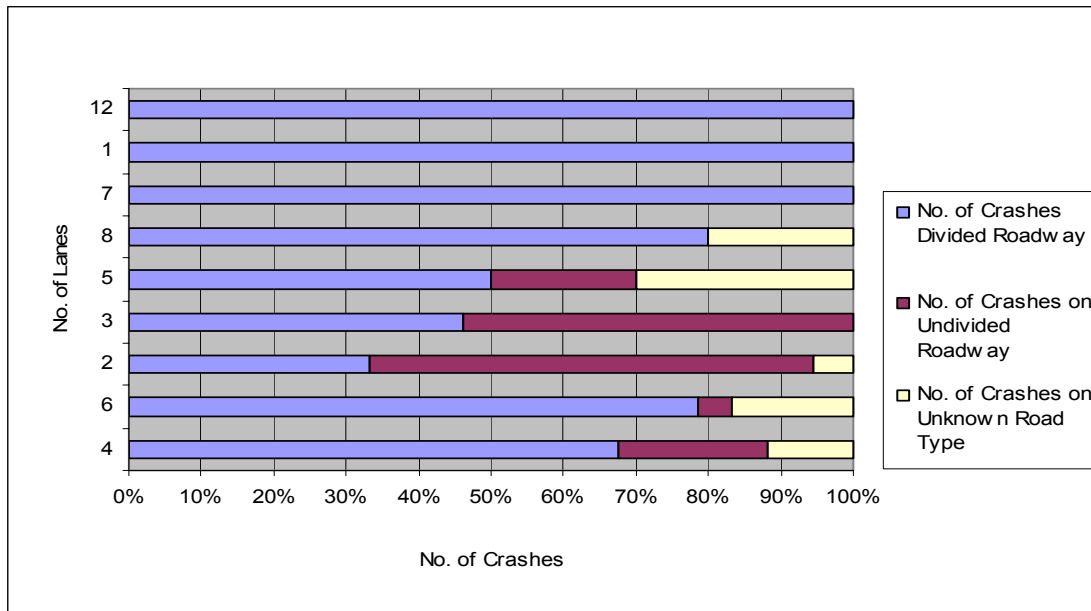


Figure 42: Fatal Intersection Crashes by Road Type and No. of Lanes at Signalized Intersections

The driver age distribution with fault involvement in fatal intersection crashes at signalized intersections as shown in Table 47 and Figure 43 is coherent with the overall fatal intersection crash study of driver age distribution, which is studied earlier in this chapter (Table 33: Drivers by Driver Age Groups in Fatal Intersection Crashes, Figure 28 and Figure 29).

Table 47: Drivers by Age Groups in Fatal Intersection Crashes at Signalized Intersections

Age Group	No. of Drivers	At Fault	Not At Fault
Above 5 - Under 15	1	1	0
Above 15 - Under 25	100	52	48
Above 25 - Under 35	100	37	63
Above 35 - Under 45	115	40	75
Above 45 - Under 55	76	22	54
Above 55 - Under 65	35	19	16
Above 65 - Under 75	41	20	21
Above 75 - Under 85	38	28	10
Above 85 - Under 95	10	8	2
Above 95	0	0	0

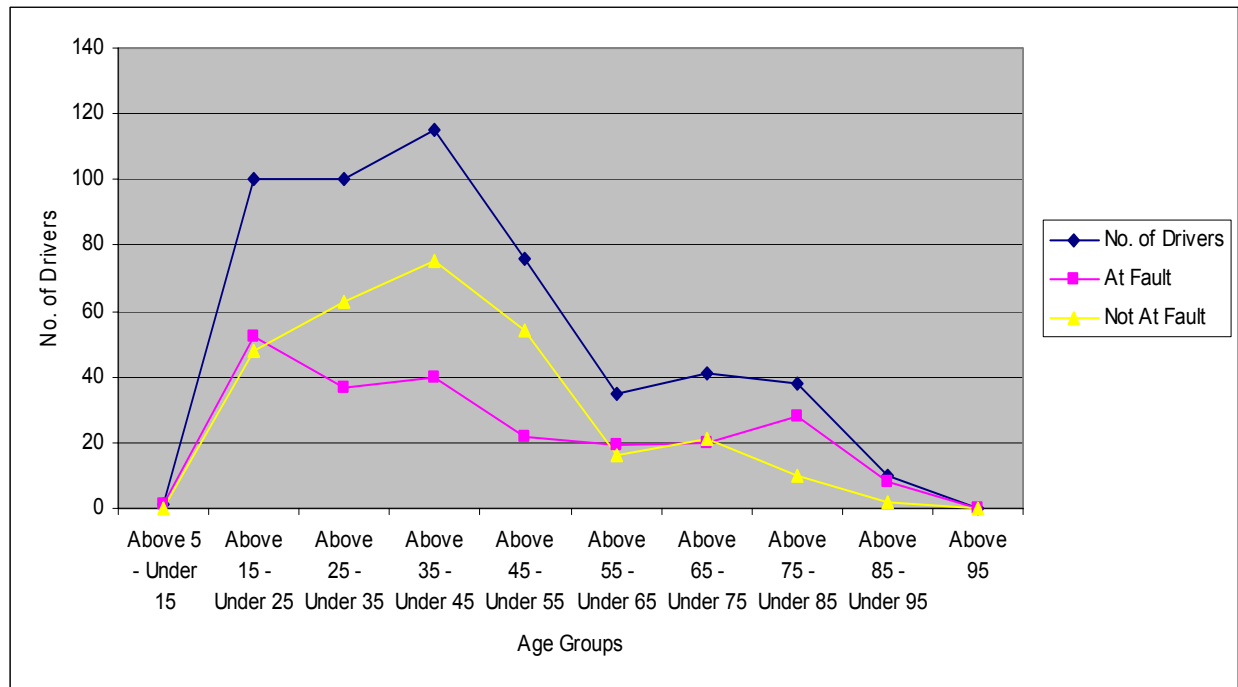


Figure 43: Distribution of Drivers by Age Groups in Fatal Intersection Crashes at Signalized Intersections

Table 48 shows the distribution of drivers by vehicle movement according to the major driver age groups. Under Age drivers are the drivers under 15 years of age, Young drivers are the drivers in the age group 15 – 25 years of age, Middle Age are in the age group 25 – 65 years of age.

The highlight from this table is the number of older drivers turning left at signalized intersection being involved in a fatal intersection crash. Around 30 % of the total drivers involved in fatal intersection crashes making a left turn belong to the older age group while the total percentage of older drivers driving on roads is far less than 30 % of the total number of drivers driving on roadways.

Table 48: Vehicle Movements by Major Driver Age Groups at Signalized Intersections

Vehicle Movement	Total Drivers	Under Age	Young	Middle Age	Older	Unknown
Straight Ahead	322	0	78	199	41	4
Slowing/Stopped/Stalled	61	0	5	46	9	1
Making Left Turn	120	0	16	66	36	2
Making Right Turn	7	0	1	5	1	0
Changing Lanes	1	0	0	0	1	0
Properly Parked	1	0	0	0	0	1
Making U-Turn	1	0	0	1	0	0
Passing	1	0	0	0	0	1
All Other	11	1	0	8	2	0
Unknown	1	0	0	0	0	1

Table 49 below shows the fatal intersection crashes at signalized intersection according to the movements of vehicles involved in a crash. It can be seen that more than 50 % of the total left turn vs. oncoming vehicle crashes in fatal intersection crashes occur at signalized intersections. It should be noted that most of the left turn oncoming crashes on signalized intersections occur while the vehicle is trying to turn in a permissive left turn phase and as such a driver judgment of available gap is involved. Just about 10 % of left turn oncoming crashes at signalized intersection occur due to the red light running by turning or straight vehicle.

Table 49: Distribution of Fatal intersection crashes by Movements of Vehicles Involved in a Crash

Vehicle Movements in Crash	No. of Crashes at Signalized Intersection	Total At Intersections	% At Signalized Intersections
Left Turning Vs Cross	14	138	10.14%
Left Turning Vs Oncoming	98	190	51.58%
Straight Vs Straight	93	238	39.08%
Rear End	23	62	37.10%
Other Movements	17	69	24.64%

Table 50 below shows the driver age distribution for the left turn oncoming crashes at signalized intersections with the fault involvements. The table shows a trend in congruence with the earlier driver age distribution trends with fault involvement. The older drivers are much more likely to be at fault if involved in a fatal intersection crash at a signalized intersection than their younger counterparts. Almost 90 % of the older drivers (above 65 years of age) involved in fatal intersection crashes at signalized intersections are at fault.

Table 50: Driver Age Distribution for Left Turn Oncoming Crashes at Signalized Intersections

Age Group	No. of Drivers		% At Fault by Age Group
	At Fault	Not At Fault	
Above 15 - Under 25	15	24	38.46%
Above 25 - Under 35	13	31	29.55%
Above 35 - Under 45	23	35	39.66%
Above 45 - Under 55	6	20	23.08%
Above 55 - Under 65	8	6	57.14%
Above 65 - Under 75	12	3	80.00%
Above 75 - Under 85	16	1	94.12%
Above 85	7	1	87.50%

CHAPTER 12

STOP SIGN CONTROLLED MOVEMENTS

Fatal intersection crashes at Stop Sign controlled movements constitute around 30 % of the total fatal intersection crashes. Table 51 below shows the distribution of the fatal intersection crashes at Stop Sign controlled movements by crash type. Unlike the signalized intersections, the left turn oncoming crashes are significantly under represented at stop controlled movements, whereas the Turn into Opposite Direction / Cross Traffic type crashes are highly over represented. Also the Rear End crashes are under represented in Table 51 as compared to Table 43. This further leads us to understand that rear end crashes at uncontrolled intersections are significantly over represented within the rear end crash category for fatal intersection crashes. The Driver Side Impact and Passenger Side Impact crash types are almost equally distributed within the crash group for know impact point in Table 51.

Table 51: Fatal Intersection Crashes at Stop Controlled Movements by Crash Type

Crash Group	Crash Type	No. of Crashes
Pedestrian	Pedestrian Crash At or Influenced by Intersection	8
Run off Road / Single Vehicle	Right Roadside Departure	1
	Right Roadside Departure With Control Loss	1
	Forward Impact	3
Same Direction	Rear End	2
Opposite Direction	Head-On	1
	Forward Impact With Control Loss	1
Change Traffic Way / Turning	Initial Opposite Directions/Oncoming Traffic	16
	Initial Same Direction	1
	Turn/Merge Into Same Direction	3
	Turn Into Opposite Directions/Cross Traffic	96

Table 52: Continued...

Intersecting Paths	Not At Fault Approaching From Left	40
	Not At Fault Approaching From Right	32

Table 52 below shows the distribution of fatal intersection crashes at Stop Controlled movements according to the movements of vehicles involved in a crash. As can be seen from the table the Stop Controlled movements principally differ from signal-controlled movements when it comes to crashes involving turning movement of vehicles. Signalized intersections while facing maximum number of left turn oncoming crashes, stop controlled movements suffer with maximum number of left turn crossing crashes. The left turn oncoming crashes in fatal intersection crashes at stop-controlled intersections are minimal. So also, the rear end crashes at stop controlled movements seem negligible as compared to signalized or uncontrolled movements. Straight vs. Straight moving vehicles are more likely to get into a fatal intersection crash at a Stop Controlled movements, with almost 35 % of total Straight vs. Straight fatal intersection crashes occurring at Stop Controlled intersections.

Table 52: Distribution of Fatal Intersection Crashes at Stop Controlled Movements by Movements of Vehicles Involved in a Crash

Vehicle Movements in Crash	No. Of Crashes at Stop Controlled Intersection	Total At Intersections	% At Stop Controlled Intersections
Left Turning Vs Cross	91	138	65.94%
Left Turning Vs Oncoming	7	190	3.68%
Straight Vs Straight	88	238	36.97%
Rear End	4	62	6.45%
Other Movements	13	69	18.84%

Table 53 below shows the driver age distribution for fatal intersection crashes at stop-controlled movements with the driver fault distribution within the age group. Following the

earlier mentioned general trends for the driver age groups, drivers above 65 years of age are highly over represented in the at fault category. So also, the drivers above 65 years of age are more likely to be in fatal intersection crashes at stop controlled movements with almost 25 % of the total drivers in fatal intersection crashes at stop controlled movements being 65 years or older, which should be supplemented with the fact mentioned earlier that only about 18% of the total drivers on the roads are older than 65 years of age in Florida.

Table 53: Driver Age Distribution for Fatal Intersection Crashes at Stop Controlled Intersections

Age Group	% In Age Group of Total Drivers in Fatal Intersection Crashes at Stop Controlled Intersections	No. of Drivers		% At Fault by Age Group
		At Fault	Not At Fault	
Above 15 - Under 25	18.53%	39	39	50.00%
Above 25 - Under 35	16.39%	29	40	42.03%
Above 35 - Under 45	19.24%	25	56	30.86%
Above 45 - Under 55	12.83%	22	32	40.74%
Above 55 - Under 65	9.74%	18	23	43.90%
Above 65 - Under 75	7.84%	22	11	66.67%
Above 75 - Under 85	10.69%	37	8	82.22%
Above 85	4.75%	17	3	85.00%

CHAPTER 13

RECOMMENDATIONS AND COUNTERMEASURES

This chapter offers potential recommendations and countermeasures as found suitable to improve the safety of intersections based on the study of the fatal crash data available. The recommendations and countermeasures are potential and not definitive and as such are not mean for implementation in the field as is. A further deeper study needs to be done considering the exposure data for the crash sites before any or a combination of these countermeasures can be implemented at any intersection. Intersections are highly prone to crashes due to the conflicting movements of vehicles. The contributing factors towards a crash in addition to driver errors may also be certain roadway or traffic operation issues, poor physical design of both the intersections and their approach roadways. Restricted sight distances or obscured lines of sight are some of the primary aspects compromising the safety of an intersection. Restricted sight distances do not offer enough time to drivers to stop or avoid hitting a pedestrian or another vehicle. Inappropriately posted traffic control devices, such as Stop Signs or other warning or regulatory signs, in terms of location, size, reflectivity or information contribute towards making the intersection unsafe or less forgiving to the drivers. Improving the engineering of intersections is the first step toward reducing accidents because vehicle conflicts, combined with flawed highway or street design and poor signage, often result in collisions of vehicles with roadside objects, pedestrians and other vehicles. Driver errors are also primarily responsible for crashes at intersections. Some crashes are solely due to the blatant disregard of traffic control devices and some others due to driver inattention or distraction due to cell phone use, eating in vehicle while driving or DUI etc. Also, sometimes the traffic operation issues need to be addressed with due regard to the changing traffic volumes and patterns at certain intersections.

There are 3 major types of vehicle crashes at intersections.

1. Crossing collisions: These result from vehicles moving straight through or turning within an intersection and when one vehicle strikes the other on the side or at an

- angle. These are the most severe and highest occurring type of crashes at intersections.
2. Rear-end collisions: These are not so common at Florida intersections. They can be the result of poor street design or inadequate traffic engineering measures; but usually are the result of dangerous driver behavior, such as speeding, following too closely, and braking too late.
 3. Pedestrian and bicycle collisions: These occur most frequently in urban areas, particularly with older and younger age groups

13.1. Countermeasures to Improve Intersection Safety

AASHTO recommends that the intersection sight distance in both directions should be equal to the distance traveled at the design speed of the major road during a period of time equal to the time gap.

An engineering review is used to identify the safety problems at the fatal intersection crash sites. A very crucial factor to remember when implementing countermeasures that improve safety at intersections and the vehicle traffic flow or reduce vehicle crashes, is that they do not compromise the safety of pedestrians.(ITE, 2004) The strategic decisions that need to be considered when improving operation and safety at intersection are discussed below: -

- Eliminate the pedestrian and vehicle conflict wherever possible.
- At intersections where this conflict elimination is not possible, reduce the unavoidable pedestrian and vehicle conflict to lower the chances of crashes.
- Make the intersections more forgiving to the drivers, so that even in the event of a crash on account of driver error it is not as serious.

Traffic engineering strategies to improve movement of vehicles and pedestrians are crucial to improving intersection safety. These strategies vary according to the critical issue that needs to be addressed at an intersection and care needs to be taken that while addressing the critical issue, other non-critical issues are not compromised, and otherwise by reducing one particular type of crash on one hand can increase the other type, thereby not really improving the safety of the intersection. The potential countermeasures are described as follows:

1. *Addition of turn-lanes at intersections:* The Basic Intersection Countermeasures chapter in the intersection safety briefing of FHWA says, “Turn lanes are used to separate turning traffic from through traffic. Studies have shown that providing turn lanes for left-turning vehicles can reduce accidents by about 32 percent. Personal injury accidents involving left-turning vehicles can be decreased by as much as 50 percent. Separating right-turning vehicles from other vehicles can significantly affect operations at an intersection.” By adding a separate right-turn lane at an intersection with a signal, the delay experienced by drivers on an approach can be reduced. At intersections without a signal, right-turn lanes can safely remove turning vehicles that are slowing down in through traffic lanes. Turn lanes at major driveways can also improve safety, especially on high-volume or high-speed roadways.

2. *Signals:* Increase the size of signal heads to increase their visibility; provide separate signals over each lane; install higher intensity signal lenses; and change the length of signal cycles, including the yellow clearance interval and the all-red phases. Experiment the use of longer all red phase rather than a longer amber phase at high crash prone intersections.

3. Since, more than 30 % of the drivers at fault in left turn oncoming crashes are older drivers with more than 65 years of age, which leads us to understand that older drivers are highly likely to make a judgmental error while making a left turn in front of oncoming traffic. It is recommended that in regions where more older age driver population is identified through demographics, reconsideration of traffic control be done and only protected green turning be allowed for left turners in front of oncoming traffic on a divided roadway.

4. *Non-traditional intersection design*: Consideration of non-traditional intersection designs such as roundabouts or traffic circles. Also, consider provision of movement splitting islands.

5. *Pavement condition*: Upgrade pavement quality to better drain the road and resist skidding.

6. *Improve drivers' sight distance*: Restrict parking near intersections and move stop lines towards intersections so that, the driver can establish proper line of sight before entering the intersection. The corners at intersections should be cleared of any such objects that might obstruct the line of sight of the driver. So also, on roadways with medians and planted shrubbery in the medians, the shrubbery should be cleared near the intersections so that the driver on the intersecting road has adequate sight triangle. To address the problem of other stopped vehicles blocking or obstructing the line of sight, offset the stop bars at intersections for turning and straight vehicles. The turning stop bars should be pushed back from the intersection so that the vehicles stopped in the turn lanes do not block the line of sight to the straight oncoming vehicles stopped at the other end of intersection.

7. *Upgrade and supplement signs*: Roadside signs should be retro reflective and prominently visible. In sections of roadways where foggy conditions are known to occur, provide flashing warning signage. Dynamic signage with the intervention of Intelligent Transportation Systems (ITS) should be thought of so as to give the current traffic conditions to the drivers on the intersecting roadway.

8. *Law Enforcement*: Enforcing laws that prohibit dangerous intersection driving is a necessity to even well designed and regulated intersections. Enforcement must be consistent because motorists who tend to violate traffic control are aware that the chances of receiving a citation are low. Sustained enforcement efforts can reduce both, intersection violations and crash rates, sometimes to a dramatic extent. Red light running can be curbed by strict enforcement and use of red light running cameras. Automated speed detecting systems should be installed on roadways and be monitored so that a patrol officer can be dispatched to intercept the speeding vehicles. Looking at the crash trend based on hour of the day, during the early morning hour of 6 am, law enforcement and patrolling should be strict in rural areas followed by strict patrol

enforcement in suburban areas during 7 AM – 8 AM and similar strict control in urban areas during 8 AM – 10 AM.

9. *In-vehicle Countermeasures*: Equipping vehicles with special in-vehicle warning or messaging systems to assist the older drivers in executing time consuming or time gap judgment involving maneuvers may be thought of in advanced stages while implementing ITS technologies.

10. *Driver Education*: Extensive driver education campaigns and public notices can be resorted to educate the drivers of the crash facts and the importance of safe driving and the property and life damage to innocent victims due to careless driving. The drivers should be educated about defensive driving. They should be educated to be alert at intersections and watch out for stop sign running or red light running rash drivers. It is important to know that taking traffic control for granted can be fatal and that more than 30 % of fatalities in fatal intersection crashes are of not at fault drivers. Drivers should be encouraged to report rash driving on road and near miss situations at intersections due to careless driving on part of other drivers.

CHAPTER 14

CONCLUSIONS

Following are the conclusions drawn based on the analyses carried for the fatal intersection crashes. A very important factor to note here is that only the fatal intersection crashes were studied as a part of this research and as such the analyses did not consider the exposure data of the crash site.

- About 1/3rd of the total Fatal Crashes studied in the limited data for the State of Florida are fatal intersection crashes.
- Within the year, fatal intersection crashes are higher in early spring months than any other month except in August, when the number of fatal intersection crashes is higher than the average 58 fatal intersection crashes in each month of the year for the data.
- Within the week, fatal intersection crashes are highly over represented on Fridays when 115 fatal intersection crashes occurred as against the average 100 fatal intersection crashes within a day of the week for the data.
- Within the day, fatal intersection crashes are highly over represented within the evening hour of 6 pm to 7 pm when 53 fatal intersection crashes occurred as against the average of 29 fatal intersection crashes within each hour of the day for the data.
- Lighting conditions do not really affect the fatal intersection crashes except for the Pedestrian Crashes at or influenced by Intersections. Though there is no correlation between geographical location and dark/daylight, but there is correlation between geographical location and presence of streetlights.
- Signalized Intersections have the highest number of fatal intersection crashes, slightly over 1/3rd of the fatal intersection crashes studied in the data occurred at Signalized Intersections, followed by around 28 % at Uncontrolled Intersections and 27 % at Stop Controlled Intersections.

- Driver Age significantly bears a correlation on the number of fatal intersection crashes. Younger drivers under 25 years are the highest likely to be involved in fatal intersection crashes followed by older drivers above 65 years of age.
- Left Turning vehicle movements are the most likely to cause a fatal intersection crash. Almost one half of the fatal intersection crashes involve a left turn by one of the drivers involved in the crash. About 30 % of the total fatal intersection crashes involve left turn oncoming vehicle movement. Around 20 % of the total fatal intersection crashes involve left turn across a crossing traffic vehicle movement.
- Rear End Crashes within the fatal intersection crashes are most prevalent at uncontrolled intersections with little under half of total rear ends in fatal intersection crashes occurring at uncontrolled intersections followed by little over 1/3rd of total rear ends in fatal intersection crashes occurring at signalized intersections.
- Primarily Human factors contribute to the occurrence of the fatal intersection crashes. Inattention or Distraction is the chief primary contributing factor to the fatal intersection crashes with almost 40% of fatal intersection crashes having Inattention as the primary contributing factor. Second most prevalent human factor is a decision error with almost 20 % of fatal intersection crashes having Human Decision as the primary contributing factor.
- Driving under the influence (Alcohol or Drugs or Both) is also primary contributing factor towards the crash for more than 20 % of the fatal intersection crashes.
- Signalized Intersections are most likely to suffer from a fatal intersection crash involving a left turning and an oncoming vehicle. More than 50 % of the total left turn oncoming crashes in fatal intersection crashes occurred at signalized intersections. Almost 90 % of the fatal intersection crashes involving left turn oncoming vehicle movements at a signalized intersection occur on a permissive left turn phase.

- Stop Sign Controlled intersections as opposed to signalized intersections are very unlikely to suffer from a left turn oncoming fatal intersection crash. Left turn and crossing movement crash is most likely at a Stop Controlled Intersection. Almost 2/3rd of the total fatal intersection crashes involving left turn crossing movements of vehicles occur at stop-controlled intersections.
- Almost 10 % of the fatal intersection crashes involved a pedestrian or bicycle in the crash and as such a revaluation of intersection facilities for the pedestrians and bicyclists needs to be done.
- Almost 10 % of the fatal intersection crashes have roadway issue involved, which had a direct bearing on the occurrence of the crash.
- Sight distance Issue is the concern in majority of the crashes wherein a roadway issue is involved. The curvature in road or the presence of trees shrubs or other fixed objects or a combination of both contributes towards limiting the sight distance on roadways or obstructing the clear line of sight.
- Medians wider than 30 feet affect the perception and judgment of driver at an intersection thereby contributing towards the fatal intersection crashes.
- More than 30 % of the drivers at fault in left turn oncoming crashes are older drivers with more than 65 years of age.

APPENDIX A

PROTOCOLS FOR REVIEWING CASES

- 1) Determine if we have the following documents available and state yes/no in the **Crash Data table**:
 - a. DHSMV Report
 - b. Traffic Homicide Report
 - c. Video Log
 - d. Photos
 - e. Audio tape
- 2) Check the database and make sure the crash has been entered. If the crash has not been entered, enter the crash (DHSMV data) into the database.
- 3) Determine which agency investigated the homicide and determine if there is a Homicide Report available.
 - a. If there is not a Traffic Homicide Investigation Report (THI), record all of the information necessary to obtain the report, such as the agency name, city, county, DOT district, date of crash, DHSMV number, & investigating agency number.
 - b. If the Traffic Homicide Investigation (THI) exists, use this report as a reference to review the case.
 - c. Check over the THI report and make sure it is complete. Check for these items; document their status in the **THI Completeness** table:
 - i. Accurate sketch of the scene with dimensions
 - ii. Is the sketch proportionate or to scale?
 - iii. Speed calculations available (where applicable)
 - iv. CMV inspection report available (where applicable)
 - v. Hours of service been reported (CMV only)? If so, are they in compliance? **See Appendix A** for compliancy.
 - vi. Driver History's for each driver
 - d. Is the Crash Report complete? (All pages/information available.)

- 4) Read the crash report narrative and look at the diagram, get a feel for what happened during the crash.
- 5) As you review and read both the DHSMV and the THI reports, check the reports for accuracy and consistency.
 - a. Is there any information given on the crash report that is incorrect or missing according to the THI?
 - i. If so, correct the data in the database and enter the list of corrections in the **Errors** table in the database
- 6) Review the officer's determination of who was at fault.
 - a. Assess each driver as at-fault or not at-fault and input the data into the database in the **Driver table**.
 - b. Determine the action of the at-fault person.
 - c. If there is any evidence that the officer's assessment may be incorrect then make a note of the differences and why you disagree so that it can be discussed in the weekly roundtable meeting. Note in **Crash Data table**.
 - d. Determine which drivers received citations; list the type of citation received and by whom, including the statute number if available. Input the data into the **Violations table** in the database. Mark whether or not citations were given in the database in the **Driver table**.
 - e. Determine whether any civil/criminal charges were filed for each driver.
 - i. If so, what were the charges, including the statute number if available? Input the data in the **Violations table** in the database. Be sure to indicate if charges were not filed due to death (in the **driver table**).
 - ii. If there are any major discrepancies in the charges, make note of them and bring them to the weekly meeting so it can be discussed, also note them in the note field in the driver table. – (This information is vital to be able to make accurate assumptions.)
- 7) Review all of the occupants in each vehicle. Input the following data into the database in the **Vehicle table**.
 - a. How many total occupants were in each vehicle?
 - b. How many injuries were there in each vehicle?

- c. How many fatalities were there in each vehicle?
- 8) Look at the safety equipment and determine whether or not the vehicle was equipped with air bags. Specifically indicate if the airbag deployed for each occupant. Input/check the following data in the database in the **Driver & Passenger tables**.
 - a. Safety Equipment Use
 - b. Position in Vehicles
 - c. Injury severity
- 9) Determine what day of the week the crash occurred on and input the data into the database in the **Crash Data table**?
 - a. Determine if the crash happened on or near a “Federally Observed” Holiday?
 - See Appendix B.**
 - i. “Near” holidays is defined as follows:
 - ❑ If holiday is on a Friday, Saturday, Sunday or Monday, near = Fri-Mon.
 - ❑ Thanksgiving, near = Wed-Sun
 - ❑ Christmas, near = Christmas Eve & Day (unless on weekend, then refer to # 1)
 - ❑ New Years, near = New Years Eve & Day (unless on weekend, then refer to # 1)
 - ❑ Otherwise, near = day of Holiday
- 10) Were there any pedestrians or bicycles involved? Input data in the database in **Crash Data table**.
- 11) Were there any heavy trucks involved? Input data in the database in the **Crash Data table**.
- 12) Look at the RCI data and get all of the necessary information? Add to **Crash Road Table**.
 - a. ADT
 - b. Pavement Quality
- 13) List, in order, the sequence of events that occurred before, during and after the crash. **See Appendix C** for specific terminology.
 - a. Do not include the contributing factors

- b. Include sufficient detail to ensure that the event is understandable. Use vehicle directions if necessary.
 - c. Input the following data into the database in the **Sequence of Events table**.
- 14) What are the harmful events listed on the crash reports?
 - a. Are the harmful events sufficient and correct?
 - b. What additional harmful events should have been included?
 - c. Report any additional information in the database in the note field in the **Crash Data table**.
 - d. Report any errors in the **Errors table**.
- 15) From the narrative of the THI, extract the factors that potentially contributed to causing this crash.
 - a. Break down the contributing factors into the following categories. Consider all of the items that are related, but do not limit the categories to those listed. **See Appendix D** for specific terminology. Input the following data into the database in the **Crash Contributing Factors table**.
 - i. Roadway
 - ☐ Traffic control devices
 - ☐ Roadway geometry / Alignment
 - ☐ Roadside Geometry / Structures
 - ☐ Striping / Pavement Condition
 - ☐ Signage
 - ☐ Location
 - ☐ Placement
 - ☐ Suitability
 - ☐ Traffic Congestion
 - ☐ Reference any ASHTO guidelines, or any other reference books.
 - ☐ Soil Characteristics
 - ☐ Type of shoulder (paved, grass, gravel)
 - ii. Driver/Person
 - ☐ Age (very old / very young)

- ❑ Alcohol or drugs
 - ❑ Distracted (Inattention)
 - ❑ Aggressive Driving
 - ❑ Driver errors / Violations (e.g. D1 misjudged gap on permissive left turn phase and turned into path of V2; D1 did not stop at red arrow and turned left into path of V2)
 - ❑ Familiarity with vehicle
 - ❑ Familiarity with area
 - ❑ Mental Condition (state of mind)
 - ❑ Physical Condition
 - iii. Environmental
 - ❑ Weather
 - ❑ Lighting
 - ❑ Vision obstructed (glare, etc)
 - ❑ Slick Roads
 - ❑ Objects in road
 - iv. Vehicle
 - ❑ Mechanical Defects
 - ❑ Age / Size
 - ❑ Vehicle Defects
 - ❑ Load shifting / Escaping
 - ❑ Trailer attachment failure
- b. After composing a list of contributing factors compare that list to the contributing factors listed on the crash report and determine if the factors were missed or listed correctly. List all the errors in the database in the **Errors table**.
- i. What are the disagreements, if any?
 - ii. What was not noted by the officer?
- c. Where there any circumstances that seemed odd or out of place?
- i. If so, what were they and why were they present? Describe in detail in the note field in the **Crash Data table** in the database.

- 16) From the narrative of the THI, extract the factors that contributed to the fatality.
- a. Follow the same system for determining contributing factors to the crash (# 15) but place the data into **fatality contributing factor table**.
 - b. Break down the contributing factors to the fatality into the following categories. **See Appendix E.**
 - i. Roadway
 - ii. Driver/Person
 - What type of safety equipment was being used?
 - Was anyone ejected from the vehicle?
 - Where was the fatally injured person located in the vehicle, with respect to the point of impact?
 - iii. Environmental
 - iv. Vehicle
- 17) Determine if there was any type of construction around the area of the crash.
- a. If so, how did the construction influence the crash?
 - b. Input the data into the database in the **Crash Data table**.
- 18) Is the driver history available for the driver(s) in the THI (From Question # 2.c.vi)?
- a. If so, answer the following questions and input the data into the database in the **Driver table**.
 - i. Was the license valid, suspended or revoked at the time of crash?
 - ii. Are there any significant entries? (such as criminal charges, DUI's).
 - iii. Rank the driving history, **see Appendix F**.
- 19) If photos are available, retrieve them and answer the following questions and input the data into the database in the **Photos table**. Note: Even though some of these questions have been noted earlier, this information needs to be extracted directly from what can be seen into photographs.
- a. Were there any roadway issues that may have influenced the crash such as tripping mechanisms or roadway design issues? If so, list.
 - b. Are there any specific details that need to be investigated on a site visit?
 - c. What is the geometry of the roadway? - Note all aspects from grade to number of lanes, curbs, etc.

- d. Are there any skid marks visible?
- e. Are there any marks on the side of the road that would indicate if the vehicle left the road?
- f. What types of intersection controls are visible (if any)?
- g. Is there any road construction visible?
- h. What do the pavement and roadway quality/conditions look like?
- i. Are there any signs of inclement weather, such as wet roadway or policemen in raincoats?
- j. Were there any obstructions hit during the crash? -- List them
- k. Were there any obstructions visible that were not hit in the crash?
- l. What is the position of the vehicle?

20) Retrieve the video log for the given roadway ID and milepost (retrieve ½ to 1 mile before crash site in the direction of all vehicles, if possible) from the DOT website.

- a. Note details that can be seen about the site not noted elsewhere, or things that need to be investigated during a site visit. Examine roadway design and traffic operations (signage, signal type and placement, etc.) issues. Note condition and placement of all roadway features.
- b. Are there any safety devices (advance warning signs, crosswalks, etc.) noticeable on the video log?
- c. Provide a specific description of the roadway features, focusing on those relevant to both preventative and contributing factors for this crash.
- d. Determine if the crash site has been altered or if there have been any significant changes in the roadway, such as lanes added/removed, traffic controls added, roadway resurfaced.
- e. Using the video log and the knowledge of the crash, determine if a site visit is warranted with respect to the video log data. Give a detailed explanation as to your decision in the **Video table**. If site has changed, note how it has changed and how the crash might have influenced the redesign.
- f. Input all information about the video log in the **Video table** in the database.

21) Review the roadway design and see if there are any attributes of the road that are not within the **AASHTO design standards**?

- a. Slope of shoulders
- b. Grade
- c. Super-elevation
- d. Width of roadway
- e. Radius of Curvature
- f. Note potential design issues in the **Crash Contributing Factors table**.

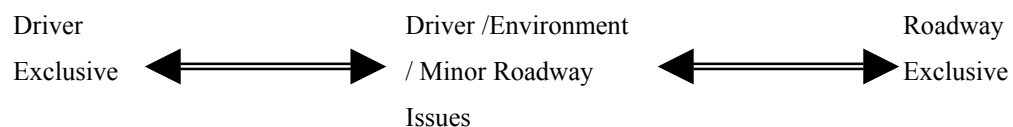
22) Speed -- Input the following data into the database in the **Vehicle table**.

- a. If speed is relevant, what was the posted speed?
- b. How fast were the vehicle(s) going? Perform reconstruction if necessary.
- c. What is the speed differential between the vehicles (if relevant) or between the vehicle speed and the posted speed?
- d. Does the speed limit change within $\frac{1}{2}$ - 1 mile before the crash site in the direction of any approaching vehicle?
- e. State who calculated the speed.

23) For the overall crash, make an assessment and on a scale of 1-5 (5 being the highest priority) and rank the crash on whether or not a site visit is needed. Give a detailed explanation as to why you chose the priority that you chose and put the data in the **Crash Data table**.

- a. If you can answer **YES** to the following items then a site visit would **NOT** be required and should be given the priority of 1:
 - i. Has the roadway been altered or reconstructed in any way since the crash?
 - ii. Is the roadway currently under construction?
 - iii. In the review of the photos and video log, the crash scene is a wide open, straight, flat, well constructed, unobstructed roadway with light to medium traffic. The crash did not occur at an intersection. The roadside features are adequate and not a hindrance. The shoulders of the road are well constructed and are not too steep. (All of these statements must be true to answer "yes.")
 - iv. Was the crash was completely unrelated to roadway and traffic operations, such as a person falling or jumping from a vehicle, etc.

- b. Review the following items to aid in the determination as to what priority each site visit should be given:
- c. Given all of the information that has been retrieved, use the following table as a guide to help determine the site visit priority. In using the priority ranges, the lowest priority should be used if the crash was exclusively related to driver error. The mid range priority can be used for issues that include driver error, minor roadway issues and the environment. The highest priority range should be used for crashes that have major roadway design and traffic operations issues. Be sure to use this as only a guideline and don't limit the priority rating to what can be seen below. Use your experience as a driver and your knowledge of roadway issues and design to help in the overall site visit assessment.



Priority 1	Priority 2	Priority 3	Priority 4	Priority 5
See question 23.a	Straight and level roadway	High speed crashes	Curvature of the roadway at the crash site	Heavy traffic volume / Congestion
	Adequate signage	*Rollover crashes	Poor approach and/or warning signage	Intersections with inadequate or excessive signage
	Good perception / Sight distance	*Simple Signalized Intersections	Illegal turns	
(with respect to access management and appropriate signage)	Poor Roadway design / **Apparent design issues			
	Clear driver error	Simple Non-signalized intersections (e.g. Driveways, T-intersections)	All major / busy intersections -	Access Management Issues

		Too fast for conditions / poor driving conditions	Inadequate sight distance	Complicated roadway designs
		Alcohol Induced		Complex intersections, complicated design issues, confusing

* Except obvious design issues.

** If the roadway issues are obvious (e.g. bridge w/no emergency lanes) and a site visit would provide no additional information, then the priority can be reduced to a lower number accordingly. However, make note of the roadway deficiency in the database.

24) After reviewing all of the information for the crash, if you have determined that a site visit is warranted, list any items in detail that need to be examined at further during the site visit and list the information in the special note field in the

Crash Data table.

This part of the protocol set refers to specific crash types, and is written so the reviewer can use this as a guide in the review of the cases. These questions should be expanded on for each case if necessary. The data collected from these questions is to be added to the contributing factors (crash and fatality) as needed. This can also be used as a guide to help determine the sequence of events. Refer to as many crash types as necessary to describe all aspects of the crash (e.g. run off the road and pedestrian, intersection and fixed object, etc.).

Run off the road crashes:

1) What movements were the vehicles making?

- a. At-Fault vehicles
 - b. Not-at fault vehicles
 - c. CMV's (if applicable)?
 - d. Was the CMV at-fault?
- 2) Was there any evasive action or steering input that took place prior to running off the road?
 - a. Any indication why the vehicle ran off the road?
 - i. Abrupt maneuver, slowing, drifting, aggressive driving, traffic congestion, incursion of another vehicle into lane, etc.
- 3) Which direction did the vehicle run off the road? (Median, gore, shoulders)
 - a. Did the vehicle overcorrect back into the travel lanes, overcorrect into opposing travel lanes, cross into opposing lanes without overcorrection, etc.?
- 4) What are the roadway characteristics, such as, but not limited to:
 - a. Ramps, rumble strips, roadway grade, curvature, super-elevation, pavement markings,
 - b. Where known, indicate coefficient of friction for road surface, age of the pavement, whether the road was under construction, etc.
 - c. Did roadway features affect crash (e.g. vehicle didn't follow curvature)?
- 5) Did the vehicle overturn?
 - a. Try to determine the cause of the overturn. (Hit object, tripping mechanisms, loss of lateral stability, slope, etc.)
- 6) Was there a difference in grade from the roadway to the shoulder?
 - a. What was the shoulder type? (paved, gravel, etc)
- 7) What were the characteristics of the shoulder?
 - a. How soft was the soil (if applicable)?
 - b. Where there any tripping mechanisms?
 - c. What was the slope of the shoulder?
 - d. Where there any obstructions in the shoulder? (refer to obstruction protocol)
 - i. Were the obstructions fixed or not fixed?
 - ii. Did the vehicle hit any of the obstructions?
 - 1. How far from the roadway were the obstructions?

2. Were the obstructions in the clear zone?
- 8) Did the roadway/shoulder characteristics influence the crash?
 - a. If so, in what way?

Signalized Intersection Crashes

- 1) What type of intersection is it?
- 2) What movements were the vehicles making?
 - b. At-Fault vehicles
 - c. Not-at fault vehicles
 - d. CMV's (if applicable)?
 - e. Was the CMV at-fault?
- 3) Did the at-fault vehicle violate the signal?
 - a. Was the movement legal?
 - b. Was the vehicle in the appropriate lane?
- 4) What type of traffic control was present for each vehicle?
- 5) Was the traffic control device working properly (electronic)?
 - a. If a traffic light, was the light flashing or cycling?
 - i. If the light was flashing, is it always flashing, or does it begin a flashing phase at a certain time. If so, what are the times that the light is flashing?
- 6) Did the crash occur in the dilemma zone?
- 7) Were there pedestrians involved? If so, refer to pedestrian protocol.
- 8) How many lanes are present for vehicle/pedestrians to cross, including turn lanes if applicable?
 - a. How many lanes did each vehicle/pedestrian cross before the impact?
- 9) Are there exclusive turn lanes for turning traffic?
 - a. Are there traffic signals for the turning movement?
 - i. Are the signals protected, permissive, or both?
 - ii. What was the condition during the crash?

- 10) Are there crosswalks present? Medians? Channelization?
- 11) Are there any sight distance issues?
 - a. On approach of the intersection?
 - b. Stopped at the intersection?
 - c. Proceeding through the intersection?
- 12) Are all of the traffic control devices clearly visible on approach of the intersection?
- 13) Was there any advisory signage on approach to the intersection?
- 14) What is the type (mast arm/pole & wire, mounted horizontally or vertically) and location of the signals? Were glare screens in place?
- 15) What are the signal times and phases like?
 - a. Are the signal times and phases appropriate for the ADT at the time of the crash?
 - b. Are the signal times and phases appropriate for the roadway configuration at the time of the crash?
 - c. Is the number of lanes appropriate for the ADT?
- 16) Are the storage bays of the turn lanes long enough for the amount of traffic turning?
- 17) Were the roadway characteristics an influence to the crash?
 - a. If so, what influences were relevant?

Non-Signalized Intersections (with/ without traffic control)

- 1) What type of intersection is it? What types of roads/driveways intersect?
- 2) What movements were the vehicles making?
 - a. At-Fault vehicles
 - b. Not-at fault vehicles
 - c. CMV's (if applicable)?
 - d. Was the CMV at-fault?
- 3) What type of traffic control was present for each vehicle (if any)?
- 4) Are all of the traffic control devices clearly visible on approach of the intersection (if applicable)?

- 5) How many lanes are present for vehicle/pedestrians to cross?
- 6) Are there turn lanes for turning traffic?
- 7) Are there crosswalks present? Medians? Channelization?
- 8) Are there any sight distance issues?
 - a. On approach of the intersection?
 - b. Stopped at the intersection?
 - c. Proceeding through the intersection?
- 9) Was there any signage on approach to the intersection?
- 10) Are the storage bays of the turn lanes long enough for the amount of traffic turning?
- 11) For movements with stop sign, did vehicle stop? Did vehicle misjudge stopping distance or gap distance?
- 12) For movements with yield sign, did vehicle yield right-of way?
- 13) Did vehicle make a legal maneuver using the appropriate lanes?
- 14) Were the roadway characteristics an influence to the crash?
 - a. If so, what influences were relevant?

Lane Changes/Crossing Centerline

- 1) Which direction was the lane change?
- 2) What movements were the vehicles making?
 - b. At-Fault vehicles
 - c. Not-at fault vehicles
 - d. CMV's (if applicable)?
 - e. Was the CMV at-fault?
- 3) Was the lane change intentional or evasive?
 - a. Was the vehicle drifting?
- 4) What was the angle of the collision?
- 5) Was sight distance an issue?
- 6) Were there pavement markings and were they clearly visible on the roadway?

- 7) Was the equipment on the vehicles working properly, e.g. headlights, taillights?
- 8) Was either of the vehicles in its correct lane?
 - a. If not, which vehicle was in the wrong lane?
 - b. Why was this vehicle in the wrong lane?
 - i. What action made the vehicle proceed to the wrong lane? (merging from shoulder, passing, merging from entrance ramp, etc)
- 9) Were there any evasive actions or steering inputs that took place prior to the lane change or after the lane change?
- 10) Did vehicle cross over the centerline into opposing lanes?
 - a. What were the speed differences in the vehicles involved?
- 11) Did the vehicle leave the roadway? If so, refer to run-off the road protocols.
- 12) Did the vehicle overturn? If so, see overturn crashes.
- 13) Were the roadway characteristics an influence to the crash?
 - a. If so, what influences were relevant?

Rear-End Crashes

- 1) What were the speed differences in the vehicles involved? (Speed is a major issue in working with rear-end crashes.)
 - a. Were vehicles above/below posted speeds?
- 2) Was there any evasive action taken prior to impact? By which vehicle?
 - a. If so, explain what actions were taken and how close to the impact were the actions taken.
 - b. If not, try to determine why, such as, was the driver not paying attention, fatigue, medical conditions, defective equipment, etc.
- 3) Why was the lead vehicle stopped/slowing? (Stopped due to traffic, U-turning, legally/illegally parked)?
 - a. Was traffic congestion an issue?

- i. If so, what was the cause of the congestion (construction, insufficient storage on turn-lanes, etc.)? Specifically look at the ADT and other traffic data to determine if the Level of Service is adequate.
 - b. If any of the vehicles were parked, determine why they were parked.
 - i. Were they parked legally and if so why/how did the vehicle get hit.
 - ii. For vehicles parked on the road side,
 - 1. Determine why the vehicle was parked on the side of the road
 - 2. Look at the shoulders/emergency-lanes and determine if they are adequate
 - 3. Was the vehicle far enough off the road
 - c. Were any vehicles making a U-turn?
 - i. Was it at a legal/illegal cross over?
 - ii. Was a left turn lane provided?
 - d. If a CMV was involved, did the CMV rear-end a vehicle or did the CMV get rear-ended?
- 4) Who was at-fault, the driver of the vehicle in the front (that was rear-ended) or the driver of the vehicle in the rear (that sustained frontal damage)?
- 5) How did the roadway design affect the crash with respect to vehicle movements?

Non-Fixed Obstructions

- 1) Where was the object located? On the road? If not on the road, how far from the road?
- 2) What was the obstruction?
- 3) Where did it come from?
- 4) Was the object large enough to be visible to the driver?
- 5) Was the perception/reaction an issue to avoid the object?

Fixed Obstructions

- 1) Where was the object located? How far from the road?
- 2) What was the obstruction?
- 3) Was the object in the clear zone?
- 4) Was the object a “break-away”?
- 5) How fast was the vehicle going when it left the road, and when it hit the object?
- 6) Was the obstruction FDOT property?
- 7) Were there guardrails/attenuators in place?
 - a. What was their condition? Why/how did they fail?

Pedestrians

- 1) What is the road type where the pedestrian was hit? (Intersection, Interstate, undivided, 4-lane divided, etc)
- 2) How many lanes were they attempting to cross?
- 3) What movement was the vehicle attempting? (Through movement, right turn, left turn, changing lanes, etc.)
- 4) What movement was the pedestrian attempting? (Walking across road, running across road, standing in road, standing on shoulder, walking with traffic, walking against traffic, etc.)
- 5) In which lane was the pedestrian hit? How many lanes did they successfully cross?
- 6) Were there crosswalks available, if applicable?
- 7) Were there sidewalks available, if applicable? On which sides of the road?
- 8) Was a median or channelization available, if applicable? Painted or raised?
- 9) If crossing roadway, were there any pedestrian signals available? If so, was the pedestrian crossing with or against the signal?
- 10) What types of signals were present at the intersection (if applicable)?
 - a. Where were the signals located?

- 11) How close was the pedestrian to the nearest pedestrian control? (crosswalk if crossing road, sidewalk if in road, etc)
- 12) If the pedestrian was walking/running in roadway, were they traveling with or against traffic?
- 13) How fast was the vehicle traveling?
 - a. Did the driver attempt any evasive action?
 - b. Did the pedestrian attempt any evasive action?
- 14) Was the pedestrian under the influence of alcohol or drugs?
- 15) How old was the pedestrian?
 - a. Could age have been a factor (very old/young)?

Mechanical Malfunctions

- 1) What type of mechanical defect caused the crash, such as tires, steering wheels, axles, etc.?
- 2) Was the driver aware of the defect before the crash?
- 3) If the defect was tire related, determine if it was a blow-out, tread separation, or a deflation.
 - a. If it was a tread separation, determine the vehicle make and model and see if the tires fall under the Ford Explorer/Firestone Tire problems.
 - b. Did tire fail prior to crash or as a result of/during the crash? (e.g. deflation due to loss of lateral stability (vehicle movement perpendicular to rolling direction))

Other Crashes

- 1) Over-correction crashes

- a. Determine what caused the driver to over-correct (overtaking vehicle, vehicle incursion into lane, sudden awareness following inattention/sleep)
 - b. What type or amount of steering input caused the over-correction?
 - c. If the over correction is due to a run-off the road type crash then refer to the run-off the road protocols.
- 2) Roll-over crashes
- a. What steering input caused the vehicle to roll over
 - b. Look at the roadway geometry and determine if the roadway was a factor
 - c. Was there a tripping mechanism to cause the overturn?
 - d. What type of vehicle? Is this vehicle susceptible to rollover?
 - e. What type of damage did the vehicle sustain?
 - f. Did the vehicle leave the roadway before overturning?

APPENDIX B

LIST OF SEQUENCE OF EVENTS

Sequence of Events	
Accelerated Into Roadway	Improper Merging
Applied Brakes Late	Improper Parking
Attempting to cross intersection	Jackknifed
Attempting to turn	Left the Scene
Caught Fire	Legally Parked
Crossed Median	Locked Brakes & Skidded
Driving Below Minimum Speed Limit	Lost Control
Driving in Excess of Maximum Speed Limit	Over Corrected
Drove off Bridge	Proper Parking
Drove Onto Shoulder	Pulled out in Front of
Ejected (Passenger or Driver)	Ran off the Side of the Road (right or left)
Entered Emergency Lane	Reentered Roadway
Entered Exit Lane	Rolled, Flipped, Overturned
Entered oncoming Lanes of Traffic	Slowing to Turn
Entered the median	Stopped in Traffic
Entered the path of	Stopped on Shoulder
Entered Travel Lanes (EB, WB, NB, SB)	Struck by Debris
Failed to Slow	Struck Obstruction (Guardrail, Bridge Pillar, Road Sign, etc.)
Failed to Stop	Tire Failed
Failed to Yield Right of Way	Took Evasive Action
Illegally Parked	Took No Evasive Action
Improper Backing	Vehicle had a Flat Tire
Improper Lane Changing	Vehicle was Disabled

APPENDIX C

CONTRIBUTING FACTORS OF THE CRASH

Contributing Factors - Crash	
Age	Lighting
Asleep	Location of TCD
BAC	Lost Control
Blind	Mentally Challenged
Cardiac Arrest	Metabolites
Careless Driving	No Headlights
Cocaine	No pedestrian control devices
Coefficient of Friction	No Rumble Strips
Construction	No TCD
Deaf	Obstruction
Driver Distraction	Overcorrected
Driver Error	Passenger fell from vehicle
Driving Experience	Perception/reaction
Drugs	Prozac
Environment	Roadway Geometrics
Excessive hours of service	Seizure/Epilepsy/Blackouts
Failure to obey traffic control devices	Sight Distance
Failure to yield right of way	Slick Roads
Fatigue	Slow Moving Vehicle
Following too closely	Speed Unsafe for Conditions
Glare	Speeding
Grade	Underage Driver
Illegal Turning	Unfamiliar Territory
Improper Parking	Unfamiliar with Vehicle
Insecure Load	Vehicle Defect
Jaywalking	Vehicle Overweight
Length of CMV and Trailer	Weather

APPENDIX D

VIDEO LOG OBSERVATION SHEET

DHSMV	Notes	Driver Ages
50241270	Complex intersection, confusing?	37
	Adequate sight distance/signage?	32
	Signal Phasing?	
	Time required to cross the intersection for line of travel of V1?	
52994747	Skewed Intersection.	18
	Time required to cross the intersection for line of travel of V1?	54
	Average speed on major road?	
	LOS for vehicle on minor road obstructed by vehicles stopped in the left turn lane on major road?	
	Signal Phasing?	
52994748	Average speed on major road?	23
	Motorcycle at 85 MPH on 45 MPH roadway. Clear driver fault.	17
	Available Gaps?	
53002974	Enough sight distance?	57
	Sun Glare?	47
	Time required for left turn maneuver?	
	Available Gaps?	
53118037	Enough sight distance?	70
	Available Gaps?	81
	Time required for left turn maneuver?	29
54126345	Vertical Curve in road, enough sight distance?	86
	Time required for left turn maneuver?	60
	Available Gaps?	
	Average speed of vehicles coming downhill?	
	Speed limit increases to 55 MPH just after the intersection.	
54441238	No crosswalks?	64
	Businesses on both sides of road, average pedestrian crossing volume?	81
	Enough lighting at intersection?	
	Nearest cross walk is almost 0.2 miles from intersection.	
54597578	Obstructions to line of sight (LOS)?	82
	Horizontal curve in road, enough sight distance?	53
	55 MPH road intersecting a 55 MPH road, not enough signage.	
	Available Gaps?	
	Average speed of through vehicles?	

54963377	Vertical curve, enough sight distance?	40
	Can the gap be judged easily for vehicle coming downhill?	32
	Average speed of through vehicle?	
	Time required for left turn maneuver?	
	Minor road has only one narrow lane, ease of maneuvering for CMV further reduced?	
55010320	Horizontal curve, enough sight distance?	84
	Average speed of through vehicles?	36
	Available Gaps?	
55219937	Horizontal curve, enough sight distance?	20
	LOS obstructed by vehicle in turn lane.	34
55362527	Trees obstruct LOS?	30
	Average speed of through vehicles?	45
	Too many access points to roadway, speed limit of 50 MPH too high?	
55551032	Signal Phasing?	19
	Average speed of through vehicles?	16
	Time required for left turn maneuver?	
55565683	Busy Intersection, available gaps?	38
	Signal Phasing?	52
	Turning Volume, enough length of protected turn phase?	
55567269	Signal Phasing?	44
	Average speed of through vehicles?	22
	Time required for left turn maneuver?	
	Available Gaps?	
	Sun Glare issue?	
55567532	Average Turning volume of traffic, is a signal warranted?	68
	LOS blocked due to vehicles in inside lane.	17
	Average speed of through vehicles?	
56123041	Average speed of through vehicles?	77
	Time required for left turn maneuver?	20
	Available Gaps?	
56328683	Signal Phasing issues?	
	Left turner entered on yellow, then how did through have a green? Amber Phase length? All red period?	
	Time required for left turn maneuver?	
	LOS blocked due to vehicles in inside lane.	
56369754	Signal Phasing?	71
	Time required for left turn maneuver?	29
	Turning Volume from the straight and through lane?	

56821112	Planted line of trees in median block the LOS for a section of the road of oncoming vehicles.	82
	Signal Phasing, Protected left turn phase timing?	43
	Time required for left turn maneuver?	
	Average speed of through vehicles?	
56824840	Sharp horizontal curve, enough sight distance?	43
	Trees block LOS.	48
	Average speed of through vehicles?	
56848926	Vertical curve in road, enough sight distance?	40
	Speed limit on major road 65 MPH, enough signage for presence of side roads?	62
	Speed limit on major road 65 MPH, enough signage on side roads?	
	Time required to cross the intersection?	
56858413	Sharp horizontal curve, not enough sight distance.	51
	Bushes and trees block LOS to oncoming vehicles.	84
	Speed Limit of 65 MPH, available gaps?	
	Time required for left turn maneuver?	
56915837	Signal Phasing?	50
	Protected left turn phase length?	42
	Turning Volume, is phase length enough?	
	Available Gaps?	
	Sun Glare Issue?	
56932581	Same intersection as above, two crashes of same type within the year.	66
	Sun Glare Issue? (Site should be visited during the morning hours between 7:00 AM and 8:00 AM)	
	Signal Phasing?	
	Protected left turn phase length?	
	Turning Volume, is phase length enough?	
	Available Gaps?	
57013265	Vertical curve, enough sight distance?	88
	Trees blocking LOS for vehicles stopped on minor road.	38
	Average speed of through vehicles coming downhill?	
57014013	Low Visibility due to early morning fog.	66
	Visibility of STOP sign and flashing lights?	36
	Speed Limit of 55 MPH on major road, enough signage?	
57501174	Horizontal curve, enough sight distance?	46
	Trees on Shoulder block LOS?	26
	No Signage for presence of side road.	
	Average turning volume?	
	Turn lane needed for vehicles slowed down or stopped to make a left turn.	
	Average speed of through vehicles?	

57514740	LOS blocked by Utility Pole and bushes?	78
	Average speed of through vehicles?	57
	Time required for left turn maneuver?	
	Available Gaps?	
58011549	Horizontal curve, enough sight distance?	79
	Signal Phasing?	43
	Turning Volume?	
	Vehicles stopped in left turn lane of opposite side possible block the LOS of the southbound turning vehicles?	
	Available Gaps?	
	Protected left turn phase length?	
58033994	Trees and traffic sign in the median possibly block the LOS of vehicles stopped to turn.	68
	Time required for left turn maneuver?	18
	Available Gaps?	
	Average speed of through vehicles?	
58086621	Enough Sight distance?	37
	Available Gaps?	41
	Signal Phasing?	23
58132138	Horizontal curve, enough sight distance?	17
	Signal Phasing?	22
	Time required for left turn maneuver?	
	Average speed of through vehicles?	
58191121	Overpass just north of intersection possibly blocks clear view of the light posts.	18
	Average speed of through vehicles?	66
	18 year old ran red light, all red period?	26
58334772	Pedestrian Walking Phase time?	37
	Time required to cross the intersection?	76
	76 year old pedestrian, trip generators?	
58389145	Pedestrian Walking Phase time?	82
	Time required to cross the intersection?	32
	82 year old pedestrian, trip generators?	
	Big Intersection.	
	Average Pedestrian Volume?	
58404623	Sharp Horizontal curve, enough sight distance?	91
	Signal Phasing?	48
	Protected left turn phase length?	
	Time required for left turn maneuver?	
	Tree line in median possibly blocks view of vehicles coming down the curve.	

58902521	Sharp horizontal curve, enough sight distance for a 60 MPH road?	48
	60 MPH crossing 55 MPH road, not enough signage?	42
	Average speed of through vehicles?	
	Utility poles possibly block LOS from V1's point of view?	
	Trees block LOS on other access points on the road near intersection.	
58960584	Average speed on both roads?	18
	Available gaps?	21
	Busy roads, signal warrants?	
59036227	Sharp curve, not enough sight distance.	44
	Speed zone sign posted just before the intersection.	73
	Sudden change from 55 MPH to 30 MPH, not enough time or distance to slow down.	
	Trees possibly block LOS of V1?	
59036262	Rolling Terrain, enough sight distance?	
	Evening Sun Glare ?	
	Trees block LOS from V2's point of view?	
	60 MPH road Crossing 55 MPH, enough signage?	
51808559	Complex intersection, confusing?	37
	Adequate sight distance/signage?	32
	Signal Phasing?	
	Time required to cross the intersection for line of travel of V1?	
52198023	Skewed Intersection.	18
	Time required to cross the intersection for line of travel of V1?	54
	Average speed on major road?	
	LOS for vehicle on minor road obstructed by vehicles stopped in the left turn lane on major road?	
	Signal Phasing?	
52457998	Average speed on major road?	23
	Motorcycle at 85 MPH on 45 MPH roadway. Clear driver fault.	17
	Available Gaps?	
53960697	Enough sight distance?	57
	Sun Glare?	47
	Time required for left turn maneuver?	
	Available Gaps?	
54029075	Enough sight distance?	70
	Available Gaps?	81
	Time required for left turn maneuver?	29
54294772	Vertical Curve in road, enough sight distance?	86
	Time required for left turn maneuver?	60
	Available Gaps?	
	Average speed of vehicles coming downhill?	
	Speed limit increases to 55 MPH just after the intersection.	

54346278	No crosswalks?	64
	Businesses on both sides of road, average pedestrian crossing volume?	81
	Enough lighting at intersection?	
	Nearest cross walk is almost 0.2 miles from intersection.	
54477658	Obstructions to line of sight (LOS)?	82
	Horizontal curve in road, enough sight distance?	53
	55 MPH road intersecting a 55 MPH road, not enough signage.	
	Available Gaps?	
	Average speed of through vehicles?	
54850042	Vertical curve, enough sight distance?	40
	Can the gap be judged easily for vehicle coming downhill?	32
	Average speed of through vehicle?	
	Time required for left turn maneuver?	
	Minor road has only one narrow lane, ease of maneuvering for CMV further reduced?	
54914083	Horizontal curve, enough sight distance?	84
	Average speed of through vehicles?	36
	Available Gaps?	
55459628	Horizontal curve, enough sight distance?	20
	LOS obstructed by vehicle in turn lane.	34
55682906	Trees obstruct LOS?	30
	Average speed of through vehicles?	45
	Too many access points to roadway, speed limit of 50 MPH too high?	
55758013	Signal Phasing?	19
	Average speed of through vehicles?	16
	Time required for left turn maneuver?	
55921953	Busy Intersection, available gaps?	38
	Signal Phasing?	52
	Turning Volume, enough length of protected turn phase?	
56419037	Signal Phasing?	44
	Average speed of through vehicles?	22
	Time required for left turn maneuver?	
	Available Gaps?	
	Sun Glare issue?	
56496358	Average Turning volume of traffic, is a signal warranted?	68
	LOS blocked due to vehicles in inside lane.	17
	Average speed of through vehicles?	
56840310	Average speed of through vehicles?	77
	Time required for left turn maneuver?	20

	Available Gaps?	
57033406	Signal Phasing issues?	
	Left turner entered on yellow, then how did through have a green? Amber Phase length? All red period?	
	Time required for left turn maneuver?	
	LOS blocked due to vehicles in inside lane.	
57090451	Signal Phasing?	71
	Time required for left turn maneuver?	29
	Turning Volume from the straight and through lane?	
58249818	Planted line of trees in median block the LOS for a section of the road of oncoming vehicles.	82
	Signal Phasing, Protected left turn phase timing?	43
	Time required for left turn maneuver?	
	Average speed of through vehicles?	
58250347	Sharp horizonatl curve, enough sight distance?	43
	Trees block LOS.	48
	Average speed of through vehicles?	
58259526	Vertical curve in road, enough sight distance?	40
	Speed limit on major road 65 MPH, enough signage for presence of side roads?	62
	Speed limit on major road 65 MPH, enough signage on side roads?	
	Time required to cross the intersection?	
58573091	Sharp horizontal curve, not enough sight distance.	51
	Bushes and trees block LOS to oncoming vehicles.	84
	Speed Limit of 65 MPH, available gaps?	
	Time required for left turn maneuver?	
58575673	Signal Phasing?	50
	Protected left turn phase length?	42
	Turning Volume, is phase length enough?	
	Available Gaps?	
	Sun Glare Issue?	
58575750	Same intersection as above, two crashes of same type within the year.	66
	Sun Glare Issue? (Site should be visited during the morning hours between 7:00 AM and 8:00 AM)	
	Signal Phasing?	
	Protected left turn phase length?	
	Turning Volume, is phase length enough?	
	Available Gaps?	
50389817	Vertical curve, enough sight distance?	88
	Trees blocking LOS for vehicles stopped on minor road.	38
	Average speed of through vehicles coming downhill?	

50656163	Low Visibility due to early morning fog.	66
	Visibility of STOP sign and flashing lights?	36
	Speed Limit of 55 MPH on major road, enough signage?	
50823295	Horizontal curve, enough sight distance?	46
	Trees on Shoulder block LOS?	26
	No Signage for presence of side road.	
	Average turning volume?	
	Turn lane needed for vehicles slowed down or stopped to make a left turn.	
	Average speed of through vehicles?	
51926843	LOS blocked by Utility Pole and bushes?	78
	Average speed of through vehicles?	57
	Time required for left turn maneuver?	
	Available Gaps?	
53122662	Horizontal curve, enough sight distance?	79
	Signal Phasing?	43
	Turning Volume?	
	Vehicles stopped in left turn lane of opposite side possible block the LOS of the southbound turning vehicles?	
	Available Gaps?	
	Protected left turn phase length?	
54963378	Trees and traffic sign in the median possibly block the LOS of vehicles stopped to turn.	68
	Time required for left turn maneuver?	18
	Available Gaps?	
	Average speed of through vehicles?	
57266520	Enough Sight distance?	37
	Available Gaps?	41
	Signal Phasing?	23
57356420	Horizontal curve, enough sight distance?	17
	Signal Phasing?	22
	Time required for left turn maneuver?	
	Average speed of through vehicles?	
57427968	Overpass just north of intersection possibly blocks clear view of the light posts.	18
	Average speed of through vehicles?	66
	18 year old ran red light, all red period?	26
57455694	Pedestrian Walking Phase time?	37
	Time required to cross the intersection?	76
	76 year old pedestrian, trip generators?	
57488495	Pedestrian Walking Phase time?	82

	Time required to cross the intersection?	32
	82 year old pedestrian, trip generators?	
	Big Intersection.	
	Average Pedestrian Volume?	
58106133	Sharp Horizontal curve, enough sight distance?	91
	Signal Phasing?	48
	Protected left turn phase length?	
	Time required for left turn maneuver?	
	Tree line in median possibly blocks view of vehicles coming down the curve.	
58328506	Sharp horizontal curve, enough sight distance for a 60 MPH road?	48
	60 MPH crossing 55 MPH road, not enough signage?	42
	Average speed of through vehicles?	
	Utility poles possibly block LOS from V1's point of view?	
	Trees block LOS on other access points on the road near intersection.	
58360181	Average speed on both roads?	18
	Available gaps?	21
	Busy roads, signal warrants?	
55565683	Sharp curve, not enough sight distance.	44
	Speed zone sign posted just before the intersection.	73
	Sudden change from 55 MPH to 30 MPH, not enough time or distance to slow down.	
	Trees possibly block LOS of V1?	
55567269	Rolling Terrain, enough sight distance?	
	Evening Sun Glare ?	
	Trees block LOS from V2's point of view?	
	60 MPH road Crossing 55 MPH, enough signage?	

REFERENCES

1. FHWA - Stop Red Light Running Facts, May 2002.
(<http://safety.fhwa.dot.gov/fourthlevel/interbriefing/02coun.htm>)
2. State data system: A summary of motor vehicle traffic crashes from state crash data files. Published: U.S. Dept. of Transportation, National Highway Traffic Safety Administration, [1997]. Library Resource.
3. Traffic and Highway Engineering, Second Edition, Garber and Hoel.
4. AASHTO Green Book, A Policy on Roadway Geometric Design, 2002.
5. Human Factors Issues in Intersection Safety, ITE, Intersection Safety Brief Compendium, FHWAY, September 2004.
6. Comparison of Fatal Traffic Crashes in Southern and Northern Regions of the State of Florida, A Study of Fatal Crashes in Florida from 1998 – 2000, N H. Kadabagere, 2003.
7. Analysis of Fatal Crashes due to Signal and Stop Sign Violations, NHTSA Report, September 2004.
8. Positive Guidance in Traffic Control, Alexander, G.J et al., 1975.
9. Multidisciplinary in-depth investigations of head-on and left turn road collisions; Danish Transport research Institute, December 2000.
10. Insurance Institute for Highway Safety, States Report, September 2001.
11. Traffic Safety Facts 2003, NHTSA, US Dept. of Transportation.
12. Traffic Crash Statistics Report 2003, A Compilation of Motor Vehicle Crash Data from Florida Crash Records Database, Fl Dept. of Highway Safety and Motor Vehicles.
13. Analysis of Traffic Crash Data in Kentucky (1998 – 2002), Kenneth Agent et al., September 2003.
14. Analysis of Fatal Crashes Due to Signal and Stop Sign Violations, NHTSA, US Dept. of Transportation, Campbell et al.
15. National Agenda for Intersection Safety, National Intersection Safety Workshop, Milwaukee, November 2001.
16. Large Truck Crash Causation Study, Interim Report, NHTSA, US Dept. of Transportation, Thiriez et al., September 2002.
17. The Unsafe Driving Acts of Motorists in the Vicinity of Large Trucks, US Dept. of Transportation, Anthony Schafer, November 1999.

18. *Impact of Left Turn Phasing on Older and Younger Drivers on High Speed Signalized Intersections*, IOWA State University Report, IOWA Dept. of Transportation, Hallmark et al. August 2004.
19. *Road Safety Research Compendium 2001/2002* (<http://www.dft.gov.uk/roadsafety>)
20. *Advantages of Split intersection: 79th Annual Meeting*, Transportation Research Board, January 2000.
21. *A Study of Fatal Rollover Crashes in the State of Florida, A Study of Fatal Traffic Crashes in Florida from 1998 – 2000*, FSU, Saravade, S N., December 2004.
22. *Basic Countermeasures to Make Intersections Safer, Intersection Safety Brief*, FHWA (<http://safety.fhwa.dot.gov/intersections/interbriefing/02coun.htm>)
23. *Safety Effectiveness of Highway Design Features*, US DOT, FHWA, Washington D.C, November 1992, vol. 5, p3.

BIOGRAPHICAL SKETCH

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